GEOTECHNICAL INVESTIGATION REPORT
FOR PORPOSED NEW SUBDIVISION AT 613 HELENA STREET, FORT ERIE, ON

Client

SS Welland Inc.
4080 Confederation Parkway, Unit 605
Mississauga, ON L5B 0G1

Prepared by:

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Project No. 2100394AG

February 16, 2022

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SS Fort Erie Inc.
4080 Confederation Parkway, Unit 605
Mississauga, ON L5B 0G1
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Attention: Hunain Siddiqui
Email: hunain.siddiqui@thefourwalls.ca

RE: Geotechnical Investigation Report for Proposed New Subdivision at 613 Helena Street, Fort Erie, ON

Enclosed is a copy of geotechnical investigation report related to the above noted site.

For and on behalf of HLV2K Engineering Limited

Irfan Ahmad Khokhar, Ph.D., P.Eng.
Vice President and Principal

Executive Summary

A geotechnical investigation based on drilling eleven boreholes (BH1 to BH11) was carried out for the proposed new subdivision at 613 Helena Street, Fort Erie, ON. The approximate project site location plan and approximate location of the drilled boreholes are shown on Drawings 1 & 1A.

Based on the information provided by the client, it is our understanding that the project consists of double storey residential dwellings.

HLV2K does not have any architectural or structural information regarding the proposed development.

The purpose of this investigation was to assess the subsurface conditions at the site and provide geotechnical engineering advice and recommendations.

A top layer of topsoil was encountered at all borehole locations except at BH1 and BH3, where asphalt and gravel were encountered as top layer respectively. Topsoil thickness was measured in the range of 150mm to 300mm at borehole locations. It should be noted that asphalt/topsoil quantities should not be calculated from the borehole information, as large variations in depth may exist between and beyond boreholes.

Under the topsoil/asphalt/grave, a layer of fill/disturbed native was encountered at all borehole locations except BH1 and BH3 and extended in general to approximately from 0.2m to 0.6m below the existing ground surface. The disturbed native consisted of silty clay, with inclusions of trace sand and gravel, trace rootlets and organic matter and was typically in loose state. Granular material consisting of silty sand and gravel was found at the location of boreholes BH1 and BH3 and was typically very moist and in loose state. It should be noted that the depth of fill can vary in the area of existing structures or in the area of previous excavations.

Native materials were encountered underlying the fill/disturbed native material in boreholes BH2, BH4 to BH11 and/or granular material at BH1 and BH3. The native materials encountered at most of the borehole locations were quite consistent and were generally cohesive in nature (i.e. firm to very stiff silty clay till) to depths ranging between 3.1m and 4.9m below ground surface followed by a layer of soft to firm silty clay to a maximum explored depth ranging from 4.6 to 6.9m below existing ground surface. Bedrock was encountered at the location of boreholes BH1, BH, BH7 and BH1 at depths 4.6 ranging from 4.6 to 6.9m below existing ground surface.

During drilling and at the completion of drilling, the short-term groundwater levels were observed in boreholes and found dry. Monitoring wells were installed at the borehole locations BH5, BH6, BH7 and BH11. Groundwater level measurements were made at different times to observe water level fluctuations in the monitoring wells and presented in table 3.3 of this report.

It should be noted that groundwater conditions vary depending on factors such as temperature, season, precipitation, construction activity and other situations, which may be different from those encountered at the time of the monitoring. The possibility of groundwater level fluctuations at the site should be considered when designing and developing the construction plans for the project.

Based on the boreholes information, the proposed structures can be supported by conventional spread and strip footings, on undisturbed native deposits predominantly silty clay till for a geotechnical reaction of 100kPa at the Serviceability Limit States (SLS), and for a factored geotechnical resistance of 150kPa at the Ultimate Limit States (ULS). The geotechnical reactions and factored geotechnical resistances including the corresponding highest founding elevations at the borehole locations are summarized on Table 4.1 The recommended founding levels and geotechnical reactions for the proposed structures would need to be confirmed by HLV2K at the time of construction.

Groundwater problems are anticipated during excavation and installation of foundations below the existing ground surface. A positive dewatering system will be required to deal with water problems during the construction. Details of dewatering requirement are provided in a hydrogeological investigation report prepared by HLV2K.

The basement floor slab can be supported on grade, the floor slab can be supported on grade, provided the base is thoroughly proof rolled and any soft and unstable areas detected are sub-excavated and can be replaced with imported Granular A and/or Granular B placed in shallow lifts (each lift not more than 200mm) and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD). The imported granular material must meet the specifications defined in OPSS-1010-13. The perimeter and under floor drainage system shown on Drawing 3 is recommended for the basement walls where open cut excavations will be undertaken.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the on-site fill material and loose to compact native soils can be classified as Type 3 soil. The dense to very dense native soils can be classified as Type 1 to Type 2 soil above the water level and Type 4 below the groundwater table. Wet sandy silt to silty sand seams can also be classified as Type 4 soils. As a general rule, the excavations in Type 1 and 2 soils can be carried out without support using side slopes 1H:1V, while the bottom 1.2m of the excavation can be cut vertically and could retain the wall for a short period of time. The excavation in Type 3 soil can be carried out maintaining the side slopes not steeper than 1H:1V. The excavations in Type 4 soils will require minimum flatter side slopes of 3H to 1V. These slopes should be visually monitored for any movement especially if workers are present within the excavation. These temporary slopes should only be utilized for a short duration. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number among the types present.

Underside of the basement floor slab should be placed above the ground water level. Prior to the cut below the groundwater level, positive dewatering system such as well points or eductors and/or deep wells will be required in the portion of basement excavation on the site. Otherwise, it will result in an unstable excavation base and flowing sides. The groundwater table must be lowered one meter below the lowest excavation level. Test pits can be carried out at the site prior to the excavation to further explore the groundwater and seepage conditions. A specialized dewatering contractor should install the dewatering system.

The select inorganic fill and native soils free from topsoil and organics can be used as general construction backfill where it can be compacted with sheep's foot type compactors. Loose lifts of soil, which are to be compacted, should not exceed 200mm. Majority of the on-site inorganic fill is not considered suitable for backfilling, imported fill materials with suitable moisture (preferably granular) must be used to replace the existing fill under the slab-on-grade and in trenches.

Based on the borehole information, the subject site for the proposed new building can be classified as Class ‘D’ for seismic site response according to Table 4.1.8.4.A of OBC 2012 provided the footings will be supported on undisturbed native deposits. Consideration could be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e. Geophysical testing – Multi-channel Analysis of Surface Waves-MASW) which can lead to an improved site classification (i.e. from Class D to Class C).

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1 INTRODUCTION

HLV2K Engineering Limited (HLV2K) was retained by SS Fort Erie Inc. (the client) to undertake a geotechnical investigation for the proposed new subdivision at 613 Helena Street, Fort Erie, ON. The approximate project site location plan and approximate location of the boreholes are shown on **Drawings 1 & 1A**.

This work was conducted in accordance with our proposal 2100394AG dated May 25, 2021. Authorization to Proceed (ATP) was issued to HLV2K dated June 14, 2021.

Based on the information provided by the client, it is our understanding that the project will consist of seventeen (17) Residential blocks and one (1) block for stormwater management.

The purpose of this investigation was to assess the subsurface conditions at eleven (11) borehole locations (BH1 to BH11) and from the findings in the boreholes make geotechnical engineering recommendations for the following:

1. Foundations
2. Floor slab and permanent drainage
3. Excavations and backfill
4. Earth pressures
5. Earthquake considerations
6. Underground Utility Trenches
7. Pavement

This report is provided based on the terms of reference presented above and, in the text, and on the assumption that the design will be in accordance with the applicable codes and standards. If there is any change in the design features relevant to the geotechnical analyses, or if any question arises concerning the geotechnical aspects of the codes and standards, HLV2K should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of HLV2K can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for SS Fort Erie Inc. and its designers. Third party use of this report without HLV2K's consent is prohibited. The limitation conditions presented in Appendix A form an integral part of the report and they must be considered in conjunction with this report.

2 FIELD AND LABORATORY WORK

Borehole locations for this investigation were established in and marked on the ground by HLV2K personnel in accordance with the client requirements. Prior to drilling operations, underground utilities were cleared at the borehole locations by the public and private utilities' companies.

For this geotechnical investigation, four boreholes (BH1 to BH11) were drilled to depths varying from 4.6m to 6.9m on September 8 & 9, 2021. The boreholes were advanced by a drilling sub-contractor Landshark Drilling Inc. located at 73 Sinclair Blvd. Brantford, ON, under the supervision of HLV2K personnel. The boreholes were advanced by utilizing continuous flight hollow stem augers. Samples were retrieved at regular intervals with a 50mm O.D. split-barrel sampler driven with a hammer weighing 624 N (63.5 kg) and dropping 760 mm in accordance with the Standard Penetration Test (SPT) method (ASTM D1586). The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 300mm (12 inches) was recorded as SPT 'N' value of the soil which indicated the consistency of cohesive soils or compactness of non-cohesive soils. The results of SPT are shown in the Record of Boreholes. The samples were logged in the field and returned to the HLV2K laboratory for detailed examination by the project engineer and for laboratory testing. The approximate borehole locations are shown on Drawing 1A.

Water level observations were made during drilling and at the completion of the drilling operations. Upon completion of drilling, each borehole was backfilled in accordance with current regulations.

The locations of the boreholes were established in the field by HLV2K accompanied by the client representative based on the plan provided by the client. The borehole elevations and locations were surveyed and established by the HLV2K staff. Note, these elevations are approximate only, for relating borehole soil stratigraphy and should not be used or relied on for other purposes.

As well as visual examination in the laboratory, soil samples were tested for water content determinations. Grain size analyses were carried out on selected soil samples as presented in Table 2.1. The results of the laboratory tests are presented on the borehole logs, and on Drawings 2.

Table 2.1: Sample Details for Grain Size Analyses

Sample No.	Approximate Depth Below the Existing Ground Surface (m)	Approximate Geodetic Elevation (m)	Type of Test	Lab Results
BH1-SS3	1.5 – 2.1	180.6 – 180	MH	Drawing 2
BH2-SS6	4.5 – 5.1	177.0 – 176.5	MH	Drawing 2

Notes: -MH stands for sieve and hydrometer grain size analyses

The results of grain size analyses are presented on subject referenced drawings.

3 RESULTS OF THE INVESTIGATION

The site is located at the west side of Helena Street, south of the intersection of Helena Street and Garrison Road in Fort Erie, Ontario. The site key plan and the borehole locations are presented on Drawings 1 and 1A. Notes on sample descriptions and the general features of fill material and native soils are presented on Drawing 1B. Detailed subsurface conditions are presented on borehole log sheets, attached as Appendix B.

Details of the subsurface conditions encountered at the borehole locations are provided on the borehole logs following the text of this report. The borehole logs indicate the subsurface conditions only at the borehole locations. Note the material boundaries indicated on the attached sheets are approximate and based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions will vary across this site. The subsurface soil and groundwater conditions are summarized as follows.

3.1 Subsurface Conditions

In general, below the fill/disturbed native materials (silty clay, trace sand and gravel), the site is underlain by native soils (silty clay till to clayey silt till/silty clay, trace sand and gravel). The subsurface conditions encountered in the boreholes are summarized as follows.

3.1.1 Pavement Structure

Pavement structure is encountered at location of boreholes: BH1. The approximate asphalt concrete thickness is 150 mm underlain by granular base/subbase (sand with gravel with asphalt inclusion). Thickness of granular material is 150 mm to 200 mm.

3.1.2 Fill/Disturbed Native Soil

Under the topsoil/asphalt/grave, a layer of fill/disturbed native was encountered at all borehole locations except BH1 and BH3 and extended in general to approximately from 0.2m to 0.6m below the existing ground surface. The disturbed native consisted of silty clay, with inclusions of trace sand and gravel, trace rootlets and organic matter. SPT N-values recorded within this material generally varied from 4 to 7 blows/300mm indicating loose state.

Based on visual observation in the field and our experience in the area, it appears that these SPT N values are not representative to determine the compactness. It also indicates that the fill did not receive a systematic compaction. It should be noted that the thickness of fill could vary between and beyond boreholes and this should be considered when estimating.

3.1.3 Granular Fill

Granular fill material consisting of silty sand and gravel was found at the location of boreholes BH1 and BH3 and was typically moist and in loose to compact state. It should be noted that the depth of fill can vary in the area of existing structures or in the area of previous excavations.

3.1.4 Native Soils:

Native materials were encountered underlying the fill/disturbed native material in boreholes BH2, BH4 to BH11 and/or granular material at BH1 and BH3. The native materials encountered at most of the borehole locations were quite consistent and were generally cohesive in nature (i.e. firm to very stiff silty clay till) to depths ranging between 3.1m and 4.9m below ground surface followed by a layer of soft to firm silty clay to a maximum explored depth ranging from 4.6 to 6.9m below existing ground surface.

The grain-size distribution of two (2) selected soil samples (BH1-SS3 and BH2-SS6) from native deposit is enclosed in Drawing 2, and results are summarized in Table 3.1.

Table 3.1: Summary of Grain-Size Distribution

Sample No.	Depth Below the Existing Ground Surface (m)	Sieve and Hydrometer Test Results			
		Gravel %	Sand %	Silt %	Clay %
BH1-SS3	1.5 – 2.1	1	7	45	47
BH2-SS6	4.5 – 5.1	1	7	52	40

It should be noted that the thickness of native deposit could vary between and beyond the borehole locations within the depth of investigation, and this should be taken into account when estimating.

3.1.5 Bedrock

Silty clay deposit is underlain by bedrock. Grey, weathered dolomite bedrock was encountered at the location of boreholes BH1, BH, BH7 and BH1 at depths 4.6 ranging from 4.6m to 6.9m below existing ground surface corresponding to geodetic elevations 175.3m to 177.1m.

3.2 Groundwater Conditions

During drilling and at the completion of drilling, the short-term groundwater levels were observed in boreholes. Monitoring wells were installed at the borehole locations BH5 to BH7 and BH11. Groundwater level measurements were made on Oct 21, 2021 to observe water level fluctuations in the monitoring wells and presented in table 3.3

Table 3.3: Summary of Groundwater Level Observations in Installed Monitoring Wells

MW ID	Ground Surface Elevation (m)	Borehole Depth (mbgs)	Groundwater Depth (mbgs)	Elevation (m)
BH5	181.4	5.2	1.6	179.8
BH6	181.2	5.2	1.3	179.9
BH7	181.7	4.6	2.2	179.5
BH11	181.9	6.1	2.05	179.85

Based on the water table readings obtained between on October 21, 2021, the groundwater level varied from 1.3m to 2.2m below the existing ground surface, corresponding to geodetic elevations of 179.5 to 179.9m. For design purpose, the groundwater table can be estimated at an approximate depth of 1.2m corresponding to geodetic elevation of 180.0m.

It should be noted that groundwater conditions vary depending on factors such as temperature, season, precipitation, construction activity and other situations, which may be different from those encountered at the time of the monitoring. The possibility of groundwater level fluctuations at the site should be considered when designing and developing the construction plans for the project.

Note that the groundwater level can vary and is subjected to seasonal fluctuations and in response to major weather events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches.

Perched water can be encountered in excavated areas during wet seasons especially at the interface of fill and native soils. A perched water condition can also occur due to the accumulation of surface water in the more permeable fill deposits overlying less permeable clayey soils.

4 DISCUSSION AND RECOMMENDATIONS

Based on the information provided by the client, it is our understanding that the project consists of proposed new subdivision at 613 Helena Street, Fort Erie, ON.

HLV2K does not have any architectural or structural information regarding the proposed development.

The following sections of the report provides our interpretation of the factual geotechnical data obtained during our field evaluation and is intended for the guidance of the design engineer only. Where comments are made on aspects of construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors bidding on or undertaking the work should make their own interpretation of the subsurface information provided as it affects their proposed construction methods, equipment selection, scheduling, safety and the like.

4.1 Foundations

The fill and/or disturbed material are unsuitable to support foundations or floor slabs due to differential settlements that could damage the structures.

4.1.1 Footings founded on Native Soils

Based on the boreholes information, the proposed structures can be supported by conventional spread and strip footings, on undisturbed native deposits predominantly silty clay till for a geotechnical reaction of 100kPa at the Serviceability Limit States (SLS), and for a factored geotechnical resistance of 150kPa at the Ultimate Limit States (ULS). The geotechnical reactions and factored geotechnical resistances including the corresponding highest founding elevations at the borehole locations are summarized on Table 4.1 The recommended founding levels and geotechnical reactions for the proposed structures would need to be confirmed by HLV2K at the time of construction.

Table 4.1: Bearing Values & Founding Levels of Footings on Native Soils

BH No.	Material	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Grade (m)	Founding Level at or Below Elevation (m)
BH1	Silty Clay Till	100	150	1.2	181.0
BH2	Silty Clay Till	100	150	1.2	180.4
BH3	Silty Clay Till	100	150	1.2	180.5

BH No.	Material	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Grade (m)	Founding Level at or Below Elevation (m)
BH4	Silty Clay Till	100	150	1.2	180.2
BH5	Silty Clay Till	100	150	1.2	180.2
BH6	Silty Clay Till	100	150	1.2	180.0
BH7	Silty Clay Till	100	150	1.2	180.5
BH8	Silty Clay Till	100	150	1.2	180.6
BH9	Silty Clay Till	100	150	1.2	180.6
BH10	Silty Clay Till	100	150	1.2	180.4
BH11	Silty Clay Till	100	150	1.2	180.7

Above geotechnical reactions and founding level are provided here with a condition that basement will not be excavated more than 1.5m below existing ground surface due to presence of a soft clay layer at or below 3.1m bgs. If client decided to excavate below 1.5 for the basements, then HLV2K should be contacted for further recommendations

All base of all foundations must be inspected by this office prior to pouring concrete or placing the mud slab.

4.1.2 Other Comments on Foundations

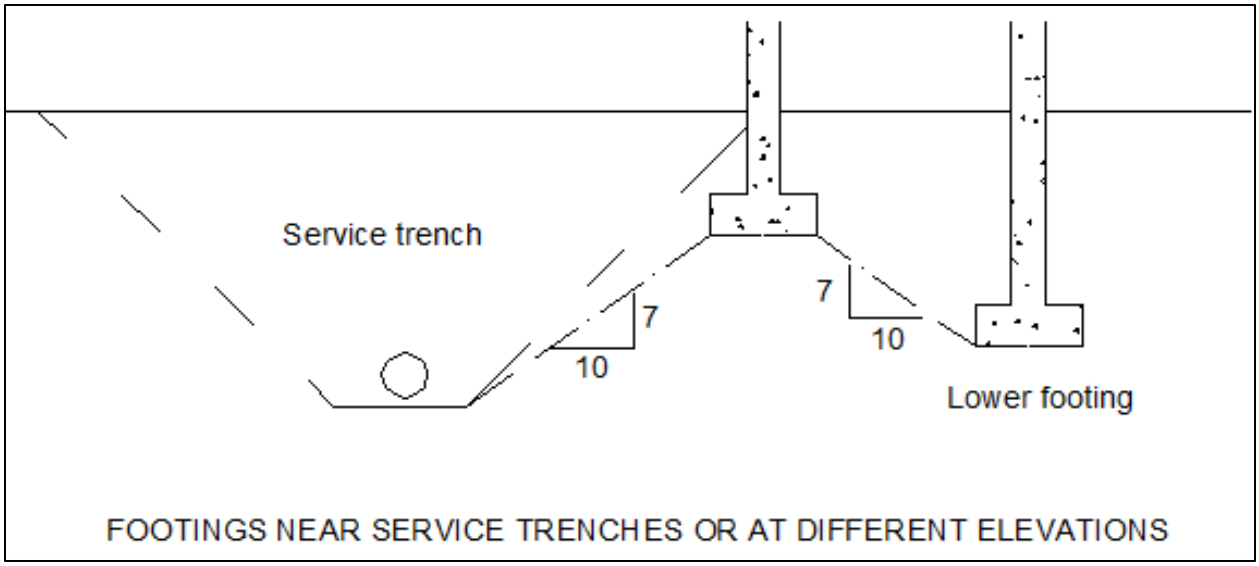
Variations in the soil conditions are expected in between the borehole locations, and during construction, the soil bearing pressures should be confirmed by the Geotechnical Engineer.

The base of all footings must be inspected by this office to ensure of their placement on the competent native soil.

Footings designed to the specified bearing capacity at the serviceability limit states (SLS) are expected to settle less than 25 mm total and 19 mm differential.

In the vicinity of the existing buried utilities, footings must be lowered to undisturbed native soils, or alternatively the services must be structurally bridged.

Where it is necessary to place footings at different levels, the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing. Footings close to underground services should also be set back from the services based on this slope limitation as shown in the following Figure.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

During winter construction, foundations and slab (if applicable) on grade must not be poured on frozen soil. Foundations must be adequately protected at all times from cold weather and freezing conditions.

Design frost protection depth for the general area is 1.2m. Therefore, for frost protection, new footings should have a permanent earth cover of at least 1.2m or be provided with an equivalent thickness of extruded rigid exterior-grade polystyrene insulation. In case of rip-rap (rock fill), only one-half of the rock fill thickness should be assumed to be effective in providing frost protection.

The recommended bearing capacities and the corresponding founding elevations would need to be confirmed by the representative of HLV2K during construction. It should be noted that the recommended bearing capacities have been calculated by HLV2K from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by HLV2K to validate the information for use during the construction stage. In this regard, HLV2K should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, HLV2K will assume no responsibility for interpretation of the recommendations in the report.

4.2 Floor Slab and Permanent Drainage

The basement floor slab can be supported on grade, the floor slab can be supported on grade, provided the base is thoroughly proof rolled and any soft and unstable areas detected are sub-excavated and can be replaced with imported Granular A and/or Granular B placed in shallow lifts (each lift not more than 200mm) and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD). The imported granular material must meet the specifications defined in OPSS-1010-13. The perimeter and under floor drainage system shown on Drawing 3 is recommended for the basement walls where open cut excavations will be undertaken.

A moisture barrier consisting of at least 200 mm thick layer of well compacted 19 mm clear crushed stone is recommended to place directly under the floor slab. The stone bed would act as a barrier and prevent capillary rise of moisture from the subgrade to the floor slab. This moisture barrier has been proven to be effective for conventional floor surfaces such as carpet, vinyl tile and ceramic tile. However, if special floor coverings such as sheet P.V.C. with heat sealed seams, as is used in gymnasiums, is considered, either a high efficiency vapour barrier or venting may be required to prevent moisture accumulating between the concrete floor and the P.V.C. flooring.

The estimated modulus of subgrade reaction (ks) equal to 25 MN/m^3 may be used for the design of slab-on-grade supported on native or structural fill soils, provided that the construction is in accordance with the recommendations provided herein. If structural fill (Granular A or B Type II) having minimum thickness of 300 mm, this value can be increased to 30 MN/m^3. The estimated value provided above may need to be adjusted based on the structure size and locations of detail design.

It should be noted that permanent, failsafe drainage should be designed around any depressed areas such as below grade pits, as well as behind retaining walls (if applicable). Frost Slab or adequate thermal insulation is required for any exterior slab which is sensitive to movement (e.g., sidewalk in front of the doors). The remaining portion of the exterior slab which is not sensitive to movement (e.g., regular sidewalks) does not require thermal insulation subject to placement of adequate granular base (min 200mm to 300mm thick), and positive drainage of the granular base. Differential frost heave should be expected where frost slab (or slab with thermal insulation) abut the slab without any thermal insulation (e.g. away from the doors) or asphalt.

Considering the basement floor slab (where applicable) of proposed building structure below the water table, the perimeter and underfloor drainage must be installed. As soils are exposed below the groundwater table, filter cloth such as Terrafix 270R or equivalent must cover the subgrade, all drains, clear stone and other openings.

The perimeter drainage system shown on **Drawing 3** is recommended for the basement walls where (if any) open cut excavations will be undertaken.

The floor slabs should not be tied to any load-bearing walls or columns unless they have been designed accordingly. Contraction/expansion joints should be provided for the slabs as required by the structural engineer.

4.3 Excavations and Backfill

Excavations can be carried out with a heavy hydraulic backhoe. Considering fill and/or disturbed material removal, it is anticipated that the excavation will be extended below the groundwater level, positive dewatering such as well points can be required to lower the water table to at least 1.0 m below the excavation base. Otherwise, it will result in an unstable base and flowing sides.

Standard borings may not assess dewatering requirements for layered granular soils below the groundwater table. Prior to excavation, we strongly recommend that test pits be carried to further explore the groundwater and seepage conditions and to confirm the need for positive dewatering. A contractor specializing in dewatering should be retained to design the dewatering systems in the area where required. For dewatering details, refer to our hydrogeological report.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the on-site fill material and compact to loose or firm native soils can be classified as Type 3 soil. The dense to very dense native soils can be classified as Type 1 to Type 2 soil above the water level and Type 4 below the groundwater table. Wet sandy silt to silty sand seams can also be classified as Type 4 soils. As a general rule, the excavations in Type 1 and 2 soils can be carried out without support using side slopes 1H:1V, while the bottom 1.2m of the excavation can be cut vertically and could retain the wall for a short period of time. The excavation in Type 3 soil can be carried out maintaining the side slopes not steeper than 1H:1V. The excavations in Type 4 soils will require minimum flatter side slopes of 3H to 1V. These slopes should be visually monitored for any movement especially if workers are present within the excavation. These temporary slopes should only be utilized for a short duration. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number among the types present.

Note that till is non-sorted sediment and therefore may contain boulders. Possible large obstructions such as buried concrete pieces may also be encountered in the fill material. Provisions must be made in the excavation contract for the removal of possible boulders in the till or obstructions in the fill material during construction.

The existing fill (free of topsoil) and native soils can be used as general construction backfill where it can be adequately compacted with suitable type compactors. Loose lifts of soil, which are to be compacted, should not exceed 200 mm. Noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should therefore be compacted at the surface or be covered with tarpaulins to help minimize moisture intake.

Imported granular fill, which can be compacted with handheld equipment, should be used in confined areas. The excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

Stockpiles should be placed well away from the edge of excavation and their height should be controlled so that they do not surcharge the sides of the excavation. Surface drainage should be controlled to prevent flow of surface water into the excavations. Excavation safety and stability of temporary construction slopes and lateral support systems are the contractor's responsibility.

During winter construction, concrete and/or fill must not be placed on frozen fill or soil. Subgrades and foundations must be placed adequately protected at all times from cold weather and freezing conditions.

4.4 Earthquake Considerations

Based on our borehole information and according to the 2012 Ontario Building Code (OBC 2012), the subject site seismic response for the proposed residential can be classified as "Class D" (Table 4.1.8.4.A of OBC 2012). Accordingly, the foundation factors F_a can be obtained from Table 4.1.8.4.B and F_v from Table 4.1.8.4.C for the design of the proposed structure.

Consideration may be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e. geophysical testing) which may lead to an improved site classification, if required.

4.5 Underground Utility Trenches

As a part of the site development, a network of utility trenches needs to be constructed.

4.5.1 Trenching

It is expected that in most cases the trenches will be excavated through loose to compact fill/disturbed native and/or firm to very stiff silty clay till soils.

Groundwater is not anticipated to be a major problem for excavating utility trenches to approximate depth of 1m from the existing grades. Any cut below the groundwater level (positive dewatering system such as well points or educators or deep wells will be required. Otherwise, it will result in an unstable excavation base and flowing sides. The groundwater table must be lowered one meter below the lowest excavation level. Test pit should be carried out in this area prior to the excavation to further explore the groundwater and seepage conditions. A specialized dewatering contractor should install the dewatering system. In accordance with OHSA, on-site fill above the groundwater table can be classified as Type 3 soil and the undisturbed native soils as Type 1 to Type 2 soils. Soils below the groundwater table can be classified as Type 4.

4.5.2 Bedding

The undisturbed native deposits or engineered fill will provide adequate support for the utility pipes and allow the use of normal Class B type bedding.

The recommended minimum thickness of granular bedding below the invert of the pipes is 150 mm. The thickness of the bedding may, however, have to be increased depending on the pipe diameter or in accordance with local standards or if wet or weak subgrade conditions such are encountered, especially when the soil at the trench base level consists of wet, dilatant silts, sandy silts and soft to firm clayey silt to silty clay. The bedding material should consist of well graded granular material such as Granular ‘A’ or equivalent. After installing the pipe on the bedding, a granular surround of approved bedding material, which extends at least 300 mm above the obvert of the pipe, or as set out by the local authority, should be placed.

To avoid the loss of soil fines from the subgrade, uniformly graded clear stone should not be used unless, below the granular bedding material, a suitable, approved filter fabric (geotextile) is placed. The geotextile should extend along the sides of the trench and should be wrapped all around the poorly graded bedding material.

4.5.3 Backfilling of Trenches

The existing fill (free of topsoil) and native soils can be used as general construction backfill where it can be adequately compacted with suitable type compactors.

The backfill should be placed in maximum 200 mm thick layers at or near (±2%) of the optimum water content and each layer should be compacted to at least 95% SPMDD to within 1.5 m to final subgrade. In the upper 1 m, the degree of compaction should be minimum 98% SPMDD, except for landscape area. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling.

The on-site excavated soils should not be used in confined areas (e.g. around catch basins and laterals under roadways) where heavy compaction equipment cannot be operated. The use of imported granular fill together with an appropriate frost taper would be preferable in confined areas and around structures, such as catch basins.

4.6 Pavements

The pavement structures presented in Table 4.2 can be used for the design of proposed parking areas and access roadways during construction under ideal or non-ideal subgrade conditions.

The explored fill generally extended not more than 2 m in the boreholes. The subgrade is expected to consist of earth fill materials and/or native soils depending upon the proposed grades of parking structure. The zone of influence of the pavement subgrade is generally estimated within 1 m below the underside of the granular sub-base.

4.6.1 Ideal Conditions

Under ideal conditions, the zone of the pavement subgrade within 1 m below the underside of the granular sub-base must be compacted to at least 95% of its Standard Proctor Maximum Dry Density (SPMDD) with moisture content 2 to 3% drier than its optimum and then the compaction should be increased to 98% of SPMDD in the upper 0.6 m of the subgrade.

4.6.2 Non-Ideal Conditions

If the roads are to be constructed during the wet seasons and if the subgrade is unsuitable then either the top 1m of the subgrade should be replaced with drier, compacted, select subgrade material meeting as OPSS 1010 or the top 0.8 m of the subgrade should be replaced with granular material meeting the specifications defined in OPSS-1010-13. This will be assessed at the time of access roadways construction and parking area.

The existing fill within 1 m from the underside of sub-base must be excavated and assessed its stability and suitability according to ideal/non-ideal conditions criteria stipulated by the local authority having jurisdiction over the project site. Depending upon evaluation either the excavated material will be re-used or if found to be unsuitable replaced with select subgrade /granular materials.

In preparation of the subgrade, prior to placement of the granular sub-base and base materials, the subgrade must be proof-rolled to determine its stability and suitability for access road construction and parking area by a qualified geotechnical professional.

The recommended pavement structures provided in Table 4.2 are based upon an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples. Consequently, the recommended pavement structures should be considered for preliminary design purposes only. A functional design life of eight to ten years has been used to establish the pavement recommendations. This represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. If required, a more refined pavement structure design can be performed based on specific traffic data and design life requirements and will involve specific laboratory tests to determine frost susceptibility and strength characteristics of the subgrade soils, as well as specific data input from the client.

Table 4.2: Recommended Pavement Structure Thickness

Pavement Layer	Compaction Requirements	Light Duty Parking (Cars)	Heavy Duty Parking (Delivery Trucks)
Asphaltic Concrete	92 to 96.5% Maximum Relative Density	40 mm OPSS HL 3 40 mm OPSS HL 8	50 mm OPSS HL 3 75 mm OPSS HL 8
OPSS Granular A Base (or 20mm Crushed Limestone)	100% SPMDD*	150 mm	150 mm
OPSS Granular B	100% SPMDD	200 mm	350 mm

* Denotes Standard Proctor Maximum Dry Density, ASTM-D698
The subgrade must be compacted to 98% SPMDD for at least the upper 300 mm unless accepted HLV2K.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure uniform subgrade moisture and density conditions are achieved.

Alternatively, consideration should be given to the use of rigid Portland Cement Concrete pavement where there is intense truck use, parking and turning of vehicles. The following Table 4.3 provides the minimum recommended rigid pavement structure.

Table 4.3: Minimum Rigid Concrete Pavement Structure

Pavement Layer	Compaction Requirements	Heavy Duty Pavement
Portland Cement Concrete (CAN3-CSA A23.1) - Class C-2	CAN3-CSA A23.1	225 mm
Base Course: Granular A (OPSS 1010) or 19 mm Crusher Run Limestone	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm

It must be noted that this structure does not provide full protection of the subgrade from frost penetration; therefore, the pavement slabs must be separated from the building structure.

Control of surface water is an important factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (preferably at a minimum grade of two percent) to provide effective drainage toward subgrade drains. Grading adjacent to the pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement. Continuous pavement subdrains should be provided along both sides of the driveway/access routes and drained into respective catch basins to facilitate drainage of the subgrade and granular materials. The subdrain invert should be maintained at least 0.3 m below subgrade level. Subdrains should also be provided at all catch basins within the parking area.

Concrete should be proportioned, mixed, placed and cured in accordance with the requirements of CSA Standard CAN/CSA-A23.1-19 for class C-2 exposure, with the following key requirements:

minimum 28-day compressive strength: 32 MPa

air entrainment: 5 to 8 %

maximum water/cementing material ratio: 0.45

Concrete should be placed and spread in a manner which avoids segregation. It should be consolidated with a vibratory screed or internal vibrators. Consolidation close to form edges must be given special consideration.

Concrete should be finished to a thickness tolerance of 0 to plus 10 mm. Concrete must be cured adequately to provide durability and strength. Curing can be accomplished by wet blankets, sprinkling, plastic sheets and curing compounds. Curing should begin immediately after loss of bleed water.

Concrete pavement should be provided with joints to control stresses and prevent the formation of irregular cracks. Recommended joint spacing is 24 to 30 times slab thickness to a maximum dimension of about 4.0m. We would also recommend that load transfer dowels be placed at 50 mm spacing at the joints.

Sawed joints should be cut before random cracking occurs in the slab, usually within 6 to 18 hours after concrete placement. The maximum thickness (aperture) of control joints should 6 mm, while the depth of control joints should be about 1/4th of the slab thickness.

The pavement should be closed to traffic until a minimum flexural strength of 2 MPa is attained or an approximate compressive strength of 20 MPa. This minimum strength is generally reached when the concrete can be saw cut without ravelling.

Additional comments on the construction of parking areas and access roadways are as follows:

1. Removal of all fill for pavement is not necessary. As part of the subgrade preparation, proposed parking areas and access roadways should be stripped fill at least in the upper 0.8 m below subgrade and surficially softened native soils and the base then should be thoroughly proof rolled by using a loaded truck. Unstable areas or areas with excessive organic materials should be further sub-excavated. The fill required to raise the grade can consist of inorganic soil, placed in shallow lifts and compacted to minimum 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

2. The locations and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed lot grading. Assuming that satisfactory crossfalls in the order of two percent have been provided, subdrains extending from and between catch basins may be satisfactory. In the event that shallower crossfalls are considered, a more extensive system of sub-drainage may be necessary and should be reviewed by HLV2K.

3. The above pavement structure considers that construction will be carried out during the dry period of the year. If the subgrade becomes excessively wet or rutted during construction activities, additional sub-base material or placement of geogrids may be required. The need for additional sub-base material and/or placement of geogrids including filter fabric to stabilize the base is best determined during construction. It is recommended that the existing subgrade be heavily proof-rolled prior to placement and any areas showing excessive deflection be replaced prior to placing the granular sub-base material.

4. It is recommended that HLV2K be retained to review the final pavement structure designs and drainage plans prior to construction to ensure that they are consistent with the recommendations.

4.6.3 Stripping, Sub-excavation and Grading

The final subgrade should be cambered or otherwise shaped properly to facilitate rapid drainage and to prevent the formation of local depressions in which water could accumulate.

Proper cambering and allowing the water to escape towards the sides (where it can be removed by means of subdrains) is considered to be beneficial for this project. Otherwise, any water collected in the granular sub-base materials could be trapped thus causing problems due to softened subgrade, differential frost heave, etc. For the same reason damaging the subgrade during and after placement of the granular materials by heavy construction traffic should be avoided. If the moisture content of the local material cannot be maintained at ±2% of the optimum moisture content, imported granular material may need to be used.

Any fill required for regarding the site or backfill should be select, clean material, free of topsoil, organic or other foreign and unsuitable matter. The fill should be placed in thin layers and compacted to at least 95% of its SPMDD. The degree of compaction should be increased to 98% within the top 1.0 m of the subgrade, or as per Region Standards. The compaction of the new fill should be checked by frequent field density tests.

4.6.4 Construction

Once the subgrade has been inspected and approved, the granular base and sub-base course materials should be placed in layers not exceeding 200 mm (uncompacted thickness) and should be compacted to

at least 100% of their respective SPMDD. The grading of the material should conform to current OPS Specifications.

The placing, spreading and rolling of the asphalt should be in accordance with OPS Specifications or, as required by the local authorities.

Frequent field density tests should be carried out on both the asphalt and granular base and sub-base materials to ensure that the required degree of compaction is achieved.

4.7 Engineered Fill and Sub-Excavation

The elevation of the existing grade varies significantly across the site. Detailed site grading plans for the proposed development were not available to us at the time of preparation of this report. However, based on the existing topography at the site, cut and fill operations are expected to require as part of the proposed development.

In the areas where earth fill is required for site grading purposes, engineered fill can be used and similarly, if the area under consideration need to be raised, engineered fill can be used

Prior to the placement of the engineered fill, all of the existing fill, the loose possible fill/disturbed soil, and surficial softened native soils must be removed, and the exposed surface proof rolled. Any soft spots revealed during proof rolling must be sub-excavated and re-engineered. The depths of sub-excavation required for the construction of engineered fill will be assessed by a geotechnical professional at the time of excavation.

General guidelines for the placement and preparation of engineered fill are presented on **Appendix C**. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) at the Serviceability Limit States (SLS) and factored geotechnical resistances of 150 to 225 kPa at the Ultimate Limit States (ULS) can be used on engineered fill, provided that all requirements on Appendix “C” are adhered to. To reduce the risk of improperly placed engineered compacted fill, full-time supervision of the contractor is essential. Despite full time supervision, it has been found that contractors frequently bulldoze loose fill into areas and compact only the surface. The inspector, either busy on other portions of the site or absent during “off hours” will be unaware of this condition. For this reason, we cannot guarantee the performance of the engineered fill, and this guarantee must be the responsibility of the contractor. The owner and his representatives must accept the risk involved in the use of engineered fill and offset this risk with the monetary savings of avoiding deep foundations/soil improvement. This potential problem must be recognized and discussed at a pre-construction meeting. Procedures can then be instigated to reduce the risk of settlement resulting from un-compacted fill.

The following is a recommended procedure for engineered fill:

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained, and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages (if applicable), etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that

the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and HLV2K Engineering Limited. Without this confirmation no responsibility for the performance of the structure can be accepted by HLV2K Engineering Limited. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by HLV2K Engineering Limited engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur.

6. Full-time geotechnical inspection by HLV2K Engineering Limited during placement of engineered fill is required. Work cannot commence or continue without the presence of the HLV2K representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings should be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

10. After completion of the pad a second contractor may be selected to install footings. All excavations must be backfilled under full time supervision by HLV2K to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of HLV2K.

11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

4.8 Geotechnical Review

It is recommended that the project design drawings be submitted to HLV2K for review for compatibility with site subsurface conditions and the recommendations contained in this report.

5 GENERAL COMMENTS

The recommended bearing capacities (Geotechnical Reaction) and the corresponding founding elevations would need to be confirmed by the representative of HLV2K during construction. It should be noted that the recommended bearing capacities have been calculated by HLV2K from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by HLV2K to validate the information for use during the construction.

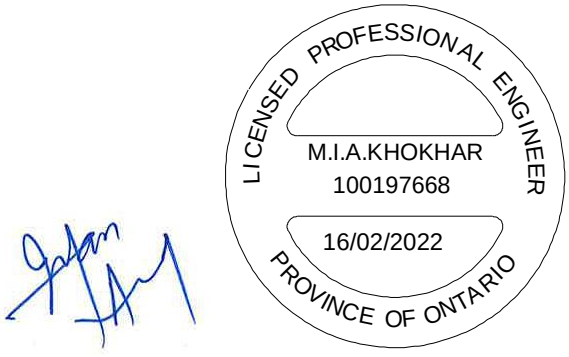
In this regard, HLV2K should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, HLV2K will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information in this report in no way reflects on any of the environmental aspects of the soil condition at the site and has not been specifically addressed in this report, since this aspect was beyond the scope and terms of reference.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

For and on behalf of HLV2K Engineering Limited



Irfan Khokhar, Ph.D., P.Eng.
Principal Geotechnical Engineer

DRAWINGS

Legend

Approx. Site Boundary

Drawn: MM	Title: SITE LOCATION PLAN
Approved: KM	Project: GEOTECHNICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS FORT ERIE INC.
HLV2K ENGINEERING LIMITED	0 125 250 500 Meters
	Drawing 1

Legend

- Approx. Site Boundary
- Borehole
- Monitoring Well

Drawn: MM	Title: BOREHOLE LOCATION PLAN
Approved: KM	Project: GEOTECHNICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS FORT ERIE INC.
HLV2K ENGINEERING LIMITED	0 20 40 80 Meters
	Drawing 1A

Drawing 1B: Notes on Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by HLV2K Engineering Limited also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

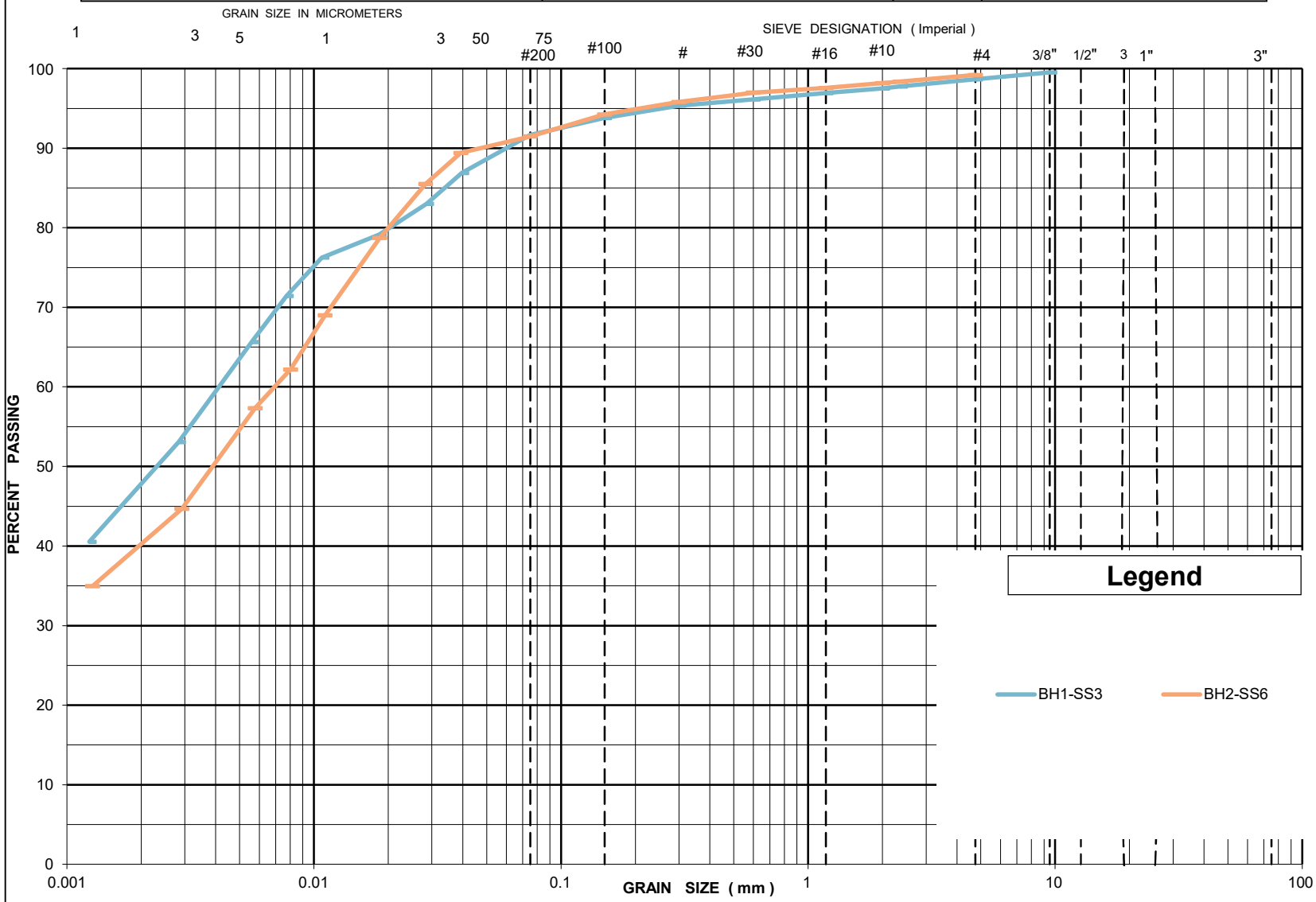
UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advice of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

UNIFIED SOIL CLASSIFICATION SYSTEM LS 702/D 422

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



HLV2K ENGINEERING LIMITED

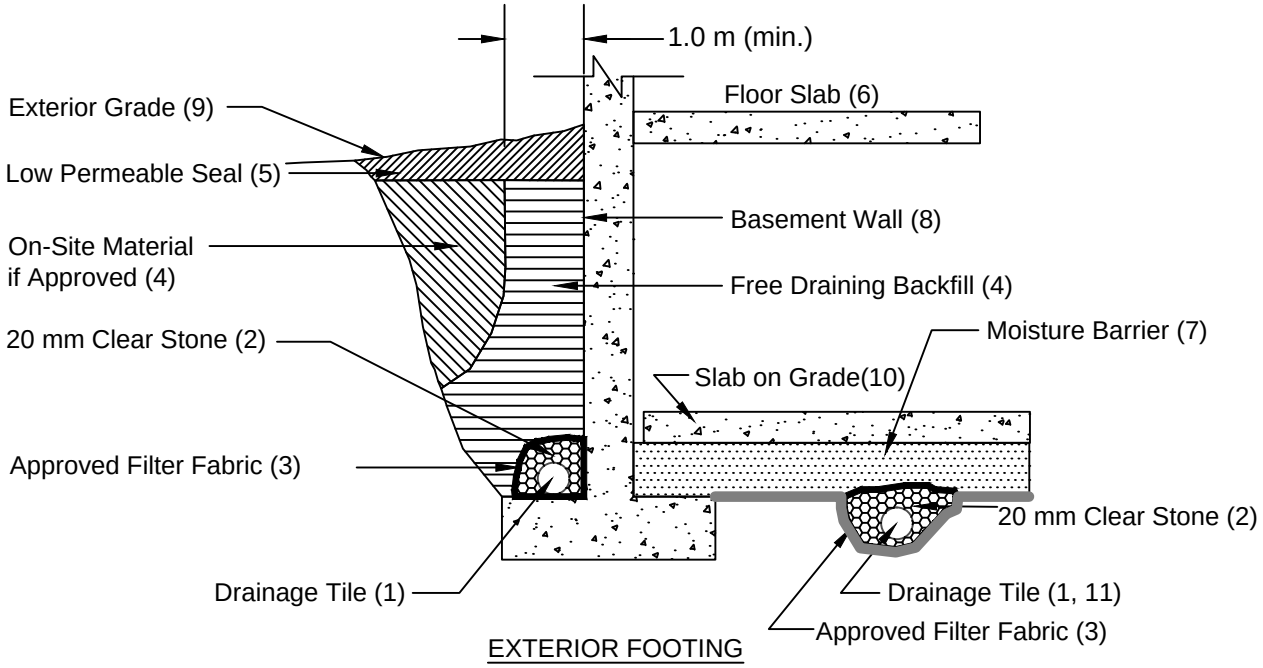
GRAIN SIZE DISTRIBUTION

Drawing No : 2

PROJECT # : 2100394AG

DATE : Sept 16, 2021

Drawing No. 3



EXTERIOR FOOTING

Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place100 mm (4 inches) of stone below drain .
3. Wrap the clear stone with an approved filter fabric (Terrafix 270R or equivalent).
4. Free Draining backfill - OPSS Granular B or equivalent compacted to the specified density. Do not use heavy compaction equipment within 450 mm (18") of the wall. Use hand controlled light compaction equipment within 1.8 m (6') of wall. The minimum width of the Granular 'B' backfill must be 1.0 m.
5. Low permeable backfill seal - compacted clay, clayey silt or paved with concrete/asphalt or equivalent. If original soil is free-draining, seal may be omitted. Maximum thickness of seal to be 0.5 m.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
8. Basement wall to be damp proofed for parking garage and water proofed for finished basement.
9. Exterior grade to slope away from building.
10. Typically slab on grade is not structurally connected to the wall or footing. However, if it is connected to the wall, it should be designed accordingly.
11. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
12. Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
13. The entire subgrade to be sealed with approved filter fabric (Terrafix 270R or equivalent) if non-cohesive (sandy) soils below ground water table encountered.
14. Do not connect the underfloor drains to perimeter drains.
15. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE AND BACKFILL RECOMMENDATIONS
Basement with Underfloor Drainage

(not to scale)

APPENDICES

Appendix A:
Limitations of Report

Limitations of Report

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to HLV2K Engineering Limited. at the time of preparation. Unless otherwise agreed in writing by HLV2K Engineering Limited, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. HLV2K Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time. Any user of this report specifically denies any right to claims against the Consultant, Sub-Consultants, their officers, agents and employees in excess of the fee paid for professional services.

Appendix B:
Borehole Logs

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH1

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4751014.752 E 668156.609

DRILLING DATA
Method: Hollow Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.2												
0.0 / 182.0	**Asphalt:** 150mm						182					
0.2	**Fill:** sand and gravel, trace silt and clay, brown, moist, compact		1	SS	57							
181.4												
0.8	**Silty Clay Till:** trace gravel and sand, brown, very moist, firm to very stiff		2	SS	7		181					
1												
			3	SS	16							1 7 45 47
2							180					
			4	SS	27							
3							179					
			5	SS	17							
4							178					
177.6												
4.6	**Silty Clay:** trace sand, brown, moist, firm to very stiff		6	SS	6		177					
5												
6												

Continued Next Page

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
$+^3$, $\times^3$: Numbers refer to Sensitivity
○ ε_f=3% Strain at Failure

LOG OF BOREHOLE BH1

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751014.752 E 668156.609

DRILLING DATA

Method: Hollow Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty Clay: trace sand, brown, moist, firm to very stiff(Continued)						176					
			7	SS	8				○			
175.3												
~~176.0~~ 6.9	~~**Bedrock:** weathered, black~~ dolomite		8	SS	~~50/50mm~~				○			
	End of Borehole: borehole terminated at 6.9m											
	Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH2

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750966.835 E 668089.3891

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
181.6						
0.0 / 181.3	**Topsoil:**300mm					
0.3 / 181.0	**Disturbed Native/Fill:** silty clay, trace sand and gravel, trace rootlets, brown to black, very moist, loose	1	SS	4		
0.6	**Silty Clay Till:** trace sand, trace gravel, brown to black, very moist, stiff to very stiff	2	SS	16		181
1		3	SS	20		180
2		4	SS	15		179
3		5	SS	8		178
4						
177.0						
4.6	**Silty Clay:** trace sand, brown, very moist, soft	6	SS	3		177
5						
176.4						
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
1	7	52	40

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH3

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4750999.13 E 668085.3975

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/09/2021

REF. NO.: 2100394AG
DRAWING NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.7												
181.6 0.0	**Gravel:** 100mm											
0.1 / 181.3	**Fill:** sandy silt with some gravel, organic inclusions, brown, very moist, loose		1	SS	6							
0.4	**Silty Clay Till:** trace sand and gravel, trace rootlets, brown, very moist, firm to stiff		2	SS	13		181					
			3	SS	18		180					
			4	SS	15		179					
			5	SS	10		178					
177.2												
4.6	**Silty Clay:** trace sand, brown, very moist, soft		6	SS	4		177					
176.6												
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH4

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750990.884 E 668007.3711

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/09/2021

REF. NO.: 2100394AG

DRAWING NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.4												
0.0 / 181.3	**Topsoil:** 150mm											
0.2 / 181.0	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown , very moist, loose		1	SS	5		181					
0.5	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff		2	SS	18							
1			3	SS	20		180					
2			4	SS	14		179					
3			5	SS	10		178					
4			6	SS	50/130mm		177					
4.9 / 176.6	**Bedrock:** weathered dolomite											
5 / 176.4												
5.0	**End of Borehole:** borehole terminated at 5.0m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES $+^3$, $\times^3$: Numbers refer to Sensitivity; ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH5

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4750949.591 E 668062.0856

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.4					
0.0 / 181.3	**Topsoil:** 150mm				
0.2 / 180.9	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, very moist, loose	1	SS	5	181
0.5	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff	2	SS	14	180
1		3	SS	21	
2		4	SS	16	179
3		5	SS	10	178
4					177
176.8					
4.6 / 176.2	**Silty Clay:** trace sand and gravel, brown, very moist, firm	6	SS	6	
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion				

GROUND WATER CONDITIONS: W. L. 179.7 m, Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

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

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

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH6

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4750942.554 E 668149.6001

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 7

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.2					
0.0 / 181.1	**Topsoil:** 150mm				
0.2 / 180.9	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, moist, loose	1	SS	5	181
0.3	**Silty Clay Till:** trace sand and gravel, greyish brown, very moist, firm to very stiff	2	SS	22	
					180
		3	SS	26	
		4	SS	14	179
		5	SS	8	178
176.7					177
4.6	**Silty Clay:** trace sand and gravel, brown, very moist, soft	6	SS	4	
176.1					
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion				

W. L. 179.9 m
Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

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

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

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

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH7

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751054.703 E 668018.9953

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 8

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
181.7						
0.0 / 181.6	**Topsoil:** 150mm					
0.2 / 181.4	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose	1	SS	7		
0.3	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff					181
1		2	SS	12		
		3	SS	22		180
2					W. L. 179.5 m Oct 21, 2021	
		4	SS	16		179
3 / 178.7						
3.1	**Silty Clay:** trace sand and gravel, brown, very moist, firm	5	SS	6		178
4						
177.2						
4.5 / 177.1	**Bedrock:** weathered dolomite	6	SS	50/50mm		
4.6	**End of Borehole:** borehole terminated at 4.6m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion					

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

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

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

WATER CONTENT (%) — 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH8

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4751060.32 E 668093.7114

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 9

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
181.8							
0.0 / 181.5	**Topsoil:**230mm						
0.2 / 181.3	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose		1	SS	5		
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff		2	SS	15		181
			3	SS	21		180
3 / 178.7			4	SS	18		179
3.1	**Silty Clay:** trace sand and gravel, brown, very moist, firm turning soft		5	SS	6		178
5 / 176.6			6	SS	3		177
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

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

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
$+^3$, $\times^3$: Numbers refer to Sensitivity
○ ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH9

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4751026.281 E 668127.6148

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/09/2021

REF. NO.: 2100394AG
DRAWING NO.: 10

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
181.8							
0.0 / 181.6	**Topsoil:**230mm						
0.2 / 181.3	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose		1	SS	6		
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff		2	SS	16		181
			3	SS	20		180
3 / 178.7			4	SS	16		179
3.1	**Silty Clay:** trace sand, brown, very moist, firm turning soft		5	SS	8		178
5 / 176.6			6	SS	3		177
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

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

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

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
$+^3$, $\times^3$: Numbers refer to Sensitivity
○ ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH10

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750966.835 E 668089.3891

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/09/2021

REF. NO.: 2100394AG

DRAWING NO.: 11

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.6					
0.0 / 181.4	**Topsoil:** 150mm				
0.2 / 181.1	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, very moist, loose	1	SS	5	
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff	2	SS	13	181
		3	SS	20	180
178.5		4	SS	23	179
3.1	**Silty Clay:** trace sand, brown, very moist, firm	5	SS	8	178
176.4		6	SS	4	177
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH11

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751054.793 E 668166.184

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 12

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.9 / 0.0	**Topsoil:** 150mm				
181.8 / 0.2	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, moist, loose	1	SS	5	
181.4 / 0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff	2	SS	14	181
		3	SS	18	180
		4	SS	20	179
		5	SS	14	178
177.3 / 4.6	**Silty Clay:** trace sand, brown, very moist, firm	6	SS	4	177
175.9 / 6.0	**Bedrock:** weathered, dolomite	7	SS	50/50mm	176
175.8 / 6.1	**End of Borehole:** borehole terminated at 6.1m				

Upon completion:
1) Cave-in: open
2) Water: dry
3) Monitoring well installed upon completion

GROUND WATER CONDITIONS: W. L. 179.8 m Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; $\circ^{\varepsilon=3\%}$ Strain at Failure

Appendix C:

General Requirements for Engineered Fill

GENERAL REQUIREMENTS FOR ENGINEERED FILL

Compacted imported soil that meets specific engineering requirements and is free of organics and debris and that has been continually monitored on a full-time basis by a qualified geotechnical representative is classified as engineered fill. Engineered fill that meets these requirements and is bearing on suitable native subsoil can be used for the support of foundations.

Imported soil used as engineered fill can be removed from other portions of a site or can be brought in from other sites if suitable. In general, most of Ontario soils are too wet to achieve the 100% Standard Proctor Maximum Dry Density (SPMDD) and will require drying and careful site management if they are to be considered for engineered fill. Imported non-cohesive granular soil is preferred for all engineered fill. For engineered fill, HLV2K Engineering Limited (HLV2K) recommends use of OPSS Granular 'B' sand and gravel fill material only.

Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill should not be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year. If the project demands placement of engineered fill in winter (December 15- April1) it can be placed only under the following conditions:

- All frozen material and or snow must be removed before placement of engineered fill on a daily basis
- Only Granular B Type 2 or Granular A (including crushed concrete or crushed limestone)
- The fill placement must be supervised on a full time basis by a geotechnical consultant

The location of the foundations on the engineered soil pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie. Foundations placed within the engineered soil pad must be backfilled with the same conditions and quality control as the original pad.

To perform satisfactorily, engineered fill requires the cooperation of the designers, engineers, contractors and all parties must be aware of the requirements. The minimum requirements are as follows, however, the geotechnical report must be reviewed for specific information and requirements.

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and HLV2K Engineering Limited. Without this confirmation no responsibility for the performance of the structure can be accepted by HLV2K Engineering Limited. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by an HLV2K engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur and should be evaluated prior to placing the fill.

6. Full-time geotechnical inspection by HLV2K during placement of engineered fill is required. Work cannot commence or continue without the presence of HLV2K representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. The allowable bearing pressure provided in the accompanying report may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

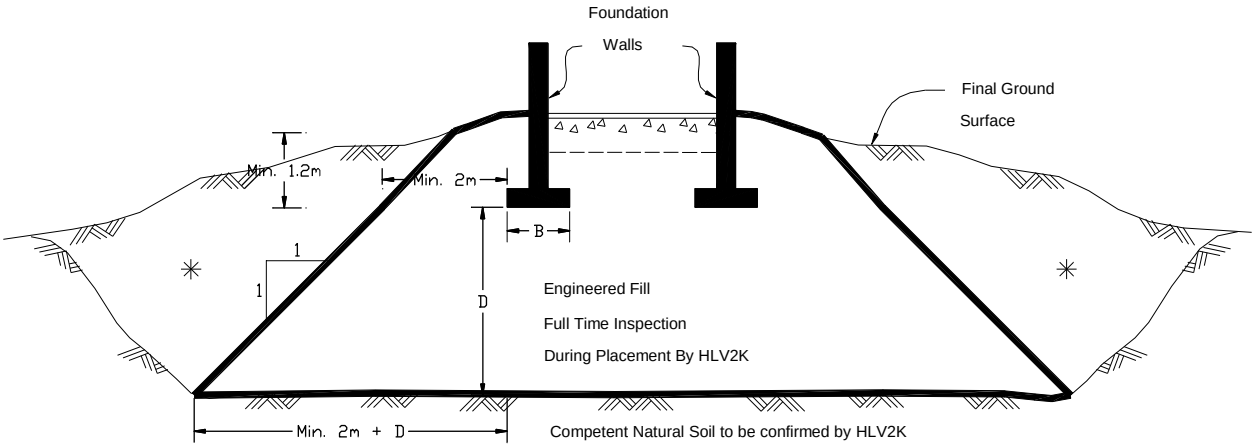
10. After completion of the pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from HLV2K Engineering Limited prior to footing concrete placements. All excavations must be backfilled under full time HLV2K Engineering Limited supervision by HLV2K to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of HLV2K Engineering Limited.

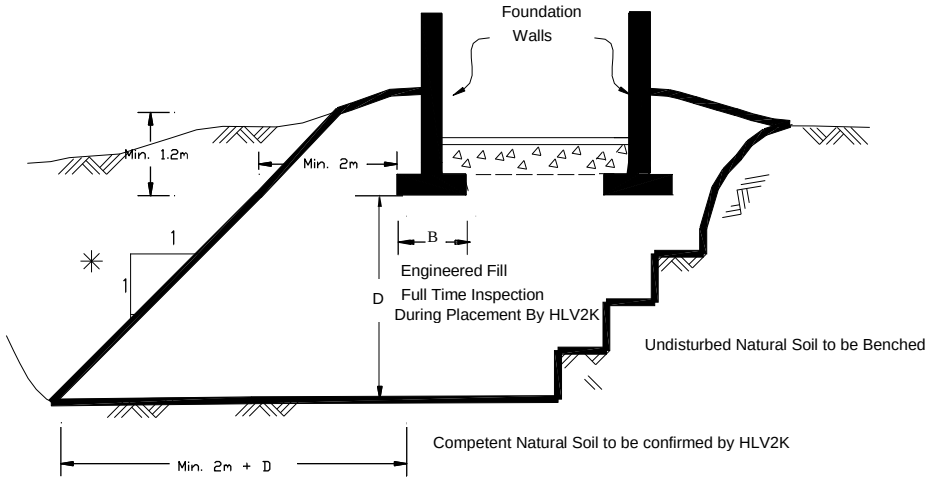
11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof rolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work in order to promote rapid runoff of rainwater and to avoid any ponding surface water. Any stockpiles of fill intended for use as engineered fill must also be smooth-bladed to promote runoff and/or protected from excessive moisture take up.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

13. The geometry of the engineered fill as illustrated in these General Requirements is general in nature. Each project will have its own unique requirements. For example, if perimeter sidewalks are to be constructed around the building, then the projection of the engineered fill beyond the foundation wall may need to be greater.

14. These guidelines are to be read in conjunction with HLV2K Engineering Limited report attached.

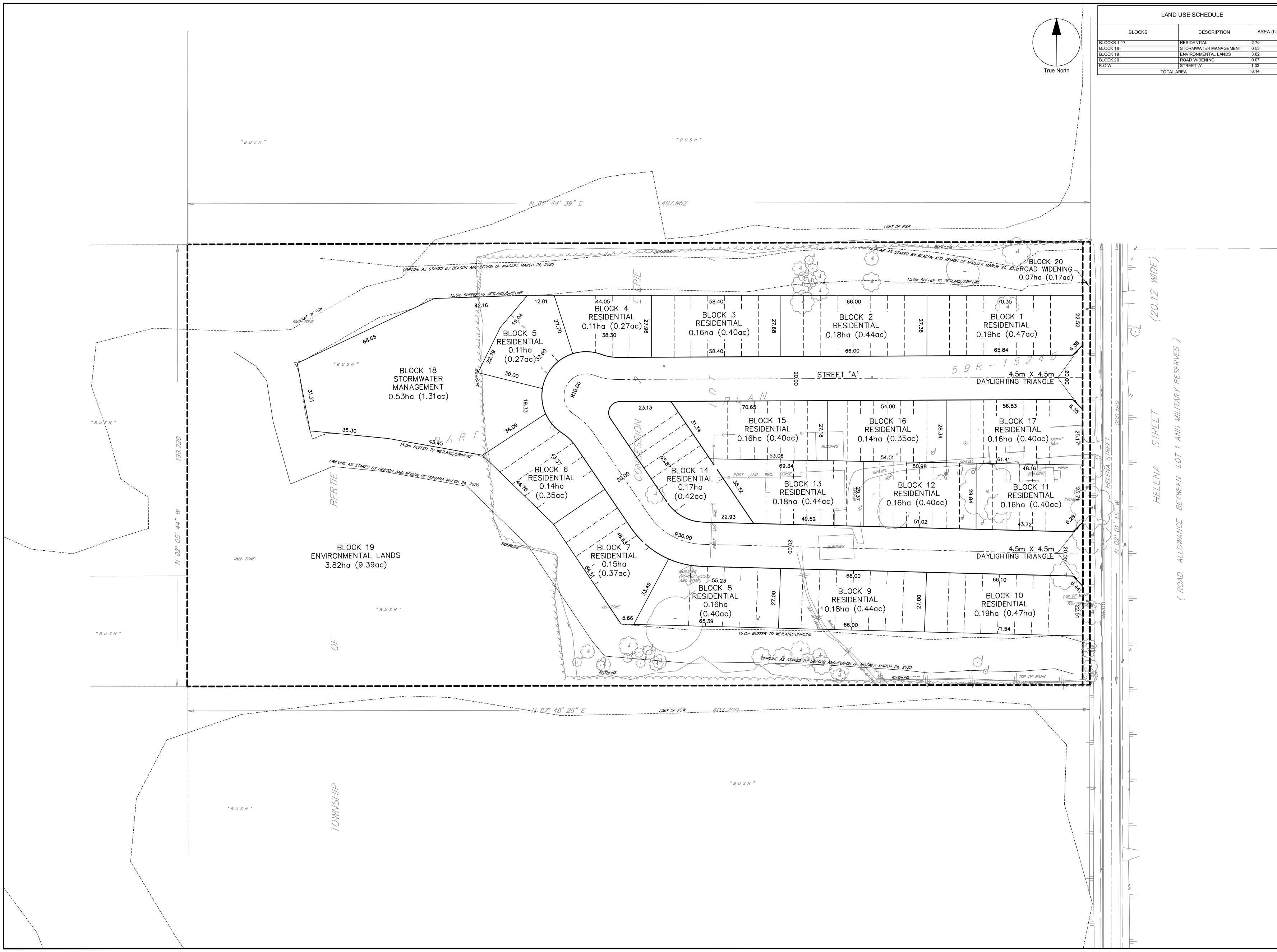




✳ Backfill in this area to be as per the HLV2K report

Appendix D:

Proposed Site Plan Provided by the Client

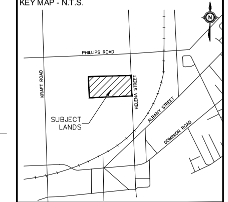


LAND USE SCHEDULE		
BLOCKS	DESCRIPTION	AREA (ha)
BLOCKS 1-17	RESIDENTIAL	2.70
BLOCK 18	STORMWATER MANAGEMENT	0.53
BLOCK 19	ENVIRONMENTAL LANDS	3.82
BLOCK 20	ROAD WIDENING	0.07
R.O.W.	STREET 'A'	1.02
TOTAL AREA		8.14

DRAFT PLAN OF SUBDIVISION 613 HELENA STREET

PART OF LOT 1, CONCESSION 2,
LAKE ERIE TOWNSHIP OF BERTIE
IN THE TOWN OF FORT ERIE
REGIONAL MUNICIPALITY OF NIAGARA

KEY MAP - N.T.S.



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
(e) - AS SHOWN
(f) - AS SHOWN
(g) - AS SHOWN
(h) - MUNICIPAL (PUBLIC)
(i) - SILTY CLAY
(j) - AS SHOWN
(k) - ALL SERVICES TO BE MADE AVAILABLE
(l) - AS SHOWN

SURVEYOR'S CERTIFICATE

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

SIGNED ____________
PHILIP S. SUDA, O.L.S.
SUDA & MALESZYK SURVEYING INC.

DATE ____________

OWNER'S CERTIFICATE

I HEREBY CONSENT TO THE FILING OF THIS PLAN BY IBI GROUP, IN DRAFT FORM.

SIGNED ____________
MARIO BEVACQUA
1891187 ONTARIO INC.
DATE ____________

#	DATE	BY	DESCRIPTION
1			

DRAWING ISSUE RECORD

APPROVALS

IBI GROUP
Suite 200 - 360 James Street North
Hamilton ON L8L 1H5 Canada
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BENCHMARK

SCALE 10 5 0 10 20 30
1:750 (m)

PROJECT NO:
131951

DRAWN BY: T. NGUYEN	CHECKED BY: T. TUCKER
PROJECT MGR: T.TUCKER	APPROVED BY:

SHEET TITLE
DRAFT PLAN OF SUBDIVISION

SHEET NUMBER DP 1.0 | ISSUE 1

File Location: J:\131951_613_Helen\7.0_Production\7.01_Sent-Received\Sent\Client\2021-04-08 - Draft Plan\131951DP 2021-04-08.dwg Last Saved: April 8, 2021, by Tracy.Tucker Plotted: Thursday, April 8, 2021 10:39:00 AM by Tracy Tucker

HYDROGEOLOGICAL INVESTIGATION
PROPOSED DEVELOPMENT

613 Helena Street, Fort Erie, Ontario

Prepared for:

SS WELLAND INC.

4080 Confederation Parkway, Unit 701
Mississauga, ON L5B 0G1

Prepared by:

HLV2K ENGINEERING LIMITED
A Consulting Engineers Company

2179 Dunwin Drive, Unit 4
Mississauga, Ontario L5L 1X2

Project No. 2100394AG

February 17, 2022

HLV2K ENGINEERING LIMITED
A Consulting Engineers Company

February 17, 2022 Reference No.: 2100394AG

SS Welland Inc.
4080 Confederation Parkway, Unit 701
Mississauga, ON L5B 0G1
L5B 0G1

Attention: Mr. Hunain Siddiqui
Email: hunain@emrahomes.ca

RE: Hydrogeological Consulting Services for Proposed Development
613 Helena Street, Fort Erie, Ontario

Dear Mr. Siddiqui,

HLV2K Engineering Limited (HLV2K) is pleased to provide the Hydrogeological Investigation Report for the above-mentioned project. The report presents HLV2K's understanding of the hydrogeological setting of the study area based on exploratory drilling, data collection, analyses, and review.

We trust that this information meets your present requirements. If we can be of additional assistance in this regard, please contact this office.

For and on behalf of HLV2K Engineering Limited,

k. Mohamadi

Kourosh Mohammadi, Ph.D., P.Eng.

President and Principal Hydrogeological Engineer

TABLE OF CONTENT

TABLES

FIGURES

APPENDICES

LIST OF ACRONYMS AND DEFINITIONS

BH	Borehole
EASR	Environmental Activity and Sector Registry
GPM	Gallon per Minute
K	Hydraulic Conductivity
mbgs	Metres Below Ground Surface
MECP	Ontario Ministry of the Environment, Conservation and Parks
O.Reg.903	Ontario's Wells Regulation
PAHs	Polycyclic Aromatic Hydrocarbons
PHCs	Petroleum Hydrocarbons
PTTW	Permit To Take Water
PWQOs	Provincial Water Quality Objectives
VOCs	Volatile Organic Compounds
WWIS	Water Well Information System
WWR	Water Well Record

1 INTRODUCTION

1.1 General

HLV2K Engineering Limited (HLV2K) was retained by SS Welland Inc. (the Client) to complete a hydrogeological investigation to evaluate the site conditions at proposed development area located at 613 Helena Street in Fort Erie, Ontario (the Site). The Site location is shown on **Figure 1**.

The Site is a rectangular shaped property, approximately 8.15 (ha), lies in a typical rural setting in an area of mixed residential, agricultural and vacant land use. Approximately 60% of the subject property is used for agricultural purposes.

The Site is currently occupied by a two-storey residential dwelling and associated garage, a two-storey barn and two storage buildings (The site buildings covered approximately 15% of the total Site area). The western portion of the Site is occupied by a forested area. Prior to the development of these structures, the Site was in agricultural use.

It is our understanding that the project involves the development of a residential subdivision on the property

1.2 Purpose

The purpose of the hydrogeological investigation was to characterize the existing hydrogeological conditions at and in the vicinity of the Site, assess the need for, and options for, groundwater control in association with the proposed construction, evaluate potential impacts to the local groundwater regime resulting from the proposed construction, and identify appropriate mitigative measures, as warranted.

This hydrogeological study may be utilized in support for an application for a Permit to Take Water (PTTW) for dewatering purposes during construction or registering in Environmental Activity and Sector Registry (EASR), if necessary. The purpose of completing the PTTW / EASR application is to conduct the work in compliance with Ontario Regulation 387/04 (as amended) and the Ontario Water Resources Act (OWRA). The water taking EASR is for construction projects that require more than 50,000 liters per day (L/day) of water and less than 400,000 L/day under normal conditions. A PTTW is required for any surface water or groundwater taking during construction in excess of 400 cubic metres per day (m^3/day).

2 METHOD OF INVESTIGATION

2.1 General

This hydrogeological investigation was based on review of previously completed geotechnical and environmental reports and published information for the study area, including previously published regional physiographic and geologic mapping and watershed planning reports. Many of these documents are referred to throughout various sections of this report and the relevant details can be found in the References section following the text of the report.

In particular, the work completed in association with this hydrogeological study consisted of the following tasks:

- Reviewing and interpreting available reports and published data;
- Developing Health & Safety and Sampling and Analysis Plans for work at the Site;
- Assessing the current Site conditions, areas of interest and to confirm the previous borehole locations;
- Developing the groundwater monitoring wells installed by geotechnical group on the Site by removing at least three well volumes of groundwater or two times to dry;
- Reviewing water well records available from the Ministry of the Environment, Conservation, and Parks (MECP);
- Reviewing measured groundwater levels in each of the monitoring wells located at the Site;
- Evaluating proposed construction dewatering requirements;
- Estimation of the underfloor and perimeter drainage flow for permanent dewatering; and,
- Prepare a final report on the findings of this investigation.

2.2 Boreholes and Monitoring Wells

As part of geotechnical investigation for this Site (HLV2K, 2021), eleven boreholes (BH1 to BH11), were drilled to depths varying from 4.6m to 6.9m on September 08 and 09, 2021. The boreholes were advanced by utilizing continuous flight hollow stem augers. Upon completion of drilling, each borehole was backfilled in accordance with current regulations.

Four boreholes (BH5, BH6, BH7 and BH11) were converted to groundwater monitoring well and were used to obtain hydrologic and groundwater quality information. Monitoring wells were constructed in accordance with Ontario Regulation 903. The sand pack was extended above the screened interval to allow for settling of the sand/expansion of overlaying bentonite seal. A 50mm diameter Schedule 40 polyvinyl chloride (PVC) pipe including a screen section of 3 m length with a factory machined slot width of 0.25 mm, completed with a PVC riser pipe was used.

All the pipe and screen sections were wrapped in plastic that was removed just prior to installation to minimize the potential for contamination. The base of the monitoring wells was covered with a PVC cap to prevent the influx of sediment. Clean silica sand supplied in bags, was placed in the annular space between the pipe and the sides of the borehole to obtain relatively sediment free groundwater. A bentonite seal was added to the annular space above the sand pack to reduce the infiltration of surface water into the borehole annulus.

The wells were extended to grade with solid PVC riser pipe. The sand pack was extended above the screened interval to allow for settling of the sand/expansion of overlaying bentonite seal. The wells were completed with slip on cap. Wells construction details and borehole logs from this investigation and previously drilled by others are presented in **Appendix A**.

The locations of the boreholes were established in the field by HLV2K based on the plan provided by the client. The borehole elevations and locations were surveyed and established by the HLV2K staff. The approximate borehole locations are shown in **Figure 2**.

It should be noted that the ground surface elevations noted on the appended borehole logs are approximate and were used for the purpose of relating borehole soil stratigraphy and should not be used or relied on for other purposes. Two existing and one newly installed

Table 1: Information on Groundwater Monitoring Wells

MW ID	Estimated Ground Surface Elevation (m)	Borehole Bottom		Well Screen Interval Depth (mbgs)		Well Screen Interval Elevation (m)	
		Depth (mbgs)	Elevation (m)	from	to	from	To
BH5	181.4	5.2	176.2	2.0	5.0	179.4	176.4
BH6	181.3	5.2	176.1	2.0	5.0	179.3	176.3
BH7	181.7	4.6	177.1	1.4	4.4	180.3	177.3
BH11	181.9	6.1	175.8	2.9	5.9	179.0	176.0

2.3 Groundwater Monitoring and Sampling

One (1) groundwater sample was collected from monitoring well (BH6) on September 28, 2021. This groundwater sample was collected and analyzed for general chemical parameters and compared with Provincial Water Quality Objectives (PWQOs).

Prior to sampling, all wells were developed. The development of the monitoring wells was conducted by purging and surging the well water to stress the formation around the well screen so that mobile particulates were removed. The purpose of the well development is to improve the hydraulic connection between the well and the geologic materials in the vicinity of the well, and to subsequently obtain a groundwater sample representative of the in-situ conditions. The groundwater level was measured in the monitoring wells and wells were developed by purging to dry, twice.

The collected sample was submitted to ALS Environmental Laboratories in Mississauga, a member of the Canadian Association for Laboratory Accreditation (CALA), for chemical analysis. Copies of the laboratory certificates of analysis are provided in **Appendix B**.

2.4 In-Situ Hydraulic Conductivity Testing

Rising head hydraulic conductivity tests (slug tests) were conducted on four (4) monitoring wells, BH5, BH6, BH7 and BH11 on October 21, 2021 to assess the subsurface hydraulic conductivity conditions.

A summary of the hydraulic conductivity test methodology is as follows:

- The static groundwater level in each monitoring well was initially measured and recorded;
- For the rising head test, a known volume of water was removed from each tested well using an inertial pump and low density tubing; and,
- The water level in each well was then measured and recorded at regular time intervals

The water level data from the monitoring wells were analysed using AQTESOLV Professional V4.5 and the Bouwer-Rice equation to estimate the hydraulic conductivity (K) of the soil adjacent to the screened portion of the well.

3 SITE CONDITIONS

3.1 Physical Setting

The Site is located on north side of Concession Road 5 and west side of Osborne Street. The surrounding areas are mostly vacant with natural cover and few residential and commercial properties. According to the Oak Ridges Moraine (ORM) Atlas which is available online at (http://www.mah.gov.on.ca/page334.aspx) and the Niagara Escarpment Plan (NEP) Maps available online at (http://www.escarpment.org/landplanning), the Site is not located within an area where either the Oak Ridges Moraine Conservation Plan or the Niagara Escarpment Plan would be applicable.

3.2 Climatic Conditions

Average monthly climate data from an Environment Canada climate station located at the Fort Erie (Station ID 6132470), approximately 2.2 km southwest of the Site, for the period between 1981 and 2010 is provided in **Table 2**, below (Environment Canada, 2021). The data indicates that the climate in the study area is typical continental with cold winters and warm summers and precipitation records showing local seasonal variation. As shown in **Table 2**, below, the mean annual precipitation is 1051.3 mm/year, with annual mean rainfall of 876.3 mm/year (83% of total precipitation). Average monthly precipitation ranged from 66.6 mm in February to 105.4 mm in September. The mean annual daily temperature is 8.6 degrees Celsius (°C), ranging from -4.1 °C in January to 21.2 °C in July.

Table 2: Climate Data Summary (1981 – 2010) – Fort Erie Station (ID 6132470)

MONTH	Daily Average Temperature (°C)	Average Rainfall (mm)	Average Snow (cm)	Average Precipitation (mm)
January	-4.1	34.2	44.7	78.9
February	-3.3	32.8	33.8	66.6
March	0.4	44.7	26.3	71.0
April	6.6	74.4	4.4	78.8
May	12.7	92.3	0.9	93.2
June	18.1	81.7	0.0	81.7
July	21.2	84.7	0.0	84.7
August	20.6	88.5	0.0	88.5
September	16.7	105.4	0.0	105.4
October	10.4	95.3	1.4	96.7
November	4.9	89.9	12.9	102.8
December	-0.8	52.5	50.7	103.2
Year	**8.6**	**876.4**	**175.1**	**1051.5**

NOTE: Data was obtained from Environment Canada website (Environment Canada 2021).

3.3 Physiography and Drainage

A review of the topographic map provided online by Natural Resources Canada (Toporama) depicts the Site as located within an area that is generally low relief at an approximate elevation of 122 m. The Site is located within Lake Erie drainage area part of Niagara Peninsula watershed. The Site located approximately 1.1 km north of Lake Erie.

Lake Erie drainage area contains several small creek watersheds and tile drained areas which flow generally south and discharge into Lake Erie. The Site is located within Krafts Drain area. The Kraft Drain is approximately 900 m west of the Site.

According to the physiographic regions of Ontario identified by Chapman and Putnam (2007), the Site is located in Haldimand Clay Plain physiographic region. The Haldimand Clay Plain consists of fine-grained silts and clays deposited at the bottom of a deep glacial lake basin. It is characterized by heavy clay soils which are relatively impermeable, resulting in a high level of runoff and little groundwater recharge.

3.4 Geological Mapping

Most of the Niagara Peninsula is covered by unconsolidated sediment. The unconsolidated sediments mainly resulted from glacial advances and retreats that occurred during the last glaciation period in southern Ontario (NPSA, 2013). A regional description of the Quaternary geology for the area of the Site can be found on the Ontario Geological Survey Digital Map - Surficial geology of southern Ontario (OGS, 2010) and Freenstra (1984). A section of this map showing the surficial geology in the vicinity of the Site is presented on **Figure 3**.

As shown on **Figure 3**, the surficial deposits in the immediate vicinity of the Site are mapped as deeper water glaciolacustrine unit consists of clay and silt overlying the Wentworth Till.

The sedimentary bedrock consists mainly of interbedded limestone and dolostone carbonate materials, and shale. Bedrock units of the Devonian Period (newest) to the Ordovician Period (oldest) are present. Dolomite bedrock was encountered in boreholes BH1, BH4, BH7, and BH11 at approximate depth of 4.5 m to 6.8 m.

3.5 Subsurface Soil Conditions

The subsurface soil conditions encountered during boreholes advanced at the Site are shown on the borehole logs in **Appendix A**. A summary of the soil conditions is provided below. Reference should be made to the geotechnical report (HLV2K, 2021) for a detailed description of the soil conditions at the Site.

In general, below the fill/disturbed native materials (silty clay, trace sand, trace gravel), the site is underlain by native soils (silty clay till to clayey silt till, trace gravel). The native materials encountered at all the borehole locations were quite consistent and were generally firm to very stiff silty clay till over silty clay to maximum explored depth ranging from 0.6 to 6.8 mbgs. In all borehole soft clayey materials found ranging 3.1 to 4.9 mbgs.

4 GROUNDWATER CONDITIONS

4.1 Regional Groundwater Recharge

Recharge is the process by which groundwater is replenished and involves the vertical infiltration of water through the subsoil deposits and geologic materials to the saturated zone. The major sources of recharge in the study area are a result of precipitation and freshet. The amount of groundwater recharge in a particular area depends on surficial geology, topography, and the extent of land development in that area. Generally, regional groundwater recharge is irregularly distributed temporally and spatially as interpreted from specific climatic conditions, local geology, and land development status.

The Site is mostly vacant and is currently occupied by a two-storey residential dwelling and associated garage, a two-storey barn and two storage buildings (The site buildings covered approximately 15% of the total Site area). The western portion of the Site is occupied by a forested area. Therefore, the groundwater recharge occurs under natural condition. The native soil in the area is dense with low hydraulic conductivity and the infiltration is expected to be low. However, a water balance analysis will be completed for the site to estimate the change in water recharge pre and post development. The results will be presented in a separate report.

4.2 Groundwater Level Fluctuations

The groundwater level data collected from the monitoring wells are provided in **Table 3**, below. The screen elevations of these monitoring wells are shown in **Table 1** above.

The groundwater level monitoring rounds were completed in September and October 2021 as part of this investigation. As shown in **Table 3** below, the groundwater levels in monitoring wells were measured at approximate depth of 0.41 to 2.59 m below the existing ground surface (mbgs). The corresponding elevations for groundwater were from 179.31 m to 180.84 m.

It should be noted that groundwater conditions vary depending on factors such as temperature, season, precipitation, construction activity and other situations, which may be different from those encountered at the time of the monitoring. The possibility of groundwater level fluctuations at the Site should be considered when designing and developing the construction plans for the project.

Regional groundwater flow in the area typically reflects the local topography and generally occurs from topographic highs to topographic lows. The dominant groundwater flow direction at the Site is north to south towards Lake Erie.

Table 3: Summary of Groundwater Level Observations in Monitoring Wells

MW ID	Ground Surface Elevation (m)	Groundwater Level Observations			
		28-SEP-21		21-OCT-21	
		Depth (mbgs)	Elevation (m)	Depth (mbgs)	Elevation (m)
BH5	181.4	0.82	180.58	0.76	180.64
BH6	181.3	0.90	180.35	0.41	180.84
BH7	181.7	1.43	180.31	1.36	180.38
BH11	181.9	2.59	179.31	1.09	180.81

4.3 Inferred Hydrostratigraphy

The subsurface investigations revealed that beneath the surficial materials, the subsurface conditions encountered in the boreholes consisted of fill materials overlaying native soil, and dolomite bedrock. The bedrock was relatively shallow at approximate depth of 4.5 to 6.8 mbgs. Groundwater was encountered in the silty clay layer. Conditions encountered in the monitoring wells in the silty clay layer indicated that the groundwater in this layer can be considered confined.

4.4 Results of In-Situ Hydraulic Conductivity Tests

Table 4 below summarizes the results of the hydraulic conductivity testing in the monitoring wells and the hydrostratigraphic units in which these monitoring wells were screened. The hydraulic conductivity and analysis data sheets are presented in **Appendix C**.

Table 4: Summary of In-Situ Hydraulic Conductivity Test Results

MW ID	Hydraulic Conductivity (cm/s)	Hydraulic Conductivity (m/day)	Stratigraphic Unit
BH5	1.2×10^{-6}	1.0×10^{-3}	Silty clay
BH6	7.3×10^{-7}	6.3×10^{-4}	Silty clay
BH7	2.2×10^{-6}	1.9×10^{-3}	Silty clay
BH11	2.5×10^{-7}	2.1×10^{-4}	Silty clay

4.5 Groundwater Use in the Study Area

As part of this hydrogeological study, HLV2K did a search of the MECP Water Well Information System (WWIS) database to identify active wells near the Site. The database search was for the area located within 500 m from the Site. The database search identified records for 8 wells.

Figure 4 presents the locations of the identified wells as well as the associated water use categories within 500 m around the Site. A detailed table showing water well record (WRR) information for these wells is provided in **Appendix D**. The classification of these wells is as follows:

- 3 wells stated as observation wells
- 5 wells stated as water supply.

The search revealed the presence of 5 domestic water wells or other water supply wells potentially in use in the area of the Site. These wells were completed between 1946 and 2000.

4.6 Groundwater Quality for Temporary Dewatering

During construction, the groundwater pumped in conjunction with excavation dewatering (where required) may be discharged into the water bodies within the Site. In this case, the discharge water quality will have to conform to the discharge limits identified in the Ontario Water Quality Objective Limits (PWQOs).

The analytical results for the groundwater samples from BH6 were compared to the PWQO limits. BH6 is screened in silty clay and silty clay till at approximate depth of 5.1 mbgs.

The laboratory certificates of analysis are provided in **Appendix B**. These results showed that all parameter concentrations were below the PWQO limits with the exception of copper. In addition, the detection limit of phosphorus concentration was higher than the PWQO limit.

5 GROUNDWATER DEWATERING ESTIMATES

5.1 Introduction

It is our understanding that the project is considered for approximately 8.15 ha of residential development. According to the drawings provided by the Client (**Appendix E**), all houses will have one level of basement. The finish floor of underground basement is expected to be at an approximate depth of 3 mbgs or the geodetic elevation of 179 m.

It is anticipated that the base of the footings will be about 1 m below the finished basement floor at approximate elevation 178 m±.

The highest stabilized groundwater level measured in the monitoring wells installed at the Site in was at about 180.4 m measured in BH6. Therefore, dewatering is anticipated to be necessary during construction.

Assuming that the groundwater level should be reduced as necessary to 1 m below the base of the excavations, the approximate groundwater elevation during the construction should be 177 m or less. For the purpose of calculations to estimate the potential dewatering rate, the excavation was considered as an open excavation.

Hydraulic conductivity is varied from 2.5 x 10-7 to 2.2 x 10^{-6} cm/s. the highest hydraulic conductivity of 2.2 x 10^{-6} cm/s was used in dewatering estimation.

Uniform aquifer thicknesses were assumed for the layer. According to the drawing provided to HLV2K by the Client (**Appendix E**) the area of the buildings is approximately 13,000 m^2 assuming approximately 50% of the lot size to be building area and basement is extended to the edge of the building.

For the purpose of the dewatering estimation, it was assumed that the excavation is carried out in stages and at each stage the excavation is a rectangular with 200 m length and 50 m wide for the largest plot.

5.2 Estimating Short-Term Dewatering Rate during Construction

The anticipated daily dewatering rates were estimated using the equations provided in the reference book "Construction Dewatering and Groundwater Control: New Methods and Applications - Third Edition. New York, New York: John Wiley & Sons (Powers et. al., 2007)", for a rectangular system of closely spaced wells to dewater an excavation. Steady flow to the excavation was assumed for the purpose of the analysis.

The estimated groundwater inflow rate (Q_R) to an excavation was calculated as follows:

$$Q_R = \frac{2\pi K\left(H^2 - h^2\right)}{\ln\left(\frac{R}{r_e}\right)}$$

Where,

K – Hydraulic conductivity = 1.9 x 10^{-3} [m/d];

H – Distance from static water level to bottom of aquifer = 5.4 [m];

h – Distance from lowered water level to bottom of the aquifer = 2.0 [m];

R - Radius of the cone of depression (zone of influence) [m], estimated approximately using the following empirical relationship developed by Sichart

$R = r_e + 3000(H - h)K^{0.5}$, (K in m/s); and

$\mathbf{r_e}=((\boldsymbol{\omega}\times\boldsymbol{\ell})/\pi)^{0.5}$

$\boldsymbol{\omega}$ – excavation width and $\boldsymbol{\ell}$ – excavation length

To lower the water table 1 m below the bottom of the excavation, it is estimated that the total dewatering rate to be approximately 2.5 m^3/day. The total flow at any time will depend on the length of excavation that needs dewatering and the expected rate of progress. The zone of influence (R) is estimated to be maximum 1.5 m from the edge of the excavation.

Allowing for changes in soil properties, specifically hydraulic conductivity and transmissivity, it is expected that there will be variations and changes in the amount of groundwater that can be pumped from any part of the site. Allowing a 100% contingency for the variability in hydraulic conductivity that could be experienced, the expected pumping rate needed for the site is about 5 m^3/day. This rate is below the MECP threshold of 50 m^3/day for registration under the Environmental Activity and Sector Registry (EASR). Considering the possibility of heavy rain during the excavation, the maximum dewatering rate is proposed to be **49 m^3/day**.

It should also be noted that the construction works will most likely be carried out in stages and dewatering of the entire site for the full term of the contract will not be necessary to achieve the required drawdown.

5.3 Estimating Long-Term Drainage Requirement

The perimeter and underfloor drainage systems were proposed by geotechnical investigation to cut-off the groundwater seepage into the excavations and lower the groundwater below the subgrade level. The rate for the long-term drainage system for each house is expected to be 1.5 m^3/day considering the largest plot and assuming 50% of the plot size area to be the basement area. The seeped water from surface should also be considered in the long-term drainage system. According to the Ontario Ministry of Transportation IDF Curve (available online: http://www.mto.gov.on.ca/IDF_Curves), the storm event with 2-year return period of Site is 58.8 mm/day. Assuming 50% infiltration rate for this storm event and 50% of the lot to be permeable surface, the expected infiltrated water is 12.5 m^3/day.

Allowing for variations in grain size in the aquifer, specifically hydraulic conductivity and transmissivity, seepage through shoring wall or from surface, and presence of sand seems, it is expected that there will be variations in the amount of groundwater that can be drained by foundation and/or underfloor drainage systems. Therefore, it is prudent to consider a contingency factor in designing the drainage capacity. It is recommended that the drainage capacity including sumps, pumps and related utilities for foundation and underfloor drains be designed for minimum 18.9 L/min (approximately 5 GPM) for each house.

The analytical results for samples collected at the monitoring location indicated that groundwater from properly filtered drains and/or with filtration/settlement of the discharge as appropriate, would meet the Region's storm and/or sanitary discharge limits. The pumped water can also discharge into the backyard or landscape area of the house.

6 PREDICTED EFFECTS

Based on the hydrogeological information and data analysis in this report, the potential impacts to surface water and groundwater resources in the vicinity of the Site due to excavation dewatering for construction of the proposed tower at the Site are described below.

6.1 Groundwater Use

As indicated in Section 4.5, the search of the MECP water well records indicated the presence of 5 water supply wells within approximately 500 m of the Site. These wells were completed between 1946 and 2000. A water well survey is recommended before commencing the excavation to ensure the existence of these wells.

6.2 Surface Water Resources

No surface watercourse was identified in the vicinity and within the zone of influence of the dewatering. Kraft Drain is approximately 900 m west of the Site and no impact is anticipated on that.

It should be noted that the flow and water level in any surface water body is naturally fluctuated with the season and precipitation regime. Therefore, these natural fluctuations should be separated from the impact of dewatering, if any.

6.3 Discharge to Municipal Sewer System

It is our understanding that discharge to sewer municipality has not been considered during the construction and pumped water can be managed on Site. Based on the results provided in the certificate of analysis, all parameters were below the PWQos limits with the exception of dissolved copper. Since no surface body is in the vicinity of the Site, as long as the pumped water is managed within the Site, no adverse impact is expected.

7 DEWATERING MONITORING AND MITIGATION PLAN

7.1 Groundwater Monitoring

The dewatering requirements may be variable depending on the size of the excavation (length, width and depth), aquifer properties and construction methods. Suitable dewatering method(s) and volume of discharge need to be identified by the contractor using technical evaluation reports and proposed dewatering plan(s). Prior to construction, and where required, discharge permits should be in place for discharging water into local sanitary and/or storm sewers. If discharge to surface water is expected, the water quality should meet the limits of PWQOs. Due to the low hydraulic conductivity and anticipated low water quantity, the impact of groundwater on the outside of the Site is expected to be minimum.

The location(s) of the point of discharge with respect to the dewatering systems need to be confirmed by the contractor and where required, Erosion and Sedimentation Control (ESC) measures such as filter bags, straw bales, and silt fences should be implemented.

Discharge locations should be monitored on a daily basis. Discharge volume should be measured using a digital totalizing flow meter (in-line flow meter).

If any impacts attributable to the dewatering are noted, then mitigation measures should be initiated. In the event of excessive sediment, these measures could potentially include use of additional filtration measures such as settlement tanks or filter bags.

Records of daily water quantity pumped, treatment method used, water quality parameters tested, and the method of discharge should be maintained and updated regularly by the construction contractor.

7.2 Water Well Survey

Based on the results provided in water well record search, 5 water supply have been identified within 500 m radius around the Site. A water well survey is recommended before the commencement of the construction to ensure the existence of these wells. Selected wells should be monitored during the construction and water level and quality of the water should be recorded and tested. If the impact of dewatering on these wells is observed, the mitigation measures should be initiated. These measures could potentially include the reduction of the dewatering rate or supplying water to the well owner.

8 SUMMARY AND CONCLUSION

Based on the results of the subsurface investigation, hydrogeological assessment, and analysis of hydraulic conductivity testing and groundwater level monitoring data, the following summary of conclusions and recommendations is provided:

- The estimated daily groundwater pumping rate for temporary dewatering is below than the 50 m^3/day PTTW or EASR threshold. The registration on MECP EASR is not required.

- It is recommended that the dewatering system be designed and evaluated by a qualified engineer and performed by a licensed dewatering contractor. The dewatering engineer/contractor should be reminded that during the dewatering activities, care must be taken to prevent the removal of fine soil particles with the pumped water or to use proper filtration prior to discharge to the Region and/or Town sewer system.

- Discharge from temporary dewatering during the construction of the proposed underground basement is expected to be managed on Site. If off-site discharge is required, the water quality should meet receiver municipality or PWQOs limits. Dissolved copper concentration was above the PWQOs limit.

- Long-term foundation and underfloor drainage system are recommended for the houses to reduce the hydrostatic pressure and remove seeped water. The anticipated flow rate including the infiltrated water from the surface is approximately 14 m^3/day or less for each house. It is prudent to consider a contingency factor in designing the drainage capacity. It is recommended that the drainage capacity including sumps, pumps and related utilities is designed for minimum 18.9 L/min (5 GPM).

- HLV2K recommends the decommissioning of existing groundwater monitoring wells after completion of the construction of the project. In conformance with Ontario's Wells Regulation (O.Reg.903) of the Ontario Water Resources Act, the installation and eventual decommissioning of groundwater wells must be carried out by a licensed well contractor. If a well will be damaged/destroyed during the construction activities, then the well should be properly decommissioned in advance of that work.

9 STATEMENT OF LIMITATIONS

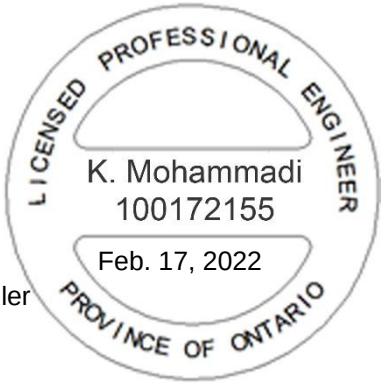
The contents of this report are subject to the attached '***Statement of Limitation***' sheet. The reader's attention is specifically drawn to these conditions as it is considered essential that they be followed for proper use and interpretation of this report. The Statement of Limitations is not intended to reduce the level of responsibility accepted by HLV2K, but rather to ensure that all parties who have been given reliance for this report are aware of the responsibilities each assumes in so doing.

This report was prepared by HLV2K exclusively for the account of SS WELLAND INC. (the CLIENT). Other than by the CLIENT, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of HLV2K. Any use, reliance on or decision made by any person other than CLIENT based on this report is the sole responsibility of such other person. The CLIENT and HLV2K make no representation or warranty to any other person with regard to this report and the work referred to in this report and the CLIENT and HLV2K accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made or any action taken based on this report or the work referred to in this report.

10 CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact this office.

For and Behalf of HLV2K Engineering Limited



k. Mohamadi

Kourosh Mohammadi, PhD., P.Eng.

Principal Hydrogeological Engineer and Groundwater Modeller

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HLV2K Engineering Limited

STATEMENT OF LIMITATIONS

Your report has been developed based on your unique project specific requirements as understood by HLV2K Engineering Limited (HLV2K) and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking HLV2K to assess how factors that changed subsequent to the date of the report affect the report's recommendations. HLV2K cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions, which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult HLV2K to be advised how time may have impacted on the project.

The findings derived from this investigation were based on information collected and/or provided by the Client. It may become apparent that soil and groundwater conditions differ between and beyond the testing locations examined during future investigations or other work that could not be detected or anticipated at the time of this study. As such, HLV2K cannot be held liable for environmental conditions that were not apparent from the available information. The conclusions presented represent the best judgment of the assessors based on limited investigations.

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature, external data source review, sampling, and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions, which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of HLV2K through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report is based on the assumption that he site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only HLV2K, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and HLV2K cannot be held responsible for such misinterpretation.

To avoid misuse of the information contained in your report it is recommended that you confer with HLV2K before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

HLV2K Engineering Limited

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain HLV2K to work with other project design professionals who are affected by the report. Have HLV2K explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.

Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact HLV2K for information relating to geoenvironmental issues.

HLV2K is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with HLV2K to develop alternative approaches to problems that may be of genuine benefit both in time and in cost.

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from HLV2K to other parties but are included to identify where HLV2K's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from HLV2K closely and do not hesitate to ask any questions you may have.

Third party information reviewed and used to formulate this report is assumed to be complete and correct. HLV2K used this information in good faith and will not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.

Nothing in this report is intended to constitute or provide a legal opinion.

Should additional information become available, HLV2K requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

FIGURES

Legend

Approx. Site Boundary

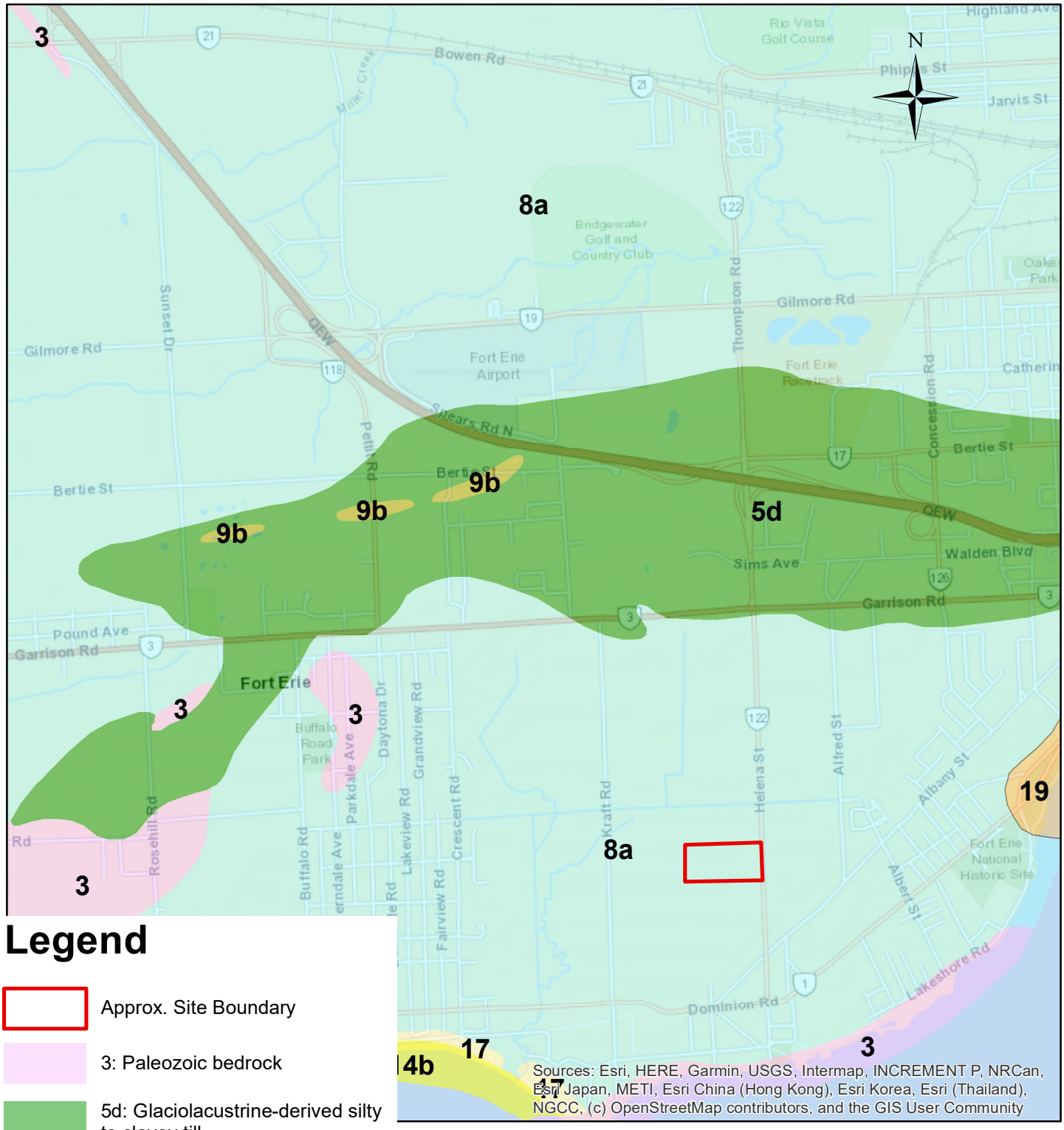
Drawn: MM	Title: SITE LOCATION PLAN
Approved: KM	Project: HYDROGEOLOGICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS WELLAND INC.
HLV2K ENGINEERING LIMITED	0 125 250 500 Meters — **FIGURE 1**

Legend

- Approx. Site Boundary
- Borehole
- Monitoring Well

Drawn: MM	Title: BOREHOLE LOCATION PLAN
Approved: KM	Project: HYDROGEOLOGICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS WELLAND INC.
HLV2K ENGINEERING LIMITED	0 20 40 80 Meters

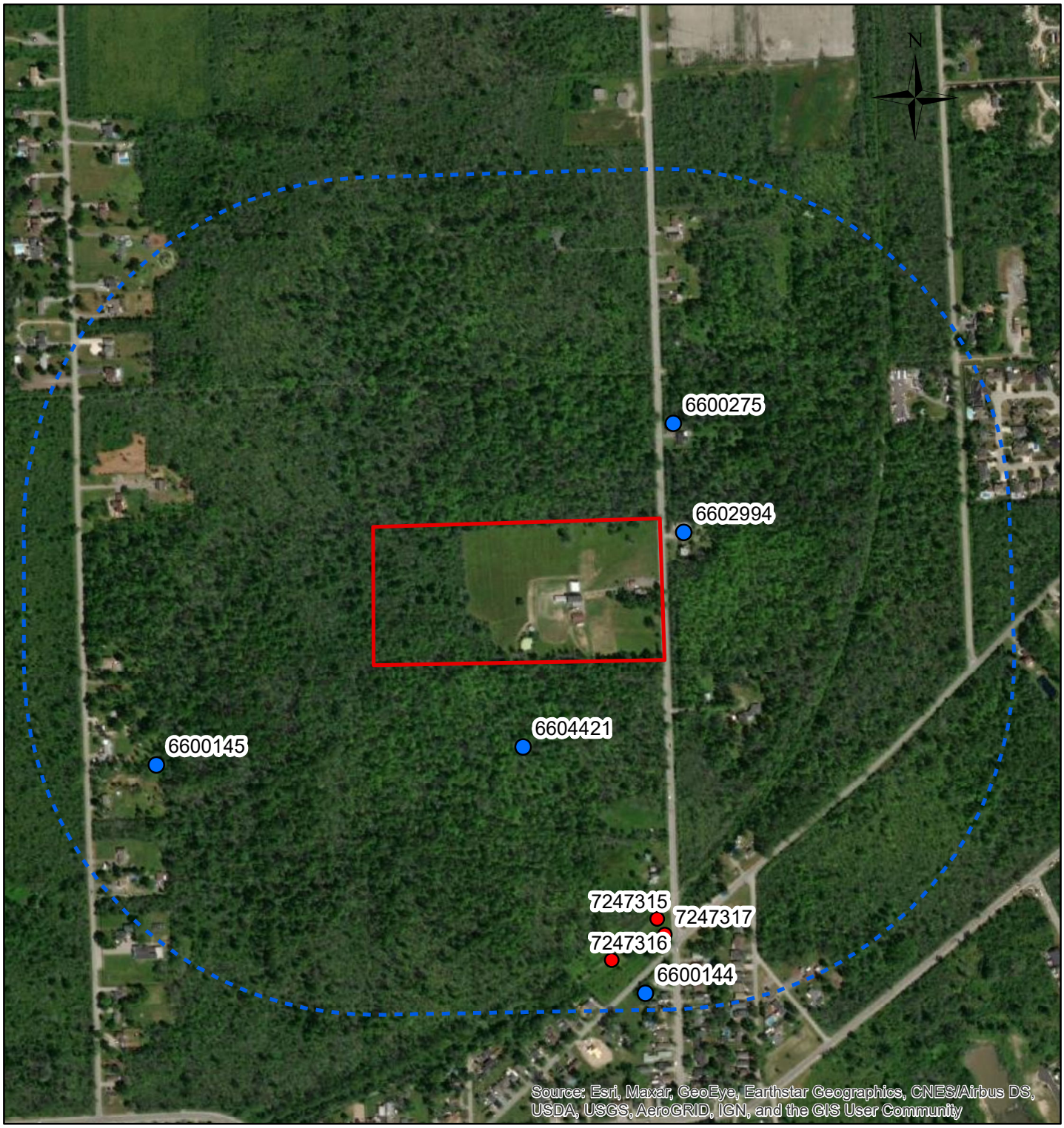
FIGURE 2



Legend

- Approx. Site Boundary
- 3: Paleozoic bedrock
- 5d: Glaciolacustrine-derived silty to clayey till
- 8a: Glaciolacustrine deep water deposits
- 9b: Littoral-foreshore deposits
- 14b: Littoral-foreshore deposits
- 17: Eolian deposits
- 19: Modern alluvial deposits

Drawn: MM	Title SURFICIAL GEOLOGY MAP	
Approved: KM	Project HYDROGEOLOGICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario	
Date: NOV. 2021		
Project No.: 2100394AG		
	Client SS WELLAND INC.	
HLV2K ENGINEERING LIMITED	0 255 510 1,020 Meters	FIGURE 3



Legend

- Approx. Site Boundary
- 500mBuffer

Final Status

- Observation Wells
- Water Supply

Drawn: MM	Title: WATER WELL RECORDS
Approved: KM	Project: HYDROGEOLOGICAL INVESTIGATION Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS WELLAND INC.
HLV2K ENGINEERING LIMITED	0 65 130 260 Meters

FIGURE 4

APPENDIX A

Borehole Logs

LOG OF BOREHOLE BH1

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751014.752 E 668156.609

DRILLING DATA

Method: Hollow Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.2						
0.0 / 182.0	**Asphalt:** 150mm				182	
0.2	**Fill:** sand and gravel, trace silt and clay, brown, moist, compact	1	SS	57		
181.4						
0.8	**Silty Clay Till:** trace gravel and sand, brown, very moist, firm to very stiff	2	SS	7	181	
		3	SS	16		1 7 45 47
		4	SS	27	180	
		5	SS	17	179	
177.6					178	
4.6	**Silty Clay:** trace sand, brown, moist, firm to very stiff	6	SS	6	177	

STRATA PLOT

GROUND WATER CONDITIONS

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES $+^3$, $\times^3$: Numbers refer to Sensitivity ○ ε_f=3% Strain at Failure

LOG OF BOREHOLE BH1

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751014.752 E 668156.609

DRILLING DATA

Method: Hollow Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE & Sensitivity, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty Clay: trace sand, brown, moist, firm to very stiff(Continued)						176				
			7	SS	8				○		
175.3											
~~176.0~~ 6.9	~~**Bedrock:** weathered, black~~ dolomite		8	SS	~~50/50mm~~				○		
	End of Borehole: borehole terminated at 6.9m										
	Upon completion: 1) Cave-in: open 2) Water: dry										

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH2

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750966.835 E 668089.3891

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.6						
0.0 / 181.3	**Topsoil:**300mm					
0.3 / 181.0	**Disturbed Native/Fill:** silty clay, trace sand and gravel, trace rootlets, brown to black, very moist, loose	1	SS	4	181	
0.6	**Silty Clay Till:** trace sand, trace gravel, brown to black, very moist, stiff to very stiff	2	SS	16		
1		3	SS	20	180	
2		4	SS	15	179	
3		5	SS	8	178	
4						
177.0						
4.6	**Silty Clay:** trace sand, brown, very moist, soft	6	SS	3	177	1 7 52 40
5 / 176.4						
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Measurement: 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ $^{\varepsilon_f=3\%}$ Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH3

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4750999.13 E 668085.3975

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/09/2021

REF. NO.: 2100394AG
DRAWING NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.7 / 0.0	**Gravel:** 100mm											
0.1 / 181.3	**Fill:** sandy silt with some gravel, organic inclusions, brown, very moist, loose		1	SS	6							
0.4	**Silty Clay Till:** trace sand and gravel, trace rootlets, brown, very moist, firm to stiff		2	SS	13		181					
			3	SS	18		180					
			4	SS	15		179					
			5	SS	10		178					
177.2 / 4.6	**Silty Clay:** trace sand, brown, very moist, soft		6	SS	4		177					
176.6 / 5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH4

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750990.884 E 668007.3711

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/09/2021

REF. NO.: 2100394AG

DRAWING NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.4												
0.0 / 181.3	**Topsoil:** 150mm											
0.2 / 181.0	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown , very moist, loose		1	SS	5							
0.5	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff		2	SS	18		181					
1			3	SS	20		180					
2			4	SS	14		179					
3			5	SS	10		178					
4			6	SS	50/130mm		177					
176.6 / 4.9 / 176.4	**Bedrock:** weathered dolomite											
5 5.0	**End of Borehole:** borehole terminated at 5.0m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH5

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750949.591 E 668062.0856

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.4					
0.0 / 181.3	**Topsoil:** 150mm				
0.2 / 180.9	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, very moist, loose	1	SS	5	181
0.5	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff	2	SS	14	180
1		3	SS	21	
2		4	SS	16	179
3		5	SS	10	178
4					177
176.8					
4.6	**Silty Clay:** trace sand and gravel, brown, very moist, firm	6	SS	6	
5 / 176.2					
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion				

GROUND WATER CONDITIONS: W. L. 179.7 m, Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

PLASTIC LIMIT (w_P) — NATURAL MOISTURE CONTENT (w) — LIQUID LIMIT (w_L)

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH6

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4750942.554 E 668149.6001

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 7

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.2					
0.0 / 181.1	**Topsoil:** 150mm				
0.2 / 180.9	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, moist, loose	1	SS	5	181
0.3	**Silty Clay Till:** trace sand and gravel, greyish brown, very moist, firm to very stiff	2	SS	22	
					180
		3	SS	26	
		4	SS	14	179
		5	SS	8	178
176.7					177
4.6	**Silty Clay:** trace sand and gravel, brown, very moist, soft	6	SS	4	
176.1					
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion				

W. L. 179.9 m
Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

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

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

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

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
$+^3$, $\times^3$: Numbers refer to Sensitivity
○ ε_f=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH7

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751054.703 E 668018.9953

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 8

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"
181.7				
0.0 / 181.6	**Topsoil:** 150mm			
0.2 / 181.4	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose	1	SS	7
0.3	**Silty Clay Till:** trace gravel, brown, very moist, firm to very stiff			
		2	SS	12
		3	SS	22
178.7		4	SS	16
3.1	**Silty Clay:** trace sand and gravel, brown, very moist, firm	5	SS	6
177.2				
4.5 / 177.1	**Bedrock:** weathered dolomite	6	SS	50/50mm
4.6	**End of Borehole:** borehole terminated at 4.6m Upon completion: 1) Cave-in: open 2) Water: dry 3) Monitoring well installed upon completion			

GROUND WATER CONDITIONS: W. L. 179.5 m Oct 21, 2021

ELEVATION: 181, 180, 179, 178

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH8

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4751060.32 E 668093.7114

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/08/2021

REF. NO.: 2100394AG
DRAWING NO.: 9

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.8												
0.0 / 181.5	**Topsoil:**230mm											
0.2 / 181.3	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose		1	SS	5							
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff		2	SS	15		181					
1			3	SS	21		180					
2			4	SS	18		179					
3 / 178.7												
3.1	**Silty Clay:** trace sand and gravel, brown, very moist, firm turning soft		5	SS	6		178					
4			6	SS	3		177					
5 / 176.6												
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH9

PROJECT: Sabrina Homes
CLIENT: Sabrina Homes
PROJECT LOCATION: 613 Helena Street, Fort Erie, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 4751026.281 E 668127.6148

DRILLING DATA
Method: Soild Stem Augur
Diameter: 150mm
Date: Sep/09/2021

REF. NO.: 2100394AG
DRAWING NO.: 10

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.8												
0.0 / 181.6	**Topsoil:**230mm											
0.2 / 181.3	**Disturbed Native/Fill:** silty clay,trace gravel, trace rootlets, brown, very moist, loose		1	SS	6							
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff		2	SS	16		181					
1			3	SS	20		180					
2			4	SS	16		179					
3 / 178.7												
3.1	**Silty Clay:** trace sand, brown, very moist, firm turning soft		5	SS	8		178					
4			6	SS	3		177					
5 / 176.6												
5.2	**End of Borehole:**borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry											

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH10

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4750966.835 E 668089.3891

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/09/2021

REF. NO.: 2100394AG

DRAWING NO.: 11

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.6					
0.0 / 181.4	**Topsoil:** 150mm				
0.2 / 181.1	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, very moist, loose	1	SS	5	
0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff	2	SS	13	181
		3	SS	20	180
178.5		4	SS	23	179
3.1	**Silty Clay:** trace sand, brown, very moist, firm	5	SS	8	178
176.4		6	SS	4	177
5.2	**End of Borehole:** borehole terminated at 5.2m Upon completion: 1) Cave-in: open 2) Water: dry				

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

HLV2K ENGINEERING LIMITED

LOG OF BOREHOLE BH11

PROJECT: Sabrina Homes

CLIENT: Sabrina Homes

PROJECT LOCATION: 613 Helena Street, Fort Erie, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4751054.793 E 668166.184

DRILLING DATA

Method: Soild Stem Augur

Diameter: 150mm

Date: Sep/08/2021

REF. NO.: 2100394AG

DRAWING NO.: 12

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
181.9 / 0.0	**Topsoil:** 150mm				
181.8 / 0.2	**Disturbed Native/Fill:** silty clay, trace gravel, trace rootlets, brown, moist, loose	1	SS	5	
181.4 / 0.5	**Silty Clay Till:** trace sand and gravel, brown, very moist, firm to very stiff	2	SS	14	181
		3	SS	18	180
		4	SS	20	179
		5	SS	14	178
177.3 / 4.6	**Silty Clay:** trace sand, brown, very moist, firm	6	SS	4	177
175.9 / 6.0	**Bedrock:** weathered, dolomite	7	SS	50/50mm	176
175.8 / 6.1	**End of Borehole:** borehole terminated at 6.1m				

Upon completion:
1) Cave-in: open
2) Water: dry
3) Monitoring well installed upon completion

GROUND WATER CONDITIONS: W. L. 179.8 m Oct 21, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

APPENDIX B

Water Quality Certificates of Analysis

HLV2K Engineering Limited (Brampton)
ATTN: Kourosh Mohammadi
2179 Dunwin Drive
Unit 4
Mississauga ON L5L 1X2

Date Received: 28-SEP-21
Report Date: 07-OCT-21 11:14 (MT)
Version: FINAL

Client Phone: 437-370-0317

Certificate of Analysis

Lab Work Order #: L2644748

Project P.O. #: NOT SUBMITTED
Job Reference: 2100394AG
C of C Numbers:
Legal Site Desc:

Comments: ADDITIONAL 29-SEP-21 07:56

Amanda Overholster
Account Manager

ANALYTICAL REPORT

Summary of Guideline Exceedances

ALS ID	Client ID	Grouping	Analyte	Result	Guideline Limit	Unit
Guideline						
Ontario Provincial Water Quality Objectives (JULY, 1994) - Surface Water PWQO						
L2644748-1	BH6	Dissolved Metals	Copper (Cu)-Dissolved	0.00133	0.001	mg/L
			Phosphorus (P)-Dissolved	<0.050	0.01	mg/L

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Physical Tests - WATER

			Lab ID	L2644748-1
			Sample Date	28-SEP-21
			Sample ID	BH6
		Guide Limits		
Analyte	**Unit**	**#1**	**#2**	
Colour, Apparent	CU	-	-	<2.0 PEHT
Conductivity	umhos/cm	-	-	968
pH	pH units	6.5-8.5	-	8.05
Total Dissolved Solids	mg/L	-	-	541 DLDS
Turbidity	NTU	-	-	<0.10

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Anions and Nutrients - WATER

			Lab ID	L2644748-1
			Sample Date	28-SEP-21
			Sample ID	BH6
		Guide Limits		
Analyte	Unit	#1	#2	
Alkalinity, Bicarbonate (as CaCO3)	mg/L	-	-	486
Alkalinity, Carbonate (as CaCO3)	mg/L	-	-	<1.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	-	-	<1.0
Alkalinity, Total (as CaCO3)	mg/L	-	-	486
Ammonia, Total (as N)	mg/L	-	-	0.041
Bromide (Br)	mg/L	-	-	<0.10
Chloride (Cl)	mg/L	-	-	4.17
Computed Conductivity	uS/cm	-	-	911
Conductivity % Difference	%	-	-	-6
Fluoride (F)	mg/L	-	-	0.699
Hardness (as CaCO3)	mg/L	-	-	514
Ion Balance	%	-	-	112
Langelier Index		-	-	1
Nitrate and Nitrite as N	mg/L	-	-	0.129
Nitrate (as N)	mg/L	-	-	0.129
Nitrite (as N)	mg/L	-	-	<0.010
Saturation pH	pH	-	-	7.09
Orthophosphate-Dissolved (as P)	mg/L	-	-	0.0099
TDS (Calculated)	mg/L	-	-	579
Sulfate (SO4)	mg/L	-	-	103
Anion Sum	me/L	-	-	10.4
Cation Sum	me/L	-	-	11.6
Cation - Anion Balance	%	-	-	6

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Organic / Inorganic Carbon - WATER

		Guide Limits		
Analyte	**Unit**	**#1**	**#2**	
Lab ID				L2644748-1
Sample Date				28-SEP-21
Sample ID				BH6
Dissolved Carbon Filtration Location		-	-	LAB
Dissolved Organic Carbon	mg/L	-	-	4.25

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Inorganic Parameters - WATER

		Guide Limits		
Analyte	Unit	#1	#2	
Lab ID				L2644748-1
Sample Date				28-SEP-21
Sample ID				BH6
Silica	mg/L	-	-	12.8

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Bacteriological Tests - WATER

			Lab ID	L2644748-1
			Sample Date	28-SEP-21
			Sample ID	BH6
		Guide Limits		
Analyte	Unit	#1	#2	
E. Coli	CFU/100mL	100	-	0
Total Coliforms	CFU/100mL	-	-	0

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Dissolved Metals - WATER

			Lab ID	L2644748-1
			Sample Date	28-SEP-21
			Sample ID	BH6
Analyte	**Unit**	**Guide Limits #1**	**#2**	
Dissolved Metals Filtration Location		-	-	LAB
Aluminum (Al)-Dissolved	mg/L	0.015	-	<0.0050
Antimony (Sb)-Dissolved	mg/L	0.02	-	0.00040
Arsenic (As)-Dissolved	mg/L	0.005	-	0.00102
Barium (Ba)-Dissolved	mg/L	-	-	0.0871
Beryllium (Be)-Dissolved	mg/L	0.011	-	<0.00010
Bismuth (Bi)-Dissolved	mg/L	-	-	<0.000050
Boron (B)-Dissolved	mg/L	0.2	-	0.133
Cadmium (Cd)-Dissolved	mg/L	0.0001	-	<0.000010
Calcium (Ca)-Dissolved	mg/L	-	-	54.1
Chromium (Cr)-Dissolved	mg/L	-	-	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0009	-	0.00027
Copper (Cu)-Dissolved	mg/L	0.001	-	0.00133
Iron (Fe)-Dissolved	mg/L	0.3	-	<0.010
Lead (Pb)-Dissolved	mg/L	0.001	-	<0.000050
Magnesium (Mg)-Dissolved	mg/L	-	-	92.0
Manganese (Mn)-Dissolved	mg/L	-	-	0.0298
Molybdenum (Mo)-Dissolved	mg/L	0.04	-	0.0105
Nickel (Ni)-Dissolved	mg/L	0.025	-	0.00148
Phosphorus (P)-Dissolved	mg/L	0.01	-	<0.050
Potassium (K)-Dissolved	mg/L	-	-	5.05
Selenium (Se)-Dissolved	mg/L	0.1	-	0.0110
Silicon (Si)-Dissolved	mg/L	-	-	6.00
Silver (Ag)-Dissolved	mg/L	0.0001	-	<0.000050
Sodium (Na)-Dissolved	mg/L	-	-	28.1
Strontium (Sr)-Dissolved	mg/L	-	-	6.75
Sulfur (S)-Dissolved	mg/L	-	-	35.0
Thallium (Tl)-Dissolved	mg/L	0.0003	-	0.000026
Tin (Sn)-Dissolved	mg/L	-	-	0.00097
Titanium (Ti)-Dissolved	mg/L	-	-	<0.00030

Guide Limit #1: Surface Water PWQO

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Dissolved Metals - WATER

			Lab ID	L2644748-1
			Sample Date	28-SEP-21
			Sample ID	BH6
		Guide Limits		
Analyte	Unit	#1	#2	
Tungsten (W)-Dissolved	mg/L	0.03	-	<0.00010
Uranium (U)-Dissolved	mg/L	0.005	-	0.00428
Vanadium (V)-Dissolved	mg/L	0.006	-	0.00183
Zinc (Zn)-Dissolved	mg/L	0.02	-	<0.0010
Zirconium (Zr)-Dissolved	mg/L	0.004	-	<0.00030

Guide Limit #1: Surface Water PWQO

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
PEHT	Parameter Exceeded Recommended Holding Time Prior to Analysis

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SPEC-PCT-WT	Water	Automated Speciated Alkalinity	APHA 2320B

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-IC-N-WT	Water	Bromide in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COLOUR-APPARENT-WT	Water	Colour	APHA 2120

Apparent Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method after sample decanting. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

DOC-WT	Water	Dissolved Organic Carbon	APHA 5310B

Sample is filtered through a 0.45um filter, then injected into a heated reaction chamber which is packed with an oxidative catalyst. The water is vaporized and the organic carbon is oxidized to carbon dioxide. The carbon dioxide is transported in a carrier gas and is measured by a non-dispersive infrared detector.

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h. Method ID: WT-TM-1200

EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

ETL-N2N3-WT	Water	Calculate from NO2 + NO3	APHA 4110 B
ETL-SILICA-CALC-WT	Water	Calculate from SI-TOT-WT	EPA 200.8
F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

IONBALANCE-OP03-WT	Water	Detailed Ion Balance Calculation	APHA 1030E, 2330B, 2510A
MET-D-CCMS-WT	Water	Dissolved Metals in Water by CRC	APHA 3030B/6020A (mod)

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference**
		ICPMS	
		Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.	
		Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.	
		Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).	
NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC
		This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.	
NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)
		Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.	
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)
		Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.	
PH-WT	Water	pH	APHA 4500 H-Electrode
		Water samples are analyzed directly by a calibrated pH meter.	
		Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days	
PO4-DO-COL-WT	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P PHOSPHORUS
		This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.	
SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)
		Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.	
SOLIDS-TDS-WT	Water	Total Dissolved Solids	APHA 2540C
		This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.	
TC-MF-WT	Water	Total Coliforms	SM 9222B
		A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35–0.5°C for 24–2h. Method ID: WT-TM-1200	
TURBIDITY-WT	Water	Turbidity	APHA 2130 B
		Sample result is based on a comparison of the intensity of the light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Sample readings are obtained from a Nephelometer.	

**ALS test methods may incorporate modifications from specified reference methods to improve performance.

Chain of Custody Numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guideline limits are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Quality Control Report

Workorder: L2644748 Report Date: 07-OCT-21

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2

Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-SPEC-PCT-WT	**Water**							
Batch R5605452								
WG3628224-4 DUP		**WG3628224-3**						
Alkalinity, Total (as CaCO3)		97.6	94.8		mg/L	2.9	20	30-SEP-21
Alkalinity, Bicarbonate (as CaCO3)		97.6	94.8		mg/L	2.9	20	30-SEP-21
Alkalinity, Carbonate (as CaCO3)		<1.0	<1.0	RPD-NA	mg/L	N/A	20	30-SEP-21
Alkalinity, Hydroxide (as CaCO3)		<1.0	<1.0	RPD-NA	mg/L	N/A	20	30-SEP-21
WG3628224-2 LCS								
Alkalinity, Total (as CaCO3)			104.3		%		85-115	30-SEP-21
WG3628224-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	30-SEP-21
Alkalinity, Bicarbonate (as CaCO3)			<2.0		mg/L		2	30-SEP-21
Alkalinity, Carbonate (as CaCO3)			<2.0		mg/L		2	30-SEP-21
Alkalinity, Hydroxide (as CaCO3)			<2.0		mg/L		2	30-SEP-21
BR-IC-N-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Bromide (Br)		<0.10	<0.10	RPD-NA	mg/L	N/A	20	01-OCT-21
WG3629471-2 LCS								
Bromide (Br)			101.5		%		85-115	01-OCT-21
WG3629471-1 MB								
Bromide (Br)			<0.10		mg/L		0.1	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						
Bromide (Br)			101.4		%		75-125	01-OCT-21
CL-IC-N-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Chloride (Cl)		7.62	7.62		mg/L	0.0	20	01-OCT-21
WG3629471-2 LCS								
Chloride (Cl)			100.6		%		90-110	01-OCT-21
WG3629471-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						
Chloride (Cl)			97.6		%		75-125	01-OCT-21
COLOUR-APPARENT-WT	**Water**							
Batch R5605759								
WG3629030-3 DUP		**L2645896-6**						
Colour, Apparent		5.1	5.1		CU	1.0	20	30-SEP-21
WG3629030-2 LCS								

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
COLOUR-APPARENT-WT	**Water**							
Batch R5605759								
WG3629030-2 LCS								
Colour, Apparent			100.0		%		85-115	30-SEP-21
WG3629030-1 MB								
Colour, Apparent			<2.0		CU		2	30-SEP-21
DOC-WT	**Water**							
Batch R5613019								
WG3630165-3 DUP		**L2645135-2**						
Dissolved Organic Carbon		12.6	14.2		mg/L	12	20	06-OCT-21
WG3630165-2 LCS								
Dissolved Organic Carbon			93.2		%		80-120	06-OCT-21
WG3630165-1 MB								
Dissolved Organic Carbon			<0.50		mg/L		0.5	06-OCT-21
WG3630165-4 MS		**L2645135-2**						
Dissolved Organic Carbon			N/A	MS-B	%		-	06-OCT-21
EC-MF-WT	**Water**							
Batch R5605334								
WG3627624-3 DUP		**L2644972-2**						
E. Coli		3	3		CFU/100mL	0.0	65	29-SEP-21
WG3627624-1 MB								
E. Coli			0		CFU/100mL		1	29-SEP-21
EC-WT	**Water**							
Batch R5605452								
WG3628224-4 DUP		**WG3628224-3**						
Conductivity		319	318		umhos/cm	0.3	10	30-SEP-21
WG3628224-2 LCS								
Conductivity			96.0		%		90-110	30-SEP-21
WG3628224-1 MB								
Conductivity			<1.0		umhos/cm		1	30-SEP-21
F-IC-N-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Fluoride (F)		0.056	0.056		mg/L	0.2	20	01-OCT-21
WG3629471-2 LCS								
Fluoride (F)			102.0		%		90-110	01-OCT-21
WG3629471-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-WT	**Water**							
Batch R5607207								
WG3629471-5 MS		**WG3629471-3**						
Fluoride (F)			98.6		%		75-125	01-OCT-21
MET-D-CCMS-WT	**Water**							
Batch R5607058								
WG3629897-4 DUP		**WG3629897-3**						
Aluminum (Al)-Dissolved		<0.050	<0.050	RPD-NA	mg/L	N/A	20	01-OCT-21
Antimony (Sb)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21
Arsenic (As)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21
Barium (Ba)-Dissolved		0.115	0.120		mg/L	4.2	20	01-OCT-21
Beryllium (Be)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21
Bismuth (Bi)-Dissolved		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	01-OCT-21
Boron (B)-Dissolved		<0.10	<0.10	RPD-NA	mg/L	N/A	20	01-OCT-21
Cadmium (Cd)-Dissolved		0.000480	0.000474		mg/L	1.3	20	01-OCT-21
Calcium (Ca)-Dissolved		135	128		mg/L	5.6	20	01-OCT-21
Chromium (Cr)-Dissolved		<0.0050	<0.0050	RPD-NA	mg/L	N/A	20	01-OCT-21
Cobalt (Co)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21
Copper (Cu)-Dissolved		<0.0020	<0.0020	RPD-NA	mg/L	N/A	20	01-OCT-21
Iron (Fe)-Dissolved		<0.10	<0.10	RPD-NA	mg/L	N/A	20	01-OCT-21
Lead (Pb)-Dissolved		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	01-OCT-21
Magnesium (Mg)-Dissolved		27.1	29.4		mg/L	8.0	20	01-OCT-21
Manganese (Mn)-Dissolved		0.0097	0.0104		mg/L	7.5	20	01-OCT-21
Molybdenum (Mo)-Dissolved		0.00135	0.00149		mg/L	9.8	20	01-OCT-21
Nickel (Ni)-Dissolved		<0.0050	<0.0050	RPD-NA	mg/L	N/A	20	01-OCT-21
Phosphorus (P)-Dissolved		<0.50	<0.50	RPD-NA	mg/L	N/A	20	01-OCT-21
Potassium (K)-Dissolved		3.84	3.95		mg/L	2.7	20	01-OCT-21
Selenium (Se)-Dissolved		0.00164	0.00175		mg/L	6.5	20	01-OCT-21
Silicon (Si)-Dissolved		4.48	4.61		mg/L	2.9	20	01-OCT-21
Silver (Ag)-Dissolved		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	01-OCT-21
Sodium (Na)-Dissolved		378	398		mg/L	5.2	20	01-OCT-21
Strontium (Sr)-Dissolved		0.646	0.622		mg/L	3.8	20	01-OCT-21
Sulfur (S)-Dissolved		15.5	16.2		mg/L	4.2	20	01-OCT-21
Thallium (Tl)-Dissolved		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	01-OCT-21
Tin (Sn)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R5607058								
WG3629897-4 DUP		**WG3629897-3**						
Titanium (Ti)-Dissolved		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	01-OCT-21
Tungsten (W)-Dissolved		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	01-OCT-21
Uranium (U)-Dissolved		0.00114	0.00112		mg/L	1.5	20	01-OCT-21
Vanadium (V)-Dissolved		<0.0050	<0.0050	RPD-NA	mg/L	N/A	20	01-OCT-21
Zinc (Zn)-Dissolved		0.078	0.083		mg/L	6.4	20	01-OCT-21
Zirconium (Zr)-Dissolved		<0.0020	<0.0020	RPD-NA	mg/L	N/A	20	01-OCT-21
WG3629897-2 LCS								
Aluminum (Al)-Dissolved			94.7		%		80-120	01-OCT-21
Antimony (Sb)-Dissolved			91.5		%		80-120	01-OCT-21
Arsenic (As)-Dissolved			95.0		%		80-120	01-OCT-21
Barium (Ba)-Dissolved			98.4		%		80-120	01-OCT-21
Beryllium (Be)-Dissolved			95.6		%		80-120	01-OCT-21
Bismuth (Bi)-Dissolved			95.7		%		80-120	01-OCT-21
Boron (B)-Dissolved			91.3		%		80-120	01-OCT-21
Cadmium (Cd)-Dissolved			95.1		%		80-120	01-OCT-21
Calcium (Ca)-Dissolved			94.9		%		80-120	01-OCT-21
Chromium (Cr)-Dissolved			92.6		%		80-120	01-OCT-21
Cobalt (Co)-Dissolved			93.0		%		80-120	01-OCT-21
Copper (Cu)-Dissolved			92.3		%		80-120	01-OCT-21
Iron (Fe)-Dissolved			92.2		%		80-120	01-OCT-21
Lead (Pb)-Dissolved			93.8		%		80-120	01-OCT-21
Magnesium (Mg)-Dissolved			100.9		%		80-120	01-OCT-21
Manganese (Mn)-Dissolved			92.3		%		80-120	01-OCT-21
Molybdenum (Mo)-Dissolved			94.2		%		80-120	01-OCT-21
Nickel (Ni)-Dissolved			92.9		%		80-120	01-OCT-21
Phosphorus (P)-Dissolved			95.8		%		80-120	01-OCT-21
Potassium (K)-Dissolved			90.0		%		80-120	01-OCT-21
Selenium (Se)-Dissolved			95.4		%		80-120	01-OCT-21
Silicon (Si)-Dissolved			89.3		%		60-140	01-OCT-21
Silver (Ag)-Dissolved			90.5		%		80-120	01-OCT-21
Sodium (Na)-Dissolved			99.2		%		80-120	01-OCT-21
Strontium (Sr)-Dissolved			96.2		%		80-120	01-OCT-21
Sulfur (S)-Dissolved			95.2		%		80-120	01-OCT-21

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R5607058								
WG3629897-2 LCS								
Thallium (Tl)-Dissolved			95.1		%		80-120	01-OCT-21
Tin (Sn)-Dissolved			90.7		%		80-120	01-OCT-21
Titanium (Ti)-Dissolved			90.4		%		80-120	01-OCT-21
Tungsten (W)-Dissolved			91.7		%		80-120	01-OCT-21
Uranium (U)-Dissolved			90.2		%		80-120	01-OCT-21
Vanadium (V)-Dissolved			94.6		%		80-120	01-OCT-21
Zinc (Zn)-Dissolved			94.7		%		80-120	01-OCT-21
Zirconium (Zr)-Dissolved			91.4		%		80-120	01-OCT-21
WG3629897-1 MB								
Aluminum (Al)-Dissolved			<0.0050		mg/L		0.005	01-OCT-21
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Barium (Ba)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Beryllium (Be)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	01-OCT-21
Boron (B)-Dissolved			<0.010		mg/L		0.01	01-OCT-21
Cadmium (Cd)-Dissolved			<0.000005C		mg/L		0.000005	01-OCT-21
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	01-OCT-21
Chromium (Cr)-Dissolved			<0.00050		mg/L		0.0005	01-OCT-21
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	01-OCT-21
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	01-OCT-21
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	01-OCT-21
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	01-OCT-21
Manganese (Mn)-Dissolved			<0.00050		mg/L		0.0005	01-OCT-21
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	01-OCT-21
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	01-OCT-21
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	01-OCT-21
Potassium (K)-Dissolved			<0.050		mg/L		0.05	01-OCT-21
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	01-OCT-21
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	01-OCT-21
Silver (Ag)-Dissolved			<0.000050		mg/L		0.00005	01-OCT-21
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	01-OCT-21
Strontium (Sr)-Dissolved			<0.0010		mg/L		0.001	01-OCT-21

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R5607058								
WG3629897-1 MB								
Sulfur (S)-Dissolved			<0.50		mg/L		0.5	01-OCT-21
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	01-OCT-21
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	01-OCT-21
Tungsten (W)-Dissolved			<0.00010		mg/L		0.0001	01-OCT-21
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	01-OCT-21
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	01-OCT-21
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	01-OCT-21
Zirconium (Zr)-Dissolved			<0.00020		mg/L		0.0002	01-OCT-21
WG3629897-5 MS		**WG3629897-6**						
Aluminum (Al)-Dissolved			88.8		%		70-130	01-OCT-21
Antimony (Sb)-Dissolved			89.8		%		70-130	01-OCT-21
Arsenic (As)-Dissolved			96.4		%		70-130	01-OCT-21
Barium (Ba)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Beryllium (Be)-Dissolved			97.0		%		70-130	01-OCT-21
Bismuth (Bi)-Dissolved			90.7		%		70-130	01-OCT-21
Boron (B)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Cadmium (Cd)-Dissolved			92.6		%		70-130	01-OCT-21
Calcium (Ca)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Chromium (Cr)-Dissolved			90.2		%		70-130	01-OCT-21
Cobalt (Co)-Dissolved			92.9		%		70-130	01-OCT-21
Copper (Cu)-Dissolved			76.0		%		70-130	01-OCT-21
Iron (Fe)-Dissolved			85.8		%		70-130	01-OCT-21
Lead (Pb)-Dissolved			89.0		%		70-130	01-OCT-21
Magnesium (Mg)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Manganese (Mn)-Dissolved			78.7		%		70-130	01-OCT-21
Molybdenum (Mo)-Dissolved			85.2		%		70-130	01-OCT-21
Nickel (Ni)-Dissolved			90.1		%		70-130	01-OCT-21
Phosphorus (P)-Dissolved			101.9		%		70-130	01-OCT-21
Potassium (K)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Selenium (Se)-Dissolved			93.2		%		70-130	01-OCT-21
Silicon (Si)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Silver (Ag)-Dissolved			88.7		%		70-130	01-OCT-21
Sodium (Na)-Dissolved			N/A	MS-B	%		-	01-OCT-21

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R5607058								
WG3629897-5 MS		**WG3629897-6**						
Strontium (Sr)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Sulfur (S)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Thallium (Tl)-Dissolved			90.8		%		70-130	01-OCT-21
Tin (Sn)-Dissolved			91.7		%		70-130	01-OCT-21
Titanium (Ti)-Dissolved			93.5		%		70-130	01-OCT-21
Tungsten (W)-Dissolved			90.5		%		70-130	01-OCT-21
Uranium (U)-Dissolved			N/A	MS-B	%		-	01-OCT-21
Vanadium (V)-Dissolved			95.9		%		70-130	01-OCT-21
Zirconium (Zr)-Dissolved			92.3		%		70-130	01-OCT-21
NH3-F-WT	**Water**							
Batch R5608036								
WG3629516-3 DUP		**WG3629516-5**						
Ammonia, Total (as N)		40.4	40.0		mg/L	1.0	20	05-OCT-21
WG3629516-2 LCS								
Ammonia, Total (as N)			106.0		%		85-115	04-OCT-21
WG3629516-1 MB								
Ammonia, Total (as N)			<0.010		mg/L		0.01	04-OCT-21
WG3629516-4 MS		**WG3629516-5**						
Ammonia, Total (as N)			N/A	MS-B	%		-	05-OCT-21
NO2-IC-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Nitrite (as N)		<0.010	<0.010	RPD-NA	mg/L	N/A	20	01-OCT-21
WG3629471-2 LCS								
Nitrite (as N)			101.5		%		90-110	01-OCT-21
WG3629471-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						
Nitrite (as N)			98.0		%		75-125	01-OCT-21
NO3-IC-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Nitrate (as N)		0.186	0.186		mg/L	0.0	20	01-OCT-21
WG3629471-2 LCS								
Nitrate (as N)			100.5		%		90-110	01-OCT-21
WG3629471-1 MB								

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R5607207								
WG3629471-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						
Nitrate (as N)			97.4		%		75-125	01-OCT-21
PH-WT	**Water**							
Batch R5605452								
WG3628224-4 DUP		**WG3628224-3**						
pH		7.75	7.67	J	pH units	0.08	0.2	30-SEP-21
WG3628224-2 LCS								
pH			7.01		pH units		6.9-7.1	30-SEP-21
PO4-DO-COL-WT	**Water**							
Batch R5605172								
WG3628180-3 DUP		**WG3628180-5**						
Orthophosphate-Dissolved (as P)		0.0073	0.0069		mg/L	6.0	20	30-SEP-21
WG3628180-2 LCS								
Orthophosphate-Dissolved (as P)			98.5		%		80-120	30-SEP-21
WG3628180-1 MB								
Orthophosphate-Dissolved (as P)			<0.0030		mg/L		0.003	30-SEP-21
WG3628180-4 MS		**WG3628180-5**						
Orthophosphate-Dissolved (as P)			98.5		%		70-130	30-SEP-21
SO4-IC-N-WT	**Water**							
Batch R5607207								
WG3629471-4 DUP		**WG3629471-3**						
Sulfate (SO4)		13.0	13.0		mg/L	0.2	20	01-OCT-21
WG3629471-2 LCS								
Sulfate (SO4)			102.0		%		90-110	01-OCT-21
WG3629471-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	01-OCT-21
WG3629471-5 MS		**WG3629471-3**						
Sulfate (SO4)			98.9		%		75-125	01-OCT-21
SOLIDS-TDS-WT	**Water**							
Batch R5606921								
WG3629395-3 DUP		**L2645224-6**						
Total Dissolved Solids		2290	2250		mg/L	1.8	20	01-OCT-21
WG3629395-2 LCS								
Total Dissolved Solids			99.9		%		85-115	01-OCT-21
WG3629395-1 MB								

Quality Control Report

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SOLIDS-TDS-WT	**Water**							
Batch R5606921								
WG3629395-1 MB								
Total Dissolved Solids			<10		mg/L		10	01-OCT-21
TC-MF-WT	**Water**							
Batch R5605352								
WG3627621-3 DUP		**L2644876-5**						
Total Coliforms		0	0		CFU/100mL	0.0	65	29-SEP-21
WG3627621-1 MB								
Total Coliforms			0		CFU/100mL		1	29-SEP-21
TURBIDITY-WT	**Water**							
Batch R5605915								
WG3628480-2 LCS								
Turbidity			102.0		%		85-115	30-SEP-21
WG3628480-1 MB								
Turbidity			<0.10		NTU		0.1	30-SEP-21

Quality Control Report

Workorder: L2644748 Report Date: 07-OCT-21

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Workorder: L2644748 Report Date: 07-OCT-21

Client: HLV2K Engineering Limited (Brampton)
2179 Dunwin Drive Unit 4
Mississauga ON L5L 1X2
Contact: Kourosh Mohammadi

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Organic / Inorganic Carbon							
Dissolved Organic Carbon							
	1	28-SEP-21 11:00	02-OCT-21 00:00	3	4	days	EHT

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2644748 were received on 28-SEP-21 14:28.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L2644748-COFC

Chain of Custody (COC) / Analytical Request Form

COC Number: 20 - 898430

www

Canada Toll Free: 1 800 668 9878

Page of

Report To	Contact and company name below will appear on the final report
Company:	HLV2K Engineering Ltd
Contact:	Kourosh Mohammadi
Phone:	905-569-2765
Company address below will appear on the final report	
Street:	2179 Dunwin Dr Unit 4
City/Province:	Mississauga
Postal Code:	L5L 1X2

Invoice To		
	Same as Report To	☑ YES ☐ NO
	Copy of Invoice with Report	☑ YES ☐ NO
Company:		
Contact:		

Reports / Recipients	
Select Report Format:	☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Merge QC/QCI Reports with COA	☐ YES ☐ NO ☐ N/A
☑ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	Kourosh.mohammadi@HLV2K.com
Email 2	
Email 3	

Invoice Recipients	
Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	
Email 2	

Project Information	
ALS Account # / Quote #:	
Job #:	21e0394AC
PO / AFE:	
LSD:	
ALS Lab Work Order # (ALS use only):	L2644748

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	
ALS Contact: AO	Sampler:

Turnaround Time (TAT) Requested

- ☑ Routine [R] if received by 3pm M-F - no surcharges apply
- ☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum
- ☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum
- ☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum
- ☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum
- ☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-routine tests

AFFIX ALS BARCODE LABEL HERE (ALS use only)

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm am/pm

For all tests with rush TATs requested, please contact your AM to confirm availability.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	SAMPLES ON HOLD	EXTENDED STORAGE REQUIRED	SUSPECTED HAZARD (see notes)
	BH6	28-9-21	11:00	GW	✓ Geochem			

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human consumption/ use? ☐ YES ☑ NO

Notes / Specify Limits for result evaluation by selecting from drop-down below (Excel COC only)

PWQOs (Provincial Water Quality Objectives)

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☒ ICE ☒ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Intact: ☐ YES ☐ N/A Sample Custody Seals Intact: ☐ YES ☐ N/A

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
7.5				7.5			

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (ALS use only)

Received by:	Date:	Time:
Karan	9/28/2021	14:28

FINAL SHIPMENT RECEPTION (ALS use only)

Received by:	Date:	Time:
W	09/28/21	17:0

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

AUG 2020 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

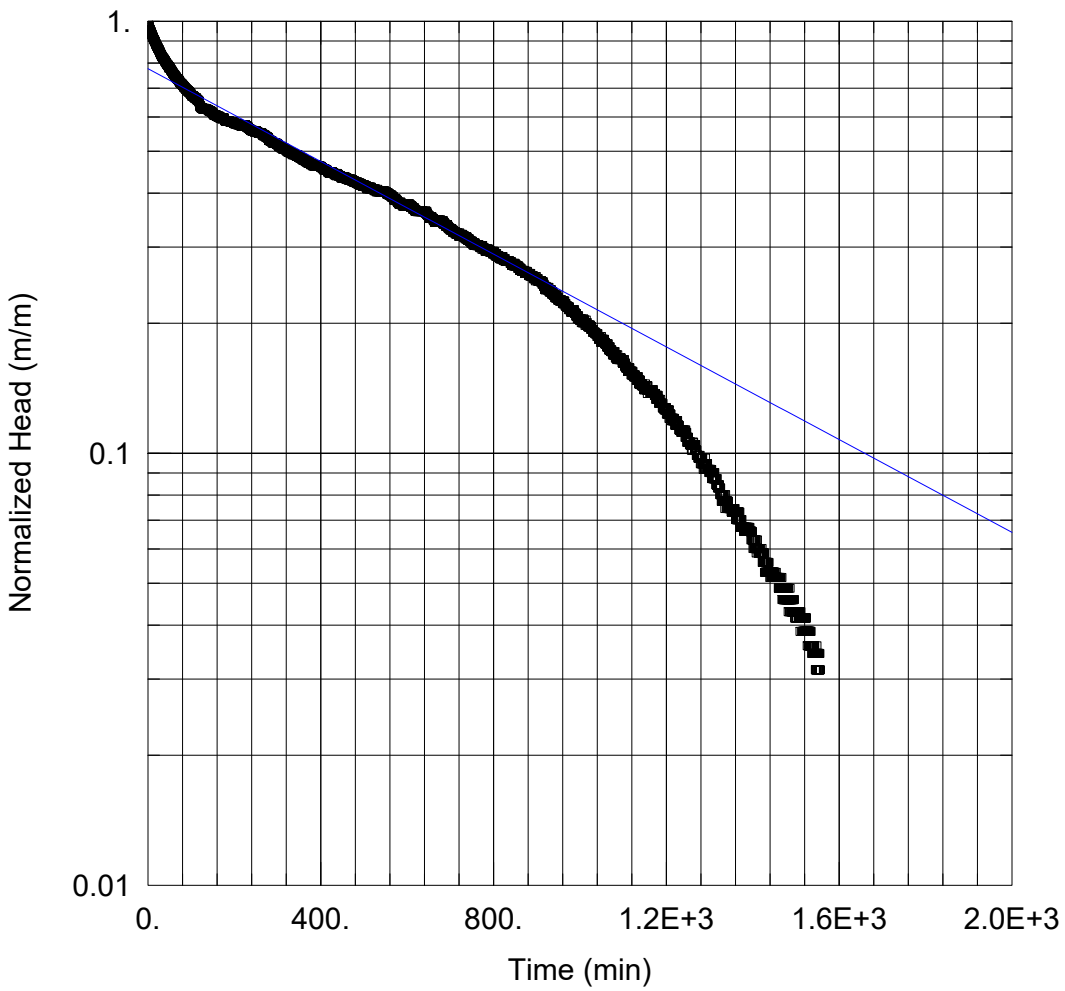
1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

APPENDIX C

In-Situ Hydraulic Conductivity Testing Results

In-Situ Hydraulic Conductivity Test (BH5)

Prepared By:	Prepared For:
HLV2K Engineering	SS Welland Inc.
Project:	**Location:**
2100394AG	Fort Erie, Ontario



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.183E-6 cm/sec y0 = 0.5419 m

AQUIFER DATA

Saturated Thickness: 1.4 m Anisotropy Ratio (Kz/Kr): 1.

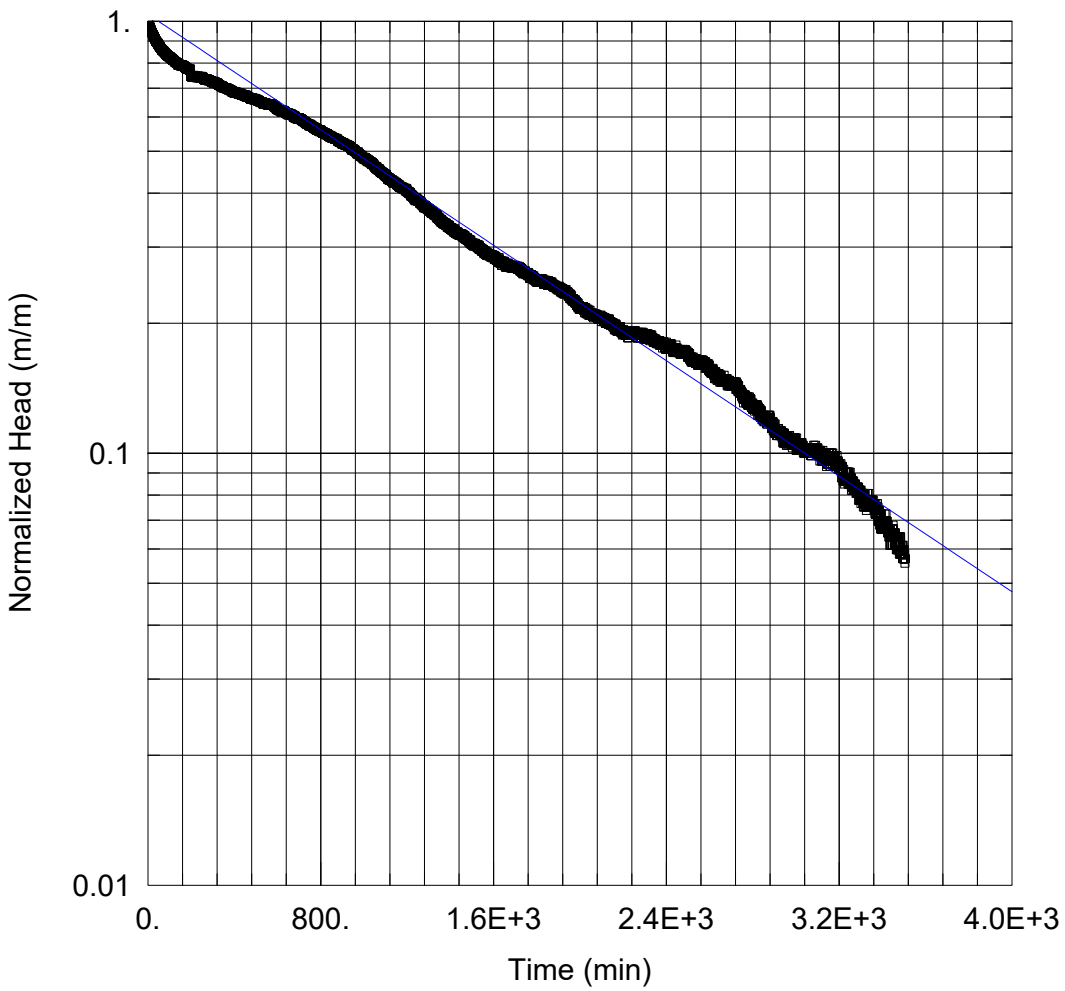
WELL DATA (BH5)

Initial Displacement: 0.698 m
Static Water Column Height: 4.24 m
Total Well Penetration Depth: 0.4 m
Screen Length: 0.4 m
Casing Radius: 0.025 m
Well Radius: 0.1 m

HLV2K ENGINEERING LIMITED

In-Situ Hydraulic Conductivity Test (BH6)

Prepared By:	Prepared For:
HLV2K Engineering	SS Welland Inc.
Project:	**Location:**
2100394AG	Fort Erie, Ontario



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 7.339E-7 cm/sec y0 = 0.7463 m

AQUIFER DATA

Saturated Thickness: 1.5 m Anisotropy Ratio (Kz/Kr): 1.

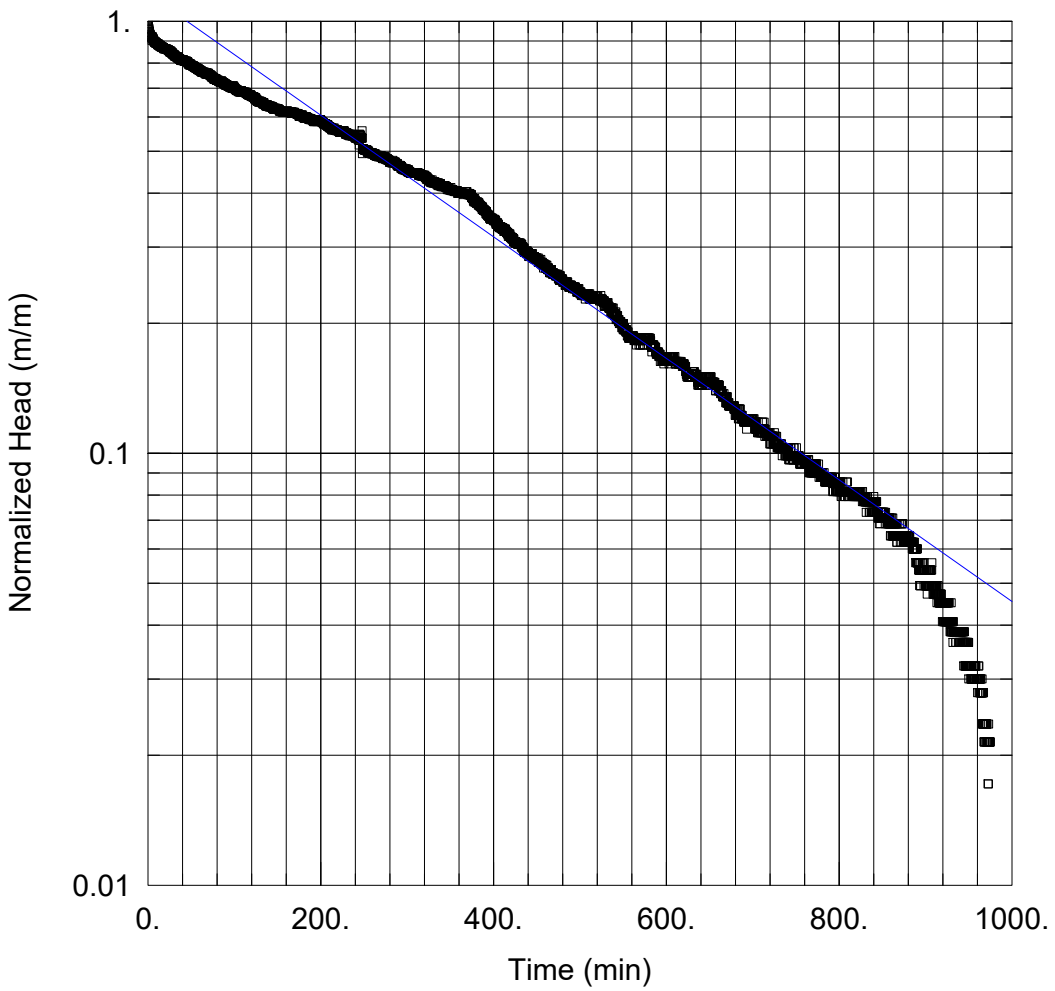
WELL DATA (BH6)

Initial Displacement: 0.719 m
Static Water Column Height: 4.54 m
Total Well Penetration Depth: 0.4 m
Screen Length: 0.4 m
Casing Radius: 0.025 m
Well Radius: 0.1 m

HLV2K ENGINEERING LIMITED

In-Situ Hydraulic Conductivity Test (BH7)

Prepared By:	Prepared For:
HLV2K Engineering	SS Welland Inc.
Project:	**Location:**
2100394AG	Fort Erie, Ontario



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.185E-6 cm/sec y0 = 0.5395 m

AQUIFER DATA

Saturated Thickness: 1.46 m Anisotropy Ratio (Kz/Kr): 1.

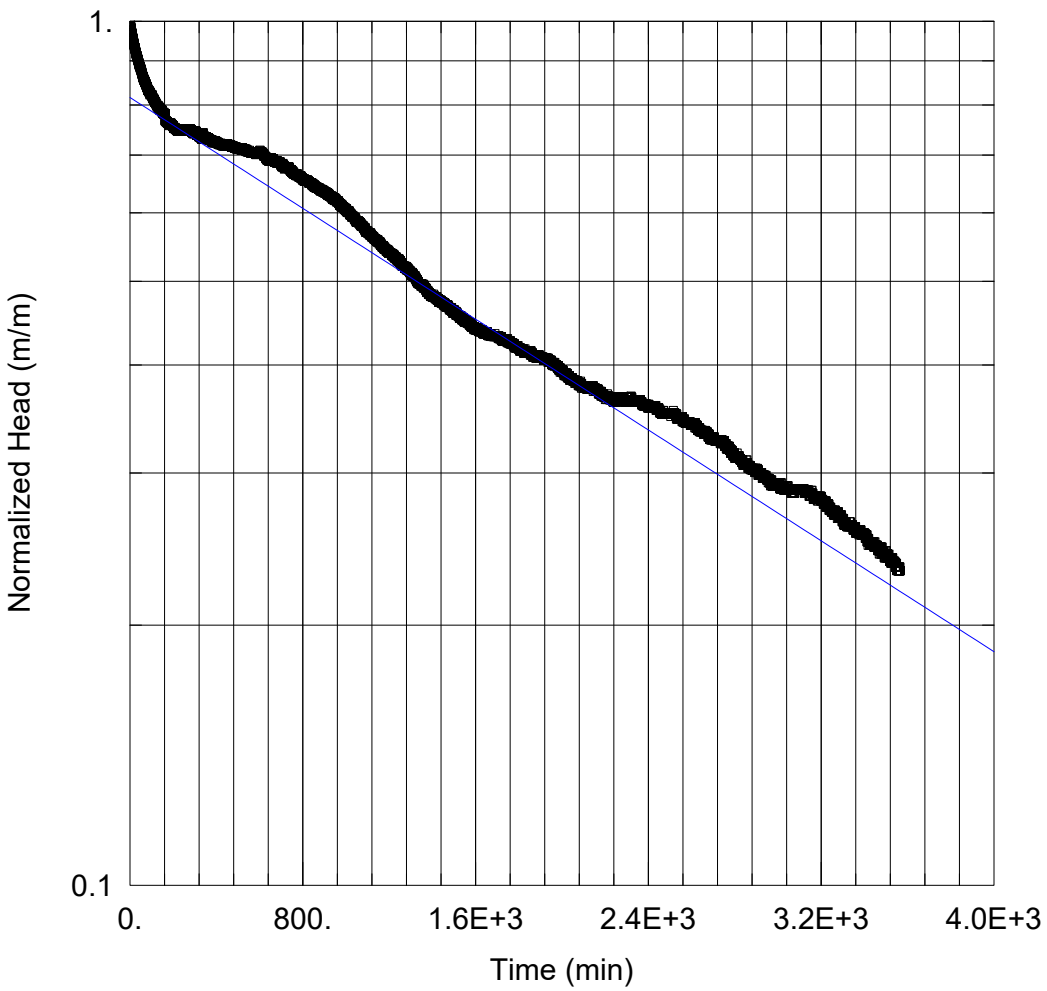
WELL DATA (BH7)

Initial Displacement: 0.466 m
Static Water Column Height: 3.04 m
Total Well Penetration Depth: 1.36 m
Screen Length: 1.36 m
Casing Radius: 0.025 m
Well Radius: 0.1 m

HLV2K ENGINEERING LIMITED

In-Situ Hydraulic Conductivity Test (BH11)

Prepared By:	Prepared For:
HLV2K Engineering	SS Welland Inc.
Project:	**Location:**
2100394AG	Fort Erie, Ontario



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.455E-7 cm/sec y0 = 0.7092 m

AQUIFER DATA

Saturated Thickness: 1.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH11)

Initial Displacement: 0.869 m
Static Water Column Height: 4.91 m
Total Well Penetration Depth: 1.4 m
Screen Length: 1.4 m
Casing Radius: 0.025 m
Well Radius: 0.1 m

HLV2K ENGINEERING LIMITED

APPENDIX D

Information on Water Well Records

Water Well Record

WELL_ID	BOREHOLE ID	Easting	Northing	Well Depth (m)	Static Depth (m)	Bedrock Depth (m)	Date Completed	Final Status
6600144	10459878	668165	4750428	8.2	1.5	5.2	1967-06-28	Water Supply
6600145	10459879	667580	4750771	9.1		7.9	1946-07-10	Water Supply
6600275	10460009	668205	4751243	6.1	2.1	4.6	1961-07-10	Water Supply
6602994	10462616	668220	4751087	13.7	4.6	5.8	1974-08-17	Water Supply
6604421	10464018	667990	4750780	12.8	4.9	0.3	2000-03-20	Water Supply
7247315	1005653589	668182	4750534	4.6			2015-07-07	Observation Wells
7247316	1005653600	668117	4750475	4.3			2015-07-07	Observation Wells
7247317	1005653639	668193	4750512	4.3			2015-07-07	Observation Wells

Water Well Records

November 9, 2021

7:24:06 PM

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
FORT ERIE TOWN (BERT	17 668193 4750512 W	2015-07 7320	2 4	UT 0013		MT	0004 10	7247317 (Z214185) A187875	BRWN CLAY 0014 GREY ROCK
FORT ERIE TOWN (BERT	17 668117 4750475 W	2015-07 7320	2 4	UT 0013		MT	0004 10	7247316 (Z214186) A187874	BRWN CLAY 0014 GREY ROCK
FORT ERIE TOWN (BERT	17 668182 4750534 W	2015-07 7320	2 4	UT 0004		MT	0005 10	7247315 (Z214187) A187873	BRWN CLAY 0015 GREY ROCK
FORT ERIE TOWN (BERT CR	17 668220 4751087 W	1974-08 3661	6	FR 0044	15/30/5/2:0	DO		6602994 ()	BRWN CLAY 0019 GREY LMSN 0045
FORT ERIE TOWN (BERT CR	17 668661 4751703 W	1974-06 3640	6 6	UK 0024	5/15/5/1:0	DO		6602964 ()	BRWN LOAM 0001 BRWN CLAY 0010 GREY CLAY 0013 GREY LMSN 0025
FORT ERIE TOWN (BERT CR	17 668205 4751243 W	1961-07 5425	6 6	FR 0018	7/17/4/0:30	DO		6600275 ()	BRWN CLAY 0015 LMSN 0020
FORT ERIE TOWN (BERT CR	17 668165 4750428 W	1967-06 4720	6 6	FR 0027	5/15/20/1:0	DO		6600144 ()	BLUE CLAY 0017 LMSN 0027
FORT ERIE TOWN (BERT CR	17 668694 4751377 W	1957-07 5425	6 6	FR 0023	10/48/2/:	DO		6600032 ()	LOAM 0001 BRWN CLAY 0014 LMSN 0048
FORT ERIE TOWN (BERT LEF 02 001	17 667990 4750780 L	2000-03 4795	5 5	FR 0040	16/16/21/1:30	DO		6604421 (211395)	BLCK LOAM PCKD 0001 GREY SHLE LYRD 0016 GREY LMSN LYRD 0042
FORT ERIE TOWN (BERT LEF 02 002	17 667580 4750771 L	1946-07 4629	6	SU 0018	///:	DO		6600146 ()	LOAM 0024 LMSN 0030
FORT ERIE TOWN (BERT LEF 02 002	17 667580 4750771 L	1946-07 4629	6 6	FR 0010	///:	DO		6600145 ()	LOAM 0026 LMSN 0030
FORT ERIE TOWN (BERT LEF 03 001	17 668139 4751669 W	2015-06 7295	1.29			MO	0015 5	7244895 (Z204805) A179624	GREY GRVL GREY CLAY

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

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

1. Core Material and Descriptive terms

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

2. Core Color

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

3. Well Use

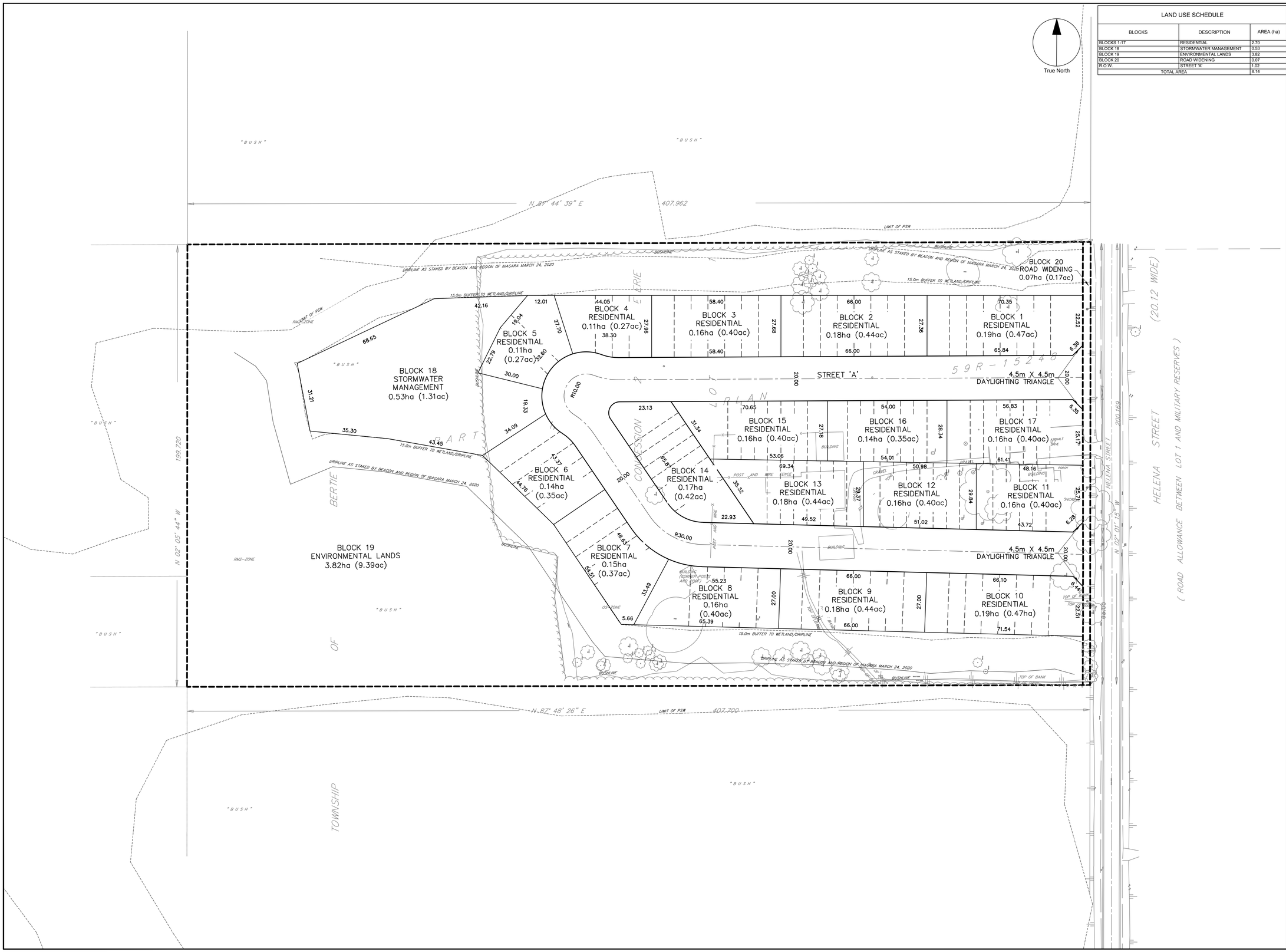
Code	Description	Code	Description
DO	Domestic	OT	Other
ST	Livestock	TH	Test Hole
IR	Irrigation	DE	Dewatering
IN	Industrial	MO	Monitoring
CO	Commercial	MT	Monitoring TestHole
MN	Municipal		
PS	Public		
AC	Cooling And A/C		
NU	Not Used		

4. Water Detail

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

APPENDIX E

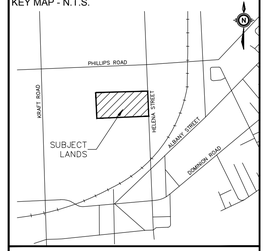
Drawing Provided by the Client



DRAFT PLAN OF SUBDIVISION 613 HELENA STREET

PART OF LOT 1, CONCESSION 2,
LAKE ERIE TOWNSHIP OF BERTIE
IN THE TOWN OF FORT ERIE
REGIONAL MUNICIPALITY OF NIAGARA

KEY MAP - N.T.S.



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
(e) - AS SHOWN
(f) - AS SHOWN
(g) - AS SHOWN
(h) - MUNICIPAL (PUBLIC)
(i) - SILTY CLAY
(j) - AS SHOWN
(k) - ALL SERVICES TO BE MADE AVAILABLE
(l) - AS SHOWN

SURVEYOR'S CERTIFICATE

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

SIGNED _____
PHILIP S. SUDA, O.L.S.
SUDA & MALESZYK SURVEYING INC.

DATE _____

OWNER'S CERTIFICATE

I HEREBY CONSENT TO THE FILING OF THIS PLAN BY IBI GROUP, IN DRAFT FORM.

SIGNED _____
MARIO BEVACQUA
1891187 ONTARIO INC.

DATE _____

#	DATE	BY	DESCRIPTION
1			

DRAWING ISSUE RECORD

APPROVALS

IBI GROUP
Suite 200 - 360 James Street North
Hamilton ON L8L 1H5 Canada
tel 905 546 1010 fax 905 546 1011
ibigroup.com

BENCHMARK

SCALE 10 5 0 10 20 30
1:750 (m)

PROJECT NO: 131951

DRAWN BY:	CHECKED BY:
T. NGUYEN	T. TUCKER
PROJECT MGR:	APPROVED BY:
T.TUCKER	

SHEET TITLE
DRAFT PLAN OF SUBDIVISION

SHEET NUMBER	ISSUE
DP 1.0	1

SCALE CHECK 10mm 1 in

File Location: J:\131951_613_Helen\7.0_Production\7.01_Sent-Received\Sent\Client\2021-04-08 - Draft Plan\131951DP 2021-04-08.dwg Last Saved: April 8, 2021, by Tracy Tucker Plotted: Thursday, April 8, 2021 10:39:00 AM by Tracy Tucker

WATER BALANCE ANALYSIS
PROPOSED RESIDENTIAL DEVELOPMENT

613 Helena Street, Fort Erie, Ontario

Prepared for:

SS WELLAND INC.

4080 Confederation Parkway, Unit 701
Mississauga, ON L5B 0G1

Prepared by:

HLV2K ENGINEERING LIMITED
A Consulting Engineers Company

2179 Dunwin Drive, Unit 4
Mississauga, Ontario L5L 1X2

Project No. 2100394AG

February 17, 2022

HLV2K ENGINEERING LIMITED
A Consulting Engineers Company

February 17, 2022 Reference No.: 2100394AG

SS Welland Inc.
4080 Confederation Parkway, Unit 701
Mississauga, ON L5B 0G1
L5B 0G1

Attention: Mr. Hunain Siddiqui
Email: hunain@emrahomes.ca

RE: Hydrogeological Consulting Services for Proposed Development
613 Helena Street, Fort Erie, Ontario

Dear Mr. Siddiqui,

HLV2K Engineering Limited (HLV2K) is pleased to provide the Water Balance Analysis Report for the above-mentioned project. We trust that this information meets your present requirements. If we can be of additional assistance in this regard, please contact this office.

For and on behalf of HLV2K Engineering Limited,

k. Mohamadi

Kourosh Mohammadi, Ph.D., P.Eng.

President and Principal Hydrogeological Engineer

TABLE OF CONTENT

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

HLV2K Engineering Limited (HLV2K) was retained by SS Welland Inc. (the Client) to complete a water balance assessment to evaluate the recharge rate for pre- and post-development conditions at the project site located at 613 Helena Street in Fort Erie, Ontario (the Site). The Site considered for development is approximately 8.15 hectares (ha) in area and is currently occupied by a two-storey residential dwelling and associated garage, a two-storey barn and two storage buildings (The site buildings covered approximately 15% of the total Site area). The western portion of the Site is occupied by a forested area. The Site location is shown on **Figure 1**. This report is intended to provide the water balance analysis for pre and post proposed development.

The proposed development would consist of seventeen blocks (17) blocks including 54 2-storey townhouses, 62 bungalow townhouses, storm pond, landscape, roads and walkways. Draft plan of subdivision shows the location of these blocks and features provided in **Appendix A**.

2 WATER BALANCE

When precipitation (P) occurs, it can either run off (R) through the surface water system, infiltrate (I) to the water table, or evapotranspire (ET) from the earth's surface and vegetation. The sum of R and I is defined as the water surplus (S). When long-term averages of P, R, I, and ET are used, there is no net change in groundwater storage (ST). On a yearly basis, however, there is a potential for small changes in ST.

The annual water budget can be stated as,

$$P = ET + R + I + ST$$

The monthly averages of P and temperature (T) were collected from Environment Canada data. Based on the physiographic setting and proximity to weather stations, the Fort Erie Station (Station ID 6132470) located approximately 2.2 km southwest of the Site chosen as the most representative precipitation and temperature data

Climate Normals are arithmetic calculations of observed climate values over a specified time period and are used to describe the climatic characteristics of a location. Real-time values, such as daily temperature, may be compared to the "climate normal" to compare departures from the "average". The Canadian Climate Normals are calculated based on World Meteorological Organization (WMO) Standards. The WMO considers 30 years sufficient to eliminate year-to-year variations. The most recently published 30-year period from Environment Canada is January 1981 to December 2010.

In addition, the WMO established that normals should be arithmetic means calculated for each month of the year from daily data. To qualify, temperature data, soil temperatures and evaporation must fit the following rule: "If more than 3 consecutive daily values are missing or more than 5 daily values in total in a given month are missing, the monthly mean should not be computed and the year-month mean should be considered missing." This is referred to as the "3/5" rule. For total precipitation, degree-days, and "days with" calculations, no missing days are allowed.

2.1 Thornthwaite Monthly Water-Balance Model

The Thornthwaite water balance (Thornthwaite, 1948; Mather, 1978; 1979) uses an accounting type procedure to analyze the allocation of water among various components of the hydrologic cycle. Inputs to the model are monthly temperature, precipitation and the site latitude. Outputs include monthly potential and actual evapotranspiration, soil moisture storage, soil moisture storage change, surplus, and runoff. For ease of calculation, an Excel spreadsheet was developed. This water balance was prepared according to the "Hydrogeological Assessment Submissions: Conservation Authority Guidelines to Support Development Application (2013).

2.2 Pre-Construction Water Balance

To predict water balance elements the 30-year average weather data was used. The detailed calculations are presented in below sections.

Precipitation (P)

Based on the 30-year average (1981-2010) for the Fort Erie meteorological station, the average precipitation is about 1051.5 mm/year. The monthly precipitation distribution is presented in **Table B.1** of **Appendix B**.

Storage (ST)

Long-term annual change in storage is 0, although there is some variation on a monthly basis. It should be noted that for the topography, soil conditions (silty sand till to sandy silt till) and vegetative cover (moderate to deep rooted crops), the maximum soil moisture storage was estimated at about 250 mm according to Table 3.1 of MECP Stormwater Management Planning and Design Manual (2003).

Evapotranspiration

Calculated potential evapotranspiration (PET) based on the Thornthwaite monthly water balance model is about 607 mm/year, or about 58% of the total precipitation. The actual evapotranspiration is calculated based on a potential evapotranspiration (PET) and soil-moisture-storage withdrawal (SMW). PET is estimated from monthly temperature and is defined as a water loss from a homogeneous, vegetation covered area that never lacks water (Thornthwaite, 1948; Mather, 1978). In Thornthwaite water balance, PET is calculated using Thornthwaite Method (Ponce, 1989). The method is based on an annual temperature efficiency index J, defined as the sum of 12 monthly values of heat index I. Each index I is a function of the mean monthly temperature T, in degrees Celsius, as follows:

$$I = \left(\frac{T}{5}\right)^{1.514}$$

Evapotranspiration is calculated by the following formula:

$$PET(0) = 1.6\left(\frac{10T}{J}\right)^{c}$$

in which PET(0) is the potential evapotranspiration at 0° latitude in centimeters per month; and c is an exponent to be evaluated as follows:

$$c = 0.000000675J^3 - 0.0000771J^2 + 0.01792J + 0.49239$$

At the latitude other than 0° potential evapotranspiration is calculated by

$$PET = K\,PET(0)$$

in which K is a constant for each month of the year, varying as a function of latitude. The latitude for Fort Erie station is 42º 53' and values of K are provided in **Table B.2** in **Appendix B**.

Water Surplus

The overall pre-construction water surplus for study area is estimated at 445 mm/year. Water surplus (S) has two components in Thornthwaite model: a runoff component, which is the overland flow component that occurs when soil moisture capacity is exceeded; and, an infiltration component. Using the MECP SWM manual (MECP, 2003) for guidance, it is estimated that about 50% of the water surplus (222.5 mm/year) infiltrates and the remaining 50% (222.5 mm/year) runs off either directly or as interflow. The details calculation is presented in **Table B.2** in **Appendix B**.

Annual Water Balance

The summary of annual water balance assessment for the pre-construction condition is provided in **Table B.3** in **Appendix B**.

2.3 Post-Construction Water Balance without LID

Based on the proposed Draft Plan provided by the Client (**Appendix A**), **Table 1** below shows a summary of post (proposed) construction land statistics.

Table 1: Post-Construction (Proposed) Land Statistics

Item	Area (m^2)
Total Area	81,500
Paved municipal roadways	10,500
Sidewalks	1,000
Townhouse driveways	2,700
Roofs	9,450
Soft landscaped lot lawns, Boulevards, Park, woodland, Open space, and (excluding SWM Pond)	56250
SWM Pond (30% of Block 18)	8,580

To predict water balance elements, the 30-year average weather data was used. Based on the provided development information, it is our understanding that about 30% of the post construction surface will be considered impervious. Additionally, the Conservation Authority guidelines suggest infiltration will be lowered by 10% (a factor of 0.1) because of site grading and compaction of the soil due to construction

work. However, the soil compaction issue might be resolved by increasing the topsoil depth to 300 mm. **Table B.4** in **Appendix B** presents the components of post construction water balance.

Precipitation (P)

Precipitation remains the same, the 30-year average (1981-2010) for the Fort Erie meteorological station (1051.5 mm/year) was used.

Storage (ST)

Long-term change in storage is 0. It should be noted that compared to pre-construction, there is a change in the distribution and magnitude of monthly soil moisture storage. It is assumed that development of the land will result in reduced grades that, with the same soil conditions (clayey silt to sandy silt till) and changed vegetative cover (shallow rooted lawns and gardens), will reduce the maximum soil moisture storage to 125 mm.

Evapotranspiration

In post construction, it was assumed that the increased impervious area would result in an additional 20% in potential evaporation from the areas covered with hard surfaces. The total water lost to evaporation increases, but the PET for pervious areas, calculated at 607 mm/year, remains about the same.

Water Surplus

The post-construction water surplus for the entire Site is calculated to be about 1,286 mm/year. Of this, about 707 mm/year will be converted to runoff on impervious areas and 579 mm/year will be available for infiltration or runoff on pervious areas in post-development condition. This exceeds the infiltration potential for the surficial soils, thus a component of the available infiltration water will also run off.

The results of the post construction water balance calculation suggest that there is enough water to maintain recharge, as there is a positive surplus (S) in the post construction scenario.

The major change between the pre- and post-construction water balance is that in the pre-construction setting, most of the water surplus is carried off the site as interflow and infiltration, whereas in the post construction setting, there is more interflow and overland flow. **Table B.5** in **Appendix B** shows that the volume of runoff will be increased from 25,551 m^3/year in pre-development to 32,287 m^3/year. The post-development infiltration volume is approximately 13,761 m^3/year which is almost 89% of the pre-development, if no mitigation measure is implemented and 30% of the site surface is converted to impervious surface.

2.4 Post-Construction Water Balance with LID

To assess the potential impacts of the proposed development on groundwater resources, the draft development plan was reviewed.

Table B.6 in **Appendix B** presents the overall post construction water balance with mitigation measures.

Post development infiltration and runoff rates will be affected by the presence of impervious surfaces (i.e. building/garage rooftops, asphalt driveways and road), which based on the proposed development plan will comprise approximately 30% of the development property. The results of the post-construction water balance assessment without LID measures (**Table B.5** in **Appendix B**) show that there will be enough water to infiltrate in the pervious areas to increase the infiltration rate and reduce the runoff in post-

construction development. Techniques to maximize the water availability in pervious areas such as designing grades to direct roof runoff towards lawns, side and rear yard swales, and other pervious areas throughout the development where possible can considerably increase the volume of infiltration in developed areas. Increasing the topsoil thickness by about two times the normal thickness is also considered as beneficial to enhance storage of water in the topsoil and increase the potential for infiltration. Other mitigation techniques that can be considered to mitigate increases in runoff and reductions in infiltration include such measures as subsurface infiltration trenches, permeable pavements, rain gardens, bioswales, galleries and pervious pipe systems. Surface methods should only be considered in areas where there is sufficient depth to water table to accommodate the systems within the unsaturated zone and sufficient soil hydraulic conductivity to function effectively. The MECP manual recommends that subsurface galleries or trenches should be about 1 m above the high water table.

The proposed LID measures for the Site would be the disconnected roof leaders to convey the rainwater from roofs to the permeable areas around the residential houses and increase the chance of infiltration.

It was considered that LID measures would be designed to infiltrate the 25 mm storm event or less which accounts for approximately 90% of precipitation. The estimated infiltration rate for the roof rainfall, then, calculated based on the followings:

- 20% of the rainfall on impervious surface (roofs) was assumed to be evaporated. It means there is 80% or 841 mm surplus.
- 90% of the rainfall event is 25 mm or less. Only 90% of the surplus was considered for infiltration (757.1 mm).
- The estimated infiltration rate on pervious areas is 45% in post-construction condition (MECP Guideline, 2003). The total infiltration rate from roof rains would be 341 mm or 32.4% of the precipitation.

Natural infiltration that occurs on pervious surfaces along with the proposed mitigative measures exceed the pre-development infiltration volume by approximately 1,524 m^3/year. The runoff volume also exceeds the pre-development runoff volume by approximately 3,728 m^3/year.

In this condition, the total infiltration volume will be 16,980 m^3/year and total runoff volume in the post-construction will be changed to 29,279 m^3/year. **Table 2** below summarizes the post-construction water balance for reducing the runoff and increasing infiltration using LID measures.

Table 2: Post -Construction Water Balance Summary

Parameter	Value
Average Annual Rainfall (mm)	1,051.5
Pre- Development Infiltration (m^3/year)	15,457
Post-Development Infiltration without Mitigation (m^3/year)	13,761
Post-Development Infiltration with Mitigation (m^3/year)	16,980
Pre- and Post-Development Infiltration Differential (%)	+10%

3 IMPACT ASSESSMENT

To assess the potential impacts of the proposed development on groundwater resources, the draft development plan was reviewed. From a hydrogeological perspective, the following changes will occur as a result of the proposed development.

- The subject site is characteristically homogeneous with respect to soil types at ground surface. There is a shallow overburden with approximate thickness of 5 to 6 m above bedrock.
- The development will create new hard surfaces over a portion of the site, increasing the impervious area. The amount of impervious areas is estimated to be about 30%.
- As a result of the increase in impervious area, the overall infiltration will decrease and the amount of overland flow runoff will increase, particularly during storm events. Runoff will be managed using conventional storm water management techniques or Low Impact Development (LID) that include storm water management (SWM) facilities.
- With the inevitable changes in impervious areas and potential changes to groundwater quality and quantity, best management practices (BMPs) that promote groundwater infiltration/recharge for the purpose of trying to establish post-development infiltration at pre-development levels makes a significant contribution to mitigate the effects of development. Some of the recommended practices includes:
  - Disconnected roof leaders to convey the rainwater from roofs to the permeable areas around the residential houses and increase the chance of infiltration. The discharge of residential roof drainage to unpaved parts of the lots and grass areas for natural infiltration can be an effective means of helping to balance pre to post development infiltration deficit. Using the roof-tops rainwater can also preserve the groundwater quality. The location of these facilities and the function/operation are addressed by others.
- Although, the increase in impervious area can potentially result in a slight lowering of shallow groundwater levels, maintaining infiltration at levels similar to existing conditions will result water levels within the current range of seasonal fluctuations. No change in the overall flow direction is expected. However, in localized areas some temporary lowering of the water table may be needed to facilitate construction below the water table, if required.
- The contribution of groundwater can be an important factor in the overall health of aquatic systems. Implementing mitigation measures to reduce the infiltration deficit will assist in maintaining the current level of groundwater contribution to the surface water features. As such, no negative impact is expected if LID measures are implemented to maintain the groundwater recharge similar to the existing conditions.

4 STATEMENT OF LIMITATIONS

The contents of this report are subject to the attached '***Statement of Limitation***' sheet. The reader's attention is specifically drawn to these conditions as it is considered essential that they be followed for proper use and interpretation of this report. The Statement of Limitations is not intended to reduce the level of responsibility accepted by Orbit, but rather to ensure that all parties who have been given reliance for this report are aware of the responsibilities each assumes in so doing.

This report was prepared by HLV2K exclusively for the account of SS Welland Inc. (the CLIENT). Other than by the CLIENT, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, or decision made by any person other than CLIENT based on this report is the sole responsibility of such other person. The CLIENT and Orbit make no representation or warranty to any other person with regard to this report and the work referred to in this report and the CLIENT and Orbit accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made or any action taken based on this report or the work referred to in this report.

5 CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact this office.

For and Behalf of HLV2K Engineering Limited

k. Mohamadi

Kourosh Mohammadi, PhD., P.Eng.

Principal Hydrogeological Engineer and Groundwater Modeller

REFERENCES

Conservation Authority (2013). Hydrogeological Assessment Submissions: Conservation Authority Guideline to Support Development Applications.

Environment Canada (2017) Canadian National Climate Archive, Canadian Climate Norms and Averages (1981 – 2010), Fort Erie – Station ID 6132470 – Website: https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnProx&txtRadius=25&selCity=&selPark=&optProxType=custom&txtCentralLatDeg=42&txtCentralLatMin=53&txtCentralLatSec=0&txtCentralLongDeg=78&txtCentralLongMin=56&txtCentralLongSec=0&txtLatDecDeg=&txtLongDecDeg=&stnID=4635&dispBack=0

HLV2K Engineering Limited. (2021). Hydrogeological Investigation for Proposed Development at 613 Helena Street, Fort Erie, Ontario, Project Number 2100394AG, dated November 2021.

Mather, J. R., 1978. The Climatic Water Budget in Environmental Analysis. Lexington, Mass.: Lexington Books.

MECP (2003). Stormwater Management Planning and Design Manual, Ontario Ministry of Environment, 379p.

HLV2K Engineering Limited

STATEMENT OF LIMITATIONS

Your report has been developed based on your unique project specific requirements as understood by HLV2K Engineering Limited (HLV2K) and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking HLV2K to assess how factors that changed subsequent to the date of the report affect the report's recommendations. HLV2K cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions, which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult HLV2K to be advised how time may have impacted on the project.

The findings derived from this investigation were based on information collected and/or provided by the Client. It may become apparent that soil and groundwater conditions differ between and beyond the testing locations examined during future investigations or other work that could not be detected or anticipated at the time of this study. As such, HLV2K cannot be held liable for environmental conditions that were not apparent from the available information. The conclusions presented represent the best judgment of the assessors based on limited investigations.

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature, external data source review, sampling, and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions, which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of HLV2K through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report is based on the assumption that he site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only HLV2K, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and HLV2K cannot be held responsible for such misinterpretation.

To avoid misuse of the information contained in your report it is recommended that you confer with HLV2K before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

HLV2K Engineering Limited

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain HLV2K to work with other project design professionals who are affected by the report. Have HLV2K explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.

Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact HLV2K for information relating to geoenvironmental issues.

HLV2K is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with HLV2K to develop alternative approaches to problems that may be of genuine benefit both in time and in cost.

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from HLV2K to other parties but are included to identify where HLV2K's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from HLV2K closely and do not hesitate to ask any questions you may have.

Third party information reviewed and used to formulate this report is assumed to be complete and correct. HLV2K used this information in good faith and will not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.

Nothing in this report is intended to constitute or provide a legal opinion.

Should additional information become available, HLV2K requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

FIGURES

Legend

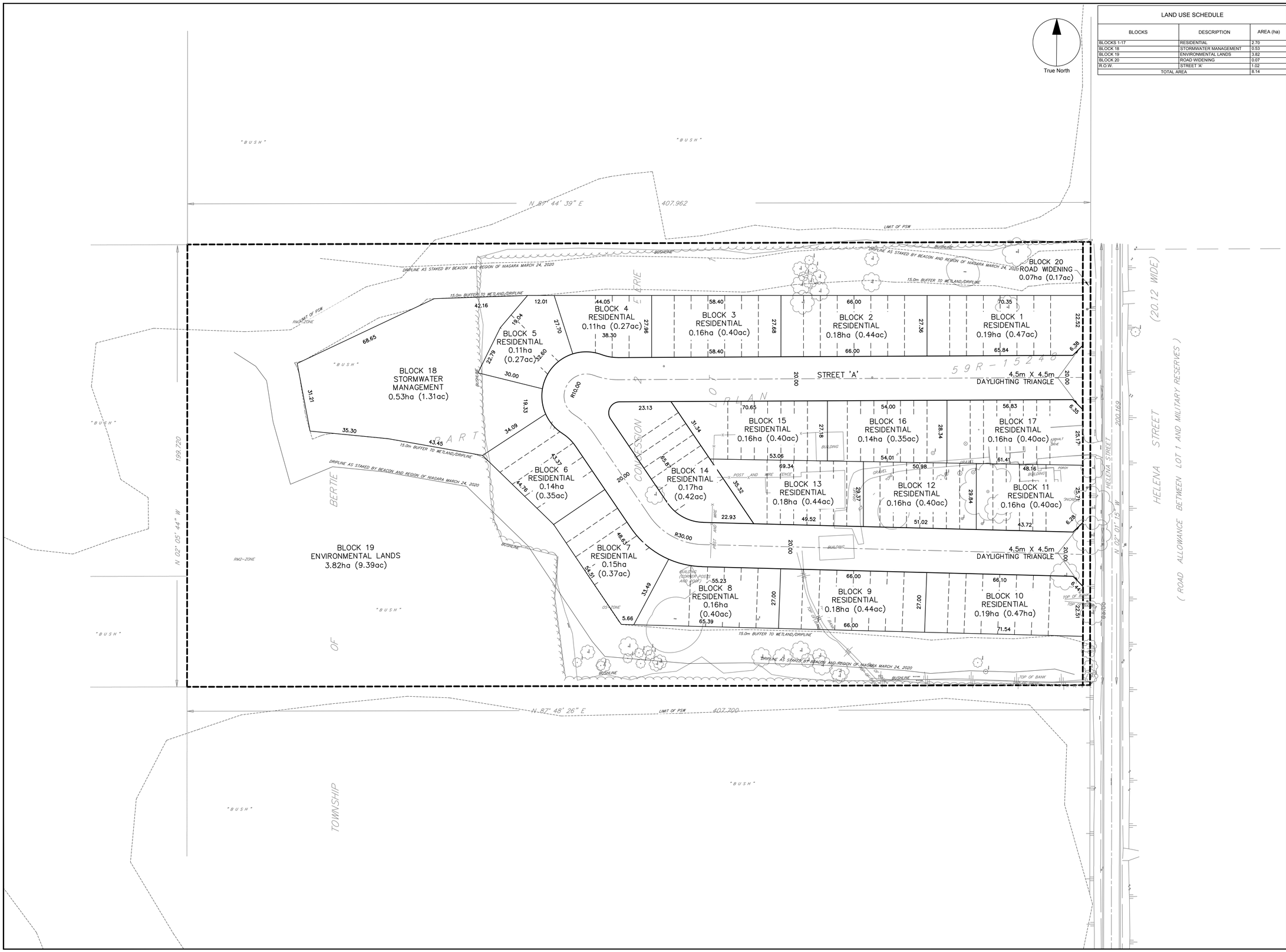
Approx. Site Boundary

Drawn: MM	Title: SITE LOCATION PLAN
Approved: KM	Project: WATER BALANCE STUDY Proposed Residential Development 613 Helena Street, Fort Erie, Ontario
Date: NOV. 2021	
Project No.: 2100394AG	
	Client: SS WELLAND INC.
HLV2K ENGINEERING LIMITED	0 125 250 500 Meters

FIGURE 1

APPENDIX A

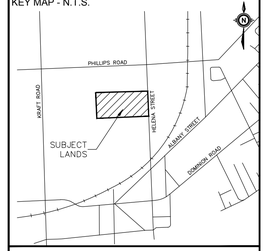
Drawing Provided by the Client



DRAFT PLAN OF SUBDIVISION 613 HELENA STREET

PART OF LOT 1, CONCESSION 2,
LAKE ERIE TOWNSHIP OF BERTIE
IN THE TOWN OF FORT ERIE
REGIONAL MUNICIPALITY OF NIAGARA

KEY MAP - N.T.S.



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
(e) - AS SHOWN
(f) - AS SHOWN
(g) - AS SHOWN
(h) - MUNICIPAL (PUBLIC)
(i) - SILTY CLAY
(j) - AS SHOWN
(k) - ALL SERVICES TO BE MADE AVAILABLE
(l) - AS SHOWN

SURVEYOR'S CERTIFICATE

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

SIGNED _____
PHILIP S. SUDA, O.L.S.
SUDA & MALESZYK SURVEYING INC.

DATE _____

OWNER'S CERTIFICATE

I HEREBY CONSENT TO THE FILING OF THIS PLAN BY IBI GROUP, IN DRAFT FORM.

SIGNED _____
MARIO BEVACQUA
1891187 ONTARIO INC.

DATE _____

#	DATE	BY	DESCRIPTION
1			

DRAWING ISSUE RECORD

APPROVALS

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BENCHMARK

SCALE 10 5 0 10 20 30
1:750 (m)

PROJECT NO: 131951

DRAWN BY:	CHECKED BY:
T. NGUYEN	T. TUCKER
PROJECT MGR:	APPROVED BY:
T.TUCKER	

SHEET TITLE
DRAFT PLAN OF SUBDIVISION

SHEET NUMBER	ISSUE
DP 1.0	1

SCALE CHECK 10mm 1 in

File Location: J:\131951_613_Helen\7.0_Production\7.01_Sent-Received\Sent\Client\2021-04-08 - Draft Plan\131951DP 2021-04-08.dwg Last Saved: April 8, 2021, by Tracy Tucker Plotted: Thursday, April 8, 2021 10:39:00 AM by Tracy Tucker

APPENDIX B

Water Balance Tables

TABLE B.1 - Climate Data

Fort Erie Station, Ontario

Latitude: 42°53' N Longitude: 79°58' W Elevation: 179.80 m

Temperature: Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-4.1	-3.3	0.4	6.6	12.7	18.1	21.2	20.6	16.7	10.4	4.9	-0.8	8.6
Rainfall (mm)	34.2	32.8	44.7	74.4	92.3	81.7	84.7	88.5	105.4	95.3	89.9	52.5	876.4
Snowfall (mm)	44.7	33.8	26.3	4.4	0.9	0.0	0.0	0.0	0.0	1.4	12.9	50.7	175.1
Precipitation (mm)	78.9	66.6	71.0	78.8	93.2	81.7	84.7	88.5	105.4	96.7	102.8	103.2	1051.5

TABLE B.2

Pre- and Post-Development Water Balance Components
Based on Thornthwaite's Soil Moisture Balance Approach

Potential Evapotranspiration Calculation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Davily Average Temperature (^{o}C)	-4	-3	0	7	13	18	21	21	17	10	5	-1	9
Heat index: i = $(t/5)^{1.514}$	0.00	0.00	0.02	1.52	4.10	7.01	8.91	8.53	6.21	3.03	0.97	0.00	**40.3**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	27.94	58.53	87.36	104.44	101.11	79.76	46.70	19.95	0.00	**526**
Adjusting Factor K for U (Latitude 42^{o} 53' N)	0.77	0.88	0.99	1.11	1.22	1.28	1.26	1.17	1.05	0.92	0.81	0.75	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	31	72	112	131	118	83	43	16	0	**607**
PRE-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	79	67	71	79	93	82	85	89	105	97	103	103	1052
Potential Evapotranspiration (PET)	0	0	0	31	72	112	131	118	83	43	16	0	607
P - PET	79	67	71	48	22	-30	-47	-30	22	54	87	103	445
Change in Soil Moisture Storage	0	0	0	0	0	-30	-47	-30	22	54	31	0	**0**
Soil Moisture Storage (Assume January Soil Moisture Storage = 100% SMS)	250	250	250	250	250	220	173	143	165	219	250	250	
Actual Evapotranspiration (AET)	0	0	0	31	72	112	131	118	83	43	16	0	607
Soil Moisture Deficit (in mm)	0	0	0	0	0	30	77	107	85	31	0	0	
Surplus - available for infiltration or runoff	79	67	71	48	22	0	0	0	0	0	56	103	**445**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	39.5	33.3	35.5	23.9	10.8	0.0	0.0	0.0	0.0	0.0	27.9	51.6	222
Potential Surface Water Runoff (independent of temperature)	39.5	33.3	35.5	23.9	10.8	0.0	0.0	0.0	0.0	0.0	27.9	51.6	222
POST- DEVELOPMENT WATER BALANCE ON IMPERVIOUS AREAS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	79	67	71	79	93	82	85	89	105	97	103	103	1052
Potential Evaporation (PE) from impervious areas (assume 20%)	15.8	13.3	14.2	15.8	18.6	16.3	16.9	17.7	21.1	19.3	20.6	20.6	210
P-PE (surplus available from impervious areas)	63	53	57	63	75	65	68	71	84	77	82	83	841
Water surplus change compared to pre-condition (for areas that change from vegetated open areas to impervious areas)	-16	-13	-14	15	53	65	68	71	84	77	27	-21	396

Soil Moisture Storage	250
PE from impervious areas %	20

*MOE SWM infiltration factor calculation	
topography - Flat aland, average slope <0.6 m/km	0.3
soils - relatively tight silty clay till materials	0.1
cover - predominantly cultivated land	0.1
Infiltration Factor	0.5

TABLE B.3 - Annual Pre-Construction Water Balance

	Pre-Construction		
	Unpaved Areas	Impervious Areas (building)	Totals
Area	69500	12000	81500
Pervious Area	69500	0	69500
Impervious Area	0	12000	12000
Infiltration Factors			
Topography Infiltration Factor	0.3	0	
Soil Infiltration Factor	0.1	0	
Land Cover Infiltration Factor	0.1	0	
MOE Infiltration Factor	0.5	0	
Actual Infiltration Factor	0.5	0	
Runoff Coefficient Pervious Surfaces	0.5	1	
Runoff from Impervious Surfaces*	0	0.8	
Inputs (per Unit Area)			
Precipitation (mm/yr)	1052	1052	1052
Run-On (mm/yr)	0	0	0
Other Inputs (mm/yr)	0	0	0
Total Inputs (mm/yr)	1052	1052	1052
Outputs (per Unit Area)			
Precipitation Surplus (mm/yr)	445	841	503
Net Surplus (mm/yr)	445	841	503
Evapotranspiration (mm/yr)	607	210	548
Infiltration (mm/yr)	222	0	190
Rooftop Infiltration (mm/yr)	0	0	0
Total Infiltration (mm/yr)	222	0	190
Runoff Pervious Areas	222	0	190
Runoff Impervious Areas	0	841	124
Total Runoff (mm/yr)	222	841	314
Total Outputs (mm/yr)	1052	1052	853
Difference (Inputs - Outputs)	0	0	
Inputs (Volumes)			
Precipitation (m3/yr)	73079	12618	85697
Run-On (m3/yr)	0	0	0
Other Inputs (m3/yr)	0	0	0
Total Inputs (m3/yr)	73079	12618.0	85697
Outputs (Volumes)			
Precipitation Surplus (m3/yr)	30913	10094	41008
Net Surplus (m3/yr)	30913	10094	41008
Evapotranspiration (m3/yr)	42166	2524	44689
Infiltration (m3/yr)	15457	0	15457
Rooftop Infiltration (m3/yr)	0	0	0
Total Infiltration (m3/yr)	15457	0	**15457**
Runoff Pervious Area (m3/yr)	15457	0	15457
Runoff Impervious Areas (m3/yr)	0	10094	10094
Total Runoff (m3/yr)	15457	10094	**25551**
Total Outputs (m3/yr)	73079	12618	85697
Difference (Inputs - Outputs)	0	0	0

* Evaporation from impervious areas was assumed to be 20% of precipitation

TABLE B.4 - WATER BALANCE COMPONENTS FOR CASE WHERE RUNOFF IS DIRECTED TO PERVIOUS AREAS

POTENTIAL EVAPOTRANSPIRATION CALCULATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average Temperature (^{o} C)	-4.1	-3.3	0.4	6.6	12.7	18.1	21.2	20.6	16.7	10.4	4.9	-0.8	8.6
Heat index: i = $(t/5)^{1.514}$	0.00	0.00	0.02	1.52	4.10	7.01	8.91	8.53	6.21	3.03	0.97	0.00	**40.3**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	27.94	58.53	87.36	104.44	101.11	79.76	46.70	19.95	0.00	**526**
Adjusting Factor K for U (Latitude 42o 53' N)	0.77	0.88	0.99	1.11	1.22	1.28	1.26	1.17	1.05	0.92	0.81	0.75	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	31	72	112	131	118	83	43	16	0	**607**
POST-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Pervious areas will receive rainfall plus some runoff from impervious areas, so the following balance calculations use this total water supply to assess potential infiltration.													
Precipitation (P)	79	67	71	79	93	82	85	89	105	97	103	103	1052
Potential Evaporation (PE) from impervious areas (assume 20% of P)	16	13	14	16	19	16	17	18	21	19	21	21	210
P-PE (surplus available for runoff from impervious areas)	63	53	57	63	75	65	68	71	84	77	82	83	**841**
WAT (Total water supply to pervious areas = rain plus impervious area runoff)	142	120	128	142	168	147	152	159	190	174	185	186	**1893**
Potential Evapotranspiration from pervious areas (PET)	0	0	0	31	72	112	131	118	83	43	16	0	**607**
WAT - PET	142	120	128	111	96	35	21	41	106	131	169	186	**1286**
Change in Soil Moisture (mm)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Soil Moisture Storage (mm)*	125	125	125	125	125	125	125	125	125	125	125	125	
Actual Evapotranspiration (AET)	0	0	0	31	72	112	131	118	83	43	16	0	**607**
Total surplus - available for infiltration or runoff on pervious areas	142	120	128	111	96	35	21	41	106	131	169	186	**1286**
Estimate of I and R (based on MOE infiltration factor)*													
Potential Infiltration* (based on soil conditions; independent of temperature)	63.9	53.9	57.5	49.9	43.3	15.8	9.4	18.6	47.8	59.0	76.0	83.6	**579**
Potential Surface Water Runoff (independent of temperature)	78.1	65.9	70.3	60.9	52.9	19.3	11.5	22.7	58.5	72.1	92.9	102.2	**707**
Estimate of I and R (based on MOE Factors and CA Guideline assumption of a 10% reduction in infiltration reduction related to soil compaction)													
Potential Infiltration (based on soil conditions; independent of temperature)	57.5	48.6	51.8	44.9	38.9	14.2	8.5	16.7	43.1	53.1	68.4	75.2	**521**
Potential Surface Water Runoff (independent of temperature)	84.5	71.3	76.0	65.9	57.2	20.9	12.5	24.6	63.3	78.0	100.5	110.5	**765**

Max SMS	125
PE from impervious areas %	20

*MOE SWM infiltration factor calculation	
topography - flat to rolling	0.25
soils - tight sandy to clayey silt till	0.1
cover - predominantly impervious paved surface	0.1
Infiltration Factor	0.45

TABLE B.5 - Annual Post-Construction Water Balance without LID

	Unpaved Areas	Impervious Areas (Paved/Buildings)	Water (Pond)	Totals
Area	56250	23650	1600	81500
Pervious Area	56250	0	0	56250
Impervious Area	0	23650	1600	25250
Infiltration Factors				
Topography Infiltration Factor	0.25	0	0	
Soil Infiltration Factor	0.1	0	0	
Land Cover Infiltration Factor	0.1	0	0	
MOE Infiltration Factor	0.45	0	0	
Actual Infiltration Factor	0.55	0	0	
Runoff Coefficient Pervious Surfaces	0.45	1	1	
Runoff from Impervious Surfaces*	0	0.8	0.8	
Inputs (per Unit Area)				
Precipitation (mm/yr)	1052	1052	886	1052
Run-On (mm/yr)	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0
Total Inputs (mm/yr)	1052	1052	886	1052
Outputs (per Unit Area)				
Precipitation Surplus (mm/yr)	445	841	841	568
Net Surplus (mm/yr)	445	841	841	568
Evapotranspiration (mm/yr)	607	210	177	483
Infiltration (mm/yr)	245	0	0	169
Rooftop Infiltration (mm/yr)	0	0	0	0
Total Infiltration (mm/yr)	245	0	0	169
Runoff Pervious Areas	200	0	0	138
Runoff Impervious Areas	0	841	709	258
Total Runoff (mm/yr)	200	841	709	396
Total Outputs (mm/yr)	1052	1052	886	1048
Difference (Inputs - Outputs)	0	0	0	
Inputs (Volumes)				
Precipitation (m3/yr)	59147	24868	1418	85432
Run-On (m3/yr)	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0
Total Inputs (m3/yr)	59147	24868	1418	85432
Outputs (Volumes)				
Precipitation Surplus (m3/yr)	25020	19894	1346	46260
Net Surplus (m3/yr)	25020	19894	1346	46260
Evapotranspiration (m3/yr)	34127	4974	284	39384
Infiltration (m3/yr)	13761	0	0	13761
Rooftop Infiltration (m3/yr)	0	0	0	0
Total Infiltration (m3/yr)	13761	0	0	**13761**
Runoff Pervious Area (m3/yr)	11259	0	0	11259
Runoff Impervious Areas (m3/yr)	0	19894	1134	21028
Total Runoff (m3/yr)	11259	19894	1134	**32287**
Total Outputs (m3/yr)	59147	24868	1418	85432
Difference (Inputs - Outputs)	0	0	0	0

* Evaporation from impervious areas was assumed to be 20% of precipitation

TABLE B.6 - Annual Post-Construction Water Balance with LID

	Unpaved Areas (Landscape/ Permeable Pavements)	Impervious Areas (Roads/Buildings)	Buildings with LID (Rooftop Rain)	Water	Totals
Area	56250	14200	9450	1600	81500
Pervious Area	56250	0	0	0	56250
Impervious Area	0	14200	9450	1600	25250
Infiltration Factors					
Topography Infiltration Factor	0.25	0	0	0	
Soil Infiltration Factor	0.1	0	0	0	
Land Cover Infiltration Factor	0.1	0	0	0	
MOE Infiltration Factor	0.45	0	0	0	
Actual Infiltration Factor	0.55	0	0	0	
Runoff Coeffcient Pervious Surfaces	0.45	1	1	1	
Runoff from Impervious Surfaces*	0	0.8	0.8	0.8	
Inputs (per Unit Area)					
Perecipitation (mm/yr)	1052	1052	1052	1052	1052
Run-On (mm/yr)	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0
Total Inputs (mm/yr)	1052	1052	1052	1052	1052
Outputs (per Unit Area)					
Precipitation Surplus (mm/yr)	445	841	841	841	568
Net Surplus (mm/yr)	445	841	841	841	568
Evapotranspiration (mm/yr)	607	210	210	210	484
Infiltration (mm/yr)	245	0	0	0	169
LID (mm/yr)	0	0	341	0	40
Total Infiltration (mm/yr)	245	0	341	0	208
Runoff Pervious Areas	200	0	0	0	138
Runoff Impervious Areas	0	841	501	841	221
Total Runoff (mm/yr)	200	841	501	841	359
Total Outputs (mm/yr)	1052	1052	1052	1052	1052
Difference (Inputs - Outputs)	0	0	0		
Inputs (Volumes)					
Precipitation (m3/yr)	59147	14931	9937	1682	85697
Run-On (m3/yr)	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0
Total Inputs (m3/yr)	59147	14931	9937	1682	85697
Outputs (Volumes)					
Precipitation Surplus (m3/yr)	25020	11945	7949	1346	46260
Net Surplus (m3/yr)	25020	11945	7949	1346	46260
Evapotranspiration (m3/yr)	34127	2986	1987	336	39437
Infiltration (m3/yr)	13761	0	0	0	13761
Rooftop Infiltration/Other LID (m3/yr)	0	0	3219	0	3219
Total Infiltration (m3/yr)	13761	0	3219	0	**16980**
Runoff Pervious Area (m3/yr)	11259	0	0	0	11259
Runoff Impervious Areas (m3/yr)	0	11945	4730	1346	18021
Total Runoff (m3/yr)	11259	11945	4730	1346	**29279**
Total Outputs (m3/yr)	59147	14931	9936	1682	85696
Difference (Inputs - Outputs)	0	0	0	0	1

* Evaporation from impervious areas was assumed to be 20% of precipitation