SOIL-MAT ENGINEERS & CONSULTANTS LTD.
401 Grays Road · Hamilton, ON · L8E 2Z3
www.soil-mat.ca ✉ info@soil-mat.ca ☎ 905.318.7440 / 800.243.1922 (*toll free*) 905.318.7455

PROJECT NO.: SM 230882-G February 13, 2024

BSF COMMUNITIES INC.
3340 Schmon Parkway
Thorold, Ontario
L2V 4Y6

Attention: Jillian Richards
Planner, Project Manager

PRELIMINARY GEOTECHNICAL INVESTIGATION AND HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL DEVELOPMENT
450 RICE ROAD
WELLAND, ONTARIO

Dear Ms. Richards,

Further to your authorisation, SOIL-MAT ENGINEERS & CONSULTANTS LTD. has completed the fieldwork, and report preparation in connection with the above noted project. The scope of work was completed in general accordance with our proposal P230882, dated November 1, 2023. Our comments and recommendations based on our findings at the five [5] borehole locations are presented in the following paragraphs.

1. INTRODUCTION

We understand that the project will involve the construction of a residential development on the vacant parcel located at 450 Rice Road in Welland, Ontario. It is understood that the development would include the construction of typical townhouses with full basement levels, along with the associated servicing, and asphalt surfaced roadways. The purpose of this investigation work is to assess the site subsurface soil and groundwater conditions, and to provide our comments and recommendations with respect to the design and construction of the proposed development, from a geotechnical point of view.

This report is based on the above summarised project description, and on the assumption that the design and construction will be performed in accordance with applicable codes and standards. Any significant deviations from the proposed project design may void the recommendations given in this report. If significant changes are made to the proposed design, this office must be consulted to review the new design with respect to the results of this investigation.

2. PROCEDURE

A total of five [5] sampled boreholes were advanced at the locations illustrated in the attached Drawing No. 1, Borehole Location Plan. The boreholes were advanced using continuous flight power auger equipment on November 29, 2023 under the direction and supervision of a staff member of SOIL-MAT ENGINEERS & CONSULTANTS LTD., to termination depths of approximately 6.7 metres below the existing ground surface.

Representative samples of the subsoils were recovered from the borings at selected depth intervals using split barrel sampling equipment driven in accordance with the requirements of ASTM test specification D1586, Standard Penetration Resistance Testing. After undergoing a general field examination, the soil samples were preserved and transported to the SOIL-MAT laboratory for visual, tactile, and olfactory classifications. Routine moisture content tests were preformed on all soil samples recovered from borings.

Groundwater observations were made during the drilling operations. Monitoring wells were installed at Borehole Nos 2, 4, and 5 to allow for future measurements of the ground water level. The monitoring wells consisted of 50-millimetre diameter PVC pipe, screened in the lower 1.5 metres. The wells were encased in well filter sand up to approximately 0.3 metres above the screened portion, then a bentonite ‘hole plug’ was installed up to the surface, and fitted with a protective steel ‘stick-up’ casing. Upon completion of drilling, the boreholes were backfilled in general accordance with Ontario Regulation 903, and the ground surface was reinstated even with the surrounding grade.

The boreholes were located in the field by representatives of SOIL-MAT ENGINEERS, based on accessibility over the site and clearance of underground utilities. The ground surface elevation at the borehole locations have been referenced to a site-specific temporary benchmark, described at the base of the hydro pole located on the east side of Rice Road. This temporary benchmark was assigned an assumed elevation of 100.00 metres for convenience.

Details of the conditions encountered in the boreholes, together with the results of the field and laboratory tests are in Log of Boreholes Nos. 1 to 5 inclusive following the text of this report. It is noted that the boundaries of soil types indicated on the borehole logs are inferred from non-continuous soil sampling and observations made during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and therefore should not be construed at the exact depths of geological change.

3. SITE DESCRIPTION AND SUBSURFACE CONDITIONS

The subject site is located at 450 Rice Road in Welland, Ontario and consists predominantly of agricultural land. The property is bounded by residential properties to the north and south, to the east by agricultural lands land and to the west by Rice Road. The overall topography of the site is generally flat and even as observed in the boreholes. A drainage swale was noted in the northern portion of the site.

The subsurface conditions encountered at the borehole locations are summarized as follows:

Topsoil

A surficial veneer of topsoil approximately 300 millimetres in thickness was encountered at all borehole locations. It is noted that the depth of topsoil may vary across the site and from the depths encountered at the borehole locations. It is also noted that the term ‘topsoil’ has been used from a geotechnical point of view and does not necessarily reflect its nutrient content or its ability to support plant life. As such, it is recommended that a conservative approach be taken when estimating topsoil quantities across the site.

Silty Clay/Clayey Silt

Native silty clay/clayey silt was encountered beneath the topsoil layer at all borehole locations. The cohesive material was brown in colour, transitioning to grey in the lower levels, containing occasional clay and silt seams. The native silty clay/clayey silt was generally firm to very stiff in consistency, and proven to termination at depths below the existing ground surface of 4.6 metres at the location of Borehole No. 1, and to 6.7 metres at all remaining borehole locations.

Sandy Silt

Native sandy silt was encountered beneath the silty clay/clayey silt layer at Borehole No. 1. The granular material was grey in colour, generally compact to dense, and proven to the termination depth of Borehole No. 1 at 6.7 metres below the existing ground surface.

A review of available published information [Quaternary Geology of Ontario, Southern Sheet Map 2556] indicate the subsurface soils consist of fine-textured glaciolacustrine deposits consisting of silt and clay with minor sand and gravel. This is consistent with our observations on site and experience in the area.

Laboratory Soil Classification

As noted above, grain size analyses were conducted on two selected samples of the native soils encountered. The results of this testing can be found appended to the end of this report, and are summarised as follows:

TABLE A: GRAIN SIZE ANALYSES

Sample ID	Depth (m)	% Clay	% Silt	% Sand	% Gravel	Estimated Permeability, k [cm/sec]	Estimated Infiltration Rate [mm/hr]
BH1 SS6	4.6	8	91	1	0	10^{-5}	30 to 35
BH3 SS4	2.3	58	38	3	1	10^{-8}	<5

According to the Unified Soil Classification Systems (USCS), the silty clay soils encountered below the surficial topsoil are classified as C.L. Inorganic clays of low to medium plasticity and the silt soils encountered in Borehole No. 1 below a depth of approximately 4.6 metres are classified as M.L. Inorganic silts and very fine sands. The Effective Diameter, D_{10}, of the tested soil samples were found to range from approximately 0.0001 (silty clay) to 0.0035 (silt) millimetres. As the estimated infiltration rate of the silty clay soils is less than 5 mm/hr, the subsurface soils are considered effectively impermeable with respect to LID stormwater infiltration systems.

Groundwater Observations

All boreholes were recorded as 'dry' upon completion of drilling. It is noted that insufficient time would have passed for the static groundwater level to stabilise in the open boreholes. As noted above groundwater monitoring wells were installed in Borehole Nos. 2, 4, 5 and the following groundwater readings have been taken:

TABLE B: GROUNDWATER READINGS

	Ground Surface Elevation* [m]	Monitoring Well Depth/Elev.* [m]	Screened Interval Depth/Elev.* [m]	12/15/2023		1/5/2024	
				Groundwater Depth [m]	Groundwater Elevation* [m]	Groundwater Depth [m]	Groundwater Elevation* [m]
MW2	99.70	6.1 / 93.6	4.6 to 6.1 95.1 to 93.6	1.17	98.53	0.77	98.93
MW4	99.13	6.1 / 93.03	4.6 to 6.1 94.5 to 93.03	1.93	97.77	1.55	98.15
MW5	99.80	6.1 / 93.7	4.6 to 6.1 95.2 to 93.6	0.91	98.79	1.66	98.04

* - All elevations provided referenced to a Temporary Benchmark with an assumed elevation of 100.0 metres.

The observed groundwater levels within the monitoring wells were relatively consistent, with groundwater depths ranging from approximately 0.8 to 1.5 metres. It is noted that the observed groundwater levels may be influenced by perched water within more permeable seams within the relatively impermeable clayey soils. Further groundwater monitoring and additional investigations including the advancement of test excavations may allow for a more accurate estimate of the static groundwater level.

4. SITE GRADING

It is anticipated that site development may require some earthworks activities over the site, and possible import or export of soils to get the site to the design pre-grade elevation. Prior to the placement of engineered fill, all existing organic, saturated, or otherwise unsuitable material should be removed, and the exposed surface evaluated by a representative of SOIL-MAT ENGINEERS. All structural fill beneath building footprints, underground infrastructure, roads, etc., should be placed in loose lifts not exceeding 300 millimetres in thickness, moisture content conditioned to within three per cent of its optimum moisture content and compacted to a minimum of 100 per cent of its standard Proctor maximum dry density [SPMDD].

As noted above, the static groundwater level tends to be relatively shallow across much of the site, on the order of 0.8 to 1.5 metres below the existing grade. In this regard, raising the grade of the site as much as possible will be helpful to reduce the potential for interaction with the ground water during, and post-development.

Depending on the extent of engineered fill works, weather conditions at the time of construction, etc., some instability or saturation of the subgrade and engineered fill soils may be experienced. In such a case it may be necessary to stabilise the exposed subgrade via the placement of a layer of rip rap, punched into the unstable subgrade soils, and/or altering placement and compaction efforts. Such efforts may include placement of material in relatively thin lifts, static rolling, and/or delay in compaction after placement to allow wet material to dry.

5. EXCAVATIONS

Excavations for the installation of foundations and underground services are anticipated to extend to depths of approximately 2 to 3 metres below the existing grade. Relatively shallow excavations through the silty clay/clayey silt soils above the groundwater level should be relatively straight forward, with side slopes through the silty clay/clayey silt soils remaining stable at inclinations of up to 60 degrees to the horizontal. Excavations through the granular sandy silt soils should be expected to remain stable at inclinations of up to 45 degrees to the horizontal for the short construction period. During periods of extended precipitation, or where the excavations extend below the observed groundwater level, the sides of the excavation should be expected to ‘slough in’ to as flat as 3 horizontal to 1 vertical, or flatter, especially within the more permeable sandy silt soils encountered.

Infiltration of water through the permeable seams, perched deposits, and from surface run off should be anticipated, especially during the ‘wet’ times of the year. For the anticipated excavations, such infiltration would be expected to be relatively slow, such that it should be readily controlled with typical construction dewatering methods i.e. pumping from sumps in the base of excavations during the relatively ‘dry’ months. However, as noted above, greater instability should be anticipated during the ‘wet’ times of the year and during periods of extended precipitation, and the contractor should expect to work in the ‘wet’ conditions. Where excavations extend below the groundwater level or are conducted during the ‘wet’ times of the year, greater dewatering efforts and increased excavation instability should be expected. It would be prudent to advance a series of test excavations across the site to observe the affect groundwater conditions will have on excavation operations.

Notwithstanding the above, all excavations must comply with the current Occupational Health and Safety Act and Regulations for Construction Projects. The silty clay/clayey silt and the sandy silt encountered would generally be considered Type 2 soils, as outlined in the Ontario Health and Safety Act, Part III – Excavations. Excavations sloped steeper than those required in the Safety Act must be supported and a senior geotechnical engineer from this office should monitor the work.

As noted above, excavations are expected to extend to depths of up to perhaps 2 to 3 metres, with groundwater levels observed at depths as shallow as approximately 1 to 2 metres below the existing ground surface, and shallower groundwater conditions may be experienced during the relatively ‘wet’ times of the year, or during periods of heavy precipitation. Infiltration of water from surface runoff into the open excavations should be anticipated, however should be possible to control using typical construction dewatering techniques. More water should be expected when connections are made to existing services. Surface water should be directed away from the excavations.

The base of the excavations above the static groundwater level in the native silty clay/clayey silt soils encountered in the boreholes should generally remain firm and stable. However, these soils will be susceptible to disturbance where excavations extend to greater depths below the groundwater table, where ‘perched’ water is encountered, or where excavations are left exposed to the elements for extended periods of time, especially during ‘wet’ times of the year. Areas experiencing base instability may be stabilised with the placement of additional bedding or ballast stone, the use of coarser stone material, etc. The appropriate measures are best assessed based on the actual conditions at the time of construction.

With a firm and stable base condition, stabilised where warranted, standard pipe bedding material as specified by the Ontario Provincial Standard Specification [OPSS] or City of Welland should be satisfactory. The bedding should be well compacted to provide sufficient support to the pipes and components (i.e. valve chambers, manholes etc.), and to minimize settlements of the roadway above the service trenches. Special attention should be paid to compaction under the pipe haunches.

Any utility poles, light poles, etc. located within 3 metres of the top of an excavation slope should be braced to ensure their stability. Likewise, temporary support might be required for other existing above and below ground structures, including existing underground services, roadways, etc. depending on their proximity to the trench excavations.

6. BACKFILL CONSIDERATIONS

The excavated material will consist primarily of the native silty clay/clayey silt soils encountered in the boreholes as described above. These soils are generally considered suitable for use as engineered fill, trench backfill, etc., provided they are free of organics, construction debris, or other deleterious material, and that its moisture content can be controlled to within 3 per cent of its standard Proctor optimum moisture content.

It is noted that the on-site silty clay/clayey silt soils encountered are not considered to be free draining and should not be used where this characteristic is necessary. The silty clay/clayey silt soils encountered are generally considered to be near to slightly ‘wet’ of their standard Proctor optimum moisture content. The sandy silt was generally noted to be generally ‘wet’ of optimum. Some moisture conditioning should be expected to be required depending upon the weather conditions at the time of construction. It is noted that these fine grained to cohesive soils will become nearly impossible to compact when wet of its optimum moisture content. Any material that becomes wet to saturated should be spread out to allow to dry, or removed and discarded, or utilised in non-settlement sensitive areas.

We note that where backfill material is placed near or slightly above its optimum moisture content, the potential for long-term settlements due to the ingress of groundwater and collapse of fill structure for long term settlement is reduced. Correspondingly, the shear strength of the ‘wet’ backfill material is also lowered, thereby reducing its ability to support construction traffic and therefore impacting roadway construction. If the soil is well dry of its optimum value, it will appear to be very strong when compacted, but will tend to settle with time as the moisture content in the fill increases to equilibrium condition. The soils encountered may require high compaction energy to achieve acceptable densities if the moisture content is not close to its standard Proctor optimum value. It is therefore very important that the moisture content of the soils be within 3 per cent of its Proctor optimum moisture content placement and compaction to minimize long term subsidence [settlement] of the fill mass. Any imported fill required in service trenches or to raise the subgrade elevation should have its moisture content within 3 per cent of its optimum moisture content and meet the necessary environmental guidelines.

A representative of SOIL-MAT should be present on-site during the backfilling and compaction operations to confirm the uniform compaction of the backfill material to project specification requirements. Close supervision is prudent in areas that are not readily accessible to compaction equipment, for instance near the end of compaction 'runs'. All structural fill, backfill within service trenches, areas to be paved, etc., should be placed in loose lifts not exceeding 300 millimetres and compacted to a minimum of 98 per cent of SPMDD. The appropriate compaction equipment should be employed based on soil type, i.e. pad-toe for cohesive soils and smooth drum/vibratory plate for granular soils. A method should be developed to assess compaction efficiency employing the on-site compaction equipment and backfill materials during construction.

7. MANHOLES, CATCH BASINS AND THRUST BLOCKS

Properly prepared bearing surfaces for manholes, valve chambers, etc., in the native competent soils, stabilized where required, will be practically non-yielding under the anticipated loads. Proper preparation of the founding soils will tend to accentuate the protrusion of these structures above the pavement surface if the compaction of the fill around these structures are not adequate, causing the settlement of the surrounding paved surfaces. Conversely, the pavement surfaces may rise above the valve chambers and around manholes under frost action. To alleviate the potential for these types of differential movements, free-draining non-frost susceptible material should be employed as backfill around the structures located within the paved roadway limits, and compacted to a minimum of 98 per cent SPMDD.

The thrust blocks in the native soils may be conservatively sized as recommended by the applicable Ontario Provincial Standard Specification conservatively using a horizontal allowable bearing pressure of up to 100 kPa [~2,000 psf]. Any backfill required behind the blocks should be a well-graded granular product and should be compacted to a minimum of 98 per cent SPMDD.

8. PAVEMENT STRUCTURE DESIGN CONSIDERATIONS.

All areas to be paved must be cleared of all organic and otherwise unsuitable materials, and the exposed subgrade proof-rolled with 3 to 4 passes of a loaded tandem truck in the presence of a representative of SOIL-MAT ENGINEERS & CONSULTANTS LTD., immediately prior to the placement of the sub-base material. Any areas of distress revealed by this or other means should be subexcavated and replaced with suitable backfill material. Alternatively, the soft areas may be repaired by punching coarse aggregate, such as a 50-millimetre clear crushed stone, into the soft areas. The need for sub-excavations of softened subgrade materials will be reduced if construction is undertaken during dry periods of the year and careful attention is paid to the compaction operations. The fill over shallow utilities cut into or across paved areas must also be compacted to a minimum of 98 per cent of its SPMDD.

Good drainage provisions will optimise the long-term performance of the pavement structure. The subgrade must be properly crowned and shaped to promote drainage to the subdrain system. Subdrains should be installed to intercept excess subsurface water and to prevent softening of the subgrade material. Surface water should not be allowed to pond adjacent to the outer limits of the paved areas.

The most severe loading conditions on the subgrade typically occur during the course of construction. Therefore, precautionary measures (such as the use of a temporary "construction road") should be taken to ensure that the subgrade is not unduly disturbed by construction traffic. Soil-Mat should be given the opportunity to review the final pavement structure design and subdrain scheme prior to construction to ensure that they are consistent with the recommendations of this report.

If construction is conducted under adverse weather conditions, additional subgrade preparation may be required. During wet weather conditions, such as typically experienced between the fall and spring months, it should be anticipated that additional subgrade preparation will be required, such as additional depth of OPSS Granular 'B', Type II (crushed limestone bedrock) sub-base material. It is also important that the sub-base and base granular layers of the pavement structure be placed as soon as possible after exposure, preparation, and approval of the exposed subgrade.

Where roads are to be assumed by the City of Welland the pavement structure should conform to the appropriate municipal standard, as follows:

Local Roads: 40 mm HL3 Surface Course, 75 mm HL8 Binder Course and 450 mm Granular 'A' Base

Collector Roads: 40 mm HL3 Surface Course 75 mm HL8 Binder Course 525 mm Granular 'A' Base

The suggested pavement structures outlined in Table C below may be also considered. These are based on the subgrade parameters estimated on the basis of visual and tactile examinations of the on-site soils and past experience. The outlined pavement structure may be expected to have an approximate fifteen to twenty year life, assuming that regular maintenance is performed. Should a more detailed pavement structure design be required, site specific traffic information would be needed, together with detailed laboratory testing of the subgrade soils.

TABLE C: TYPICAL SUGGESTED PAVEMENT STRUCTURES

LAYER DESCRIPTION	COMPACTION REQUIREMENTS	LIGHT DUTY SECTIONS	HEAVY DUTY [TRUCK ROUTE]
Asphaltic Concrete Wearing course OPSS HL 3 or HL 3A	Min. 92 % Marshall MRD	40 millimetres	40 millimetres
Binder Course OPSS HL 8	Min. 92 % Marshall MRD	50 millimetres	65 millimetres
Base Course OPSS Granular A	100% SPMDD	150 millimetres	150 millimetres
Sub-base Course OPSS Granular B Type II	100% SPMDD	300 millimetres	450 millimetres

* Marshall MRD denotes Maximum Relative Density.
* SPMDD denotes Standard Proctor Maximum Dry Density, ASTM-D698.

To minimize segregation of the finished asphalt mat, the asphalt temperature must be maintained uniform throughout the mat during placement and compaction. All to often, significant temperature gradients exist in the delivered and placed asphalt with the cooler portions of the mat resisting compaction and presenting a honeycomb surface. As the spreader moves forward, a responsible member of the paving crew should monitor the pavement surface, to ensure a smooth uniform surface. The contactor can mitigate the surface segregation by ‘back-casting’ or scattering shovels of the full mix material over the segregated areas and raking out the course particles during compaction operations. Of course, the above assumes that the asphalt mix is sufficiently hot to allow the ‘back-casting’ to be performed.

9. HOUSE CONSTRUCTION

The native soils encountered at the borehole locations are considered capable of supporting the loads associated with typical residential dwelling and townhouse structures on conventional spread footings below any fill, organic, or otherwise unsuitable materials, considering a nominal design bearing capacity of up to 150 kPa. The founding surfaces must be hand cleaned of any loose or disturbed material, along with any ponded water or surficially soft soils, immediately prior to placement of foundation concrete.

It is noted that the measurement of the groundwater level indicates groundwater on the order of 0.8 to 1.5 metres below the existing ground surface, perhaps deeper. As such, pending a more detailed assessment of the groundwater level, it is recommended that the basement levels of the buildings be limited to elevations greater than the existing groundwater table to prevent frequent cycling of the sump pump.

In the event that site grading works require engineered fill below the founding elevations on the proposed structures, the general recommendations presented in the Site Grading and Backfill Considerations sections above should be strictly adhered to, with compaction to a minimum of 98 per cent SPMDD, verified by monitoring and testing by a representative of SOIL-MAT ENGINEERS present on a fulltime basis. If there is a shortfall in the volume of fill required, then the source of imported fill should be reviewed for gradation, Proctor value, compatibility with existing fill, environmental characteristics and be approved by this office prior to use. On a preliminary basis the design bearing capacity for footings within the engineered fill should be limited to 100 kPa [~2,000 psf] SLS and 150 kPa [~3,000 psf] ULS, pending confirmation based on monitoring and testing of the engineered fill works. It is anticipated that the placement of engineered fill may be required to the raise the grade to allow for building foundations above the static groundwater level.

The support conditions afforded by the supporting soils are generally not uniform across the building footprint, nor are the loads on the various foundation elements. As such it is recommended that consideration be given to the provision of nominal reinforcement in the footings and foundation walls to account for the variable support and loading conditions. The use of nominal reinforcement is considered good construction practice as it will act to reduce the potential for cracking in the foundation walls due to settlements, heaving, shrinkage, etc. and will assist in resisting the pressures generated against the foundation walls by the backfill. Such nominal reinforcement would typically consist of two continuous 15M steel bars placed in the footings [directly below the foundation wall], and similarly two steel bars placed approximately 300 millimetres from the top of the foundation walls at a minimum depending on the ground conditions exposed during construction. These reinforcement bars would be bent to reinforce all corners and under basement windows, and be provided with sufficient overlap at staggered splice locations. At ‘steps’ in the foundations and at window locations, the reinforcing steel should transition diagonally, rather than at 90 degrees, to maintain the tensile capacity of the reinforcement. In the event that houses are founded on, or partially on engineered fill, the provision of such nominal steel reinforcement would be a requirement.

All basement foundation walls should be suitably damp proofed in accordance with the Ontario Building Code, including the provision of a 'dimple board' type drainage product, and provided with a perimeter drainage tile system outlet to a gravity sewer connection or a positive sump pump a minimum of 150 millimetres below the basement floor slab. The clear stone surrounding the weeping tile system should be encased with a geotextile material to prevent the migration of fines from the foundation wall backfill into the clear stone product. The sump pump system should be constructed with an 'oversized' reservoir and a 'back-flow' prevention valve so that the sump pump will not cycle repeatedly within short time periods.

All footings exposed to the environment must be provided with a minimum of 1.2 metres of earth or equivalent insulation to protect against frost penetration. This equivalent frost protection would also be required if construction were undertaken during the winter months, to prevent freezing of founding soils and frost damage to the buildings under construction. All footings must be proportioned to satisfy the requirements of the Ontario Provincial Building Code. In cases where proximity to the groundwater level may limit excavation depths, the use of rigid foam insulation may be provided in lieu of earth cover. The supplier of such products should be consulted regarding the proper use of such insulating materials.

It is imperative that a soils engineer be retained from this office to provide geotechnical engineering services during the excavation and foundation construction phases of the project. This is to observe compliance with the design concepts and recommendations outlined in this report, and to allow changes to be made in the event that subsurface conditions differ from the conditions identified at the borehole locations.

10. PRELIMINARY HYDROGEOLOGICAL CONSIDERATIONS

As noted above, it is understood that the development will consist of multiple blocks of typical townhouses with full basements, asphalt paved roadways, and associated servicing.. Excavations for the proposed development services are expected to extend to depths of up to approximately 3 metres below the existing ground surface, while excavations for foundations would expect to extend to approximately 2 metres. Measurements of the groundwater level at the monitoring well locations conservatively suggest a groundwater level on the order of approximately 0.8 to 1.5 metres below the exiting ground surface, however further groundwater monitoring may be conducted to more accurately assess the static ground water level.

Excavations for the proposed servicing may extend through the relatively impermeable silty clay/clayey silt soils and into deeper more permeable sandy silt soils below. Such excavations would be expected to be subject to relatively minor groundwater infiltration, however this would be heavily influenced by the weather conditions, time of year of construction, etc. It should be possible to adequately control such infiltration using conventional construction dewatering techniques such as pumping from sums in the base of the excavations, even for excavations extending a short distance below the static groundwater level within the cohesive soils. During wet times of the year, some instability of the upper levels of the excavation requiring wider excavations, working in the 'wet', etc., should be anticipated. The rate of dewatering would be expected to be below 50,000 L/day, and certainly below 400,000 L/day, such that an EASR or PTTW should not be required.

As noted above, basement levels should be limited to depths above the groundwater table to avoid close proximity to the observed groundwater levels, pending a more detailed assessment of the groundwater level. Raising the grade as much as feasible above the existing ground surface would be beneficial in this regard, to maximize separation between basement levels and groundwater. Where dwellings are founded within the less permeable cohesive soils, sumps would be expected to run more frequently during 'wet' times of the year. As such it is recommended that oversized reservoirs and backflow prevention valves be provided with a backup pump or power source.

11. SOIL IMPORT/EXPORT CONSIDERATIONS

At this time, it is unknown if the project will be a balanced site, require import, or export of excess soils during construction. In the event that the site will require import of soil, a Fill Management Plan will be required to manage and support the acceptance of material proposed for import to the site where import is required. Material to be imported should be reviewed by our office and meet the necessary geotechnical and environmental requirements for acceptance and use as engineered fill across the site. In the event that soils are to be exported from the site, specific environmental assessment, testing, and reporting would be required to support acceptance at an off-site property. Regardless, SOIL-MAT ENGINEERS may be retained to perform the necessary Qualified Person [QP] services during soil import operations at the time of construction.

12. GENERAL COMMENTS

The comments provided in this document are intended only for the guidance of the design team. The material in it reflects SOIL-MAT ENGINEERS' best judgement in light of the information available at the time of preparation. The subsurface descriptions and borehole information are intended to describe conditions at the borehole locations only. It is the contractors' responsibility to determine how these conditions will affect the scheduling and methods of construction for the project. 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. SOIL-MAT ENGINEERS 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 trust that this geotechnical report is sufficient for your present requirements. Should you require any additional information or clarification as to the contents of this document, please do not hesitate to contact the undersigned.

Yours very truly,
SOIL-MAT ENGINEERS & CONSULTANTS LTD.

Kevin Reid, B. Eng.
Junior Engineer

Malcolm Green, B. Tech
Junior Engineer

Stephen R. Sears, B. Eng. Mgmt., P. Eng., QP_{ESA}
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
FEB 13/24
S. R. SEARS
PROVINCE OF ONTARIO

Enclosures: Drawing No. 1, Borehole Location Plan
Log of Borehole Nos. 1 to 5, inclusive
Drawing No. 2 Typical Basement Construction with Perimeter Drainage

Distribution: BSF Communities Inc.

LEGEND

⊕ BH# Borehole Location

⊕ MW# Monitoring Well Location

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Report No. SM 230882-G.

2. Borehole locations are approximate.

SOIL-MAT

ENGINEERS & CONSULTANTS LTD.

Geotechnical Investigation
Proposed Residential Development
450 Rice Road
Welland, Ontario

Borehole Location Plan

Project No. SM 230882-G

Date: February, 2024

Drawn: KJR

Checked: IS

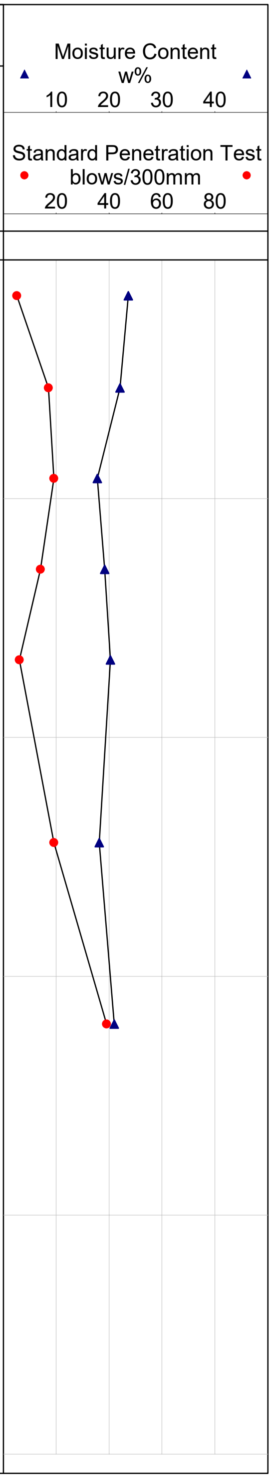
Drawing No. 1

Log of Borehole No. 1

Project No: SM 230882-G
Project: Proposed Residential Development
Location: 450 Rice Road, Welland
Client: BSF Communities Inc.

Project Manager: Ian Shaw, P. Eng. QPESA
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764950
E: 640988

Depth	Elevation (m)	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
ft m	100.03		Ground Surface								
0 0	99.73		**Topsoil** Approximately 300 millimetres of topsoil.		SS	1	2,2,3,5	5	▨		
			Silty Clay/Clayey Silt Brown, very stiff to firm.		SS	2	5,7,10,14	17	▨	2.5	
					SS	3	5,7,12,18	19	▨	>4.5	
					SS	4	4,6,8,8	14	▨	4.5	
	97.20		Transition to Grey		SS	5	3,3,3,5	6	▨	1.5	
	95.40		**Sandy Silt** Grey, trace clay, compact to dense.		SS	6	5,8,11,11	19	▨		
					SS	7	8,16,23,28	39	▨		
	93.30		End of Borehole								



NOTES:

1. Borehole was advanced using solid stem auger equipment on November 29, 2023 to termination at a depth of 6.7 metres.

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

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

Drill Method: Soild Stem Augers
Drill Date: November 29, 2023
Hole Size: 150 millimetres
Drilling Contractor: Elements Geo

Soil-Mat Engineers & Consultants Ltd.
401 Grays Road · Hamilton, Ontario · L8E 2Z3
T: 905.318.7440 · TF: 800.243.1922 · F: 905.318.7455
www.soil-mat.ca · E: info@soil-mat.ca

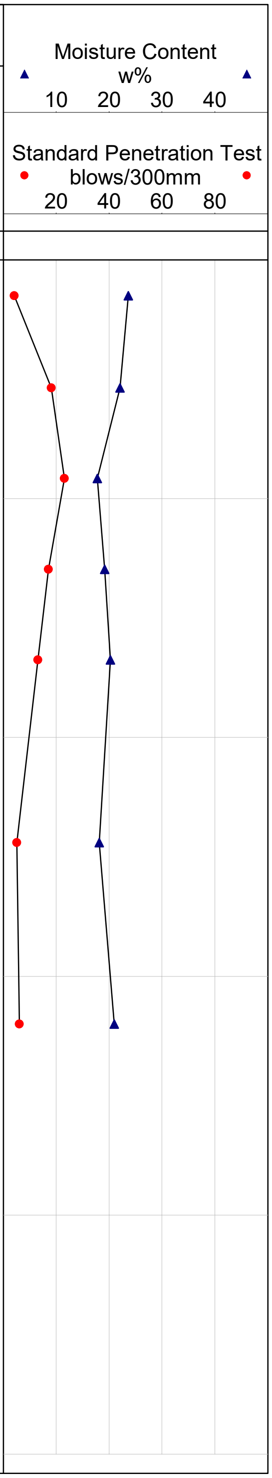
Datum: Temporary Bench Mark
Field Logged by: MG
Checked by: KJR
Sheet: 1 of 1

Log of Borehole No. 2

Project No: SM 230882-G
Project: Proposed Residential Development
Location: 450 Rice Road, Welland
Client: BSF Communities Inc.

Project Manager: Ian Shaw, P. Eng. QPESA
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764966
E: 641093

Elevation (m)	Description	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
99.70	Ground Surface							
99.40	**Topsoil** Approximately 300 millimetres of topsoil.	SS	1	1,2,2,4	4	■		
	Silty Clay/Clayey Silt Greyish brown, occasional clay seams, very stiff to stiff.	SS	2	3,7,11,15	18	■	2.0	
		SS	3	4,9,14,16	23	■	4.5	
97.20	Transition to Grey	SS	4	4,7,10,12	17	■	>4.5	
		SS	5	3,6,7,9	13	■	2.0	
		SS	6	2,2,3,4	5	■	0.5	
93.00		SS	7	3,3,3,5	6	■	0.5	
	End of Borehole							



NOTES:

1. Borehole was advanced using solid stem auger equipment on November 29, 2023 to termination at a depth of 6.7 metres.

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

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

4. A monitoring well was installed. The following free groundwater level readings have been measured:

December 15, 2023 - 1.17 metres below the existing ground surface

January 5, 2024 - 0.77 metres below the existing ground surface

Drill Method: Soild Stem Augers
Drill Date: November 29, 2023
Hole Size: 150 millimetres
Drilling Contractor: Elements Geo

Soil-Mat Engineers & Consultants Ltd.
401 Grays Road · Hamilton, Ontario · L8E 2Z3
T: 905.318.7440 · TF: 800.243.1922 · F: 905.318.7455
www.soil-mat.ca · E: info@soil-mat.ca

Datum: Temporary Bench Mark
Field Logged by: MG
Checked by: KJR
Sheet: 1 of 1

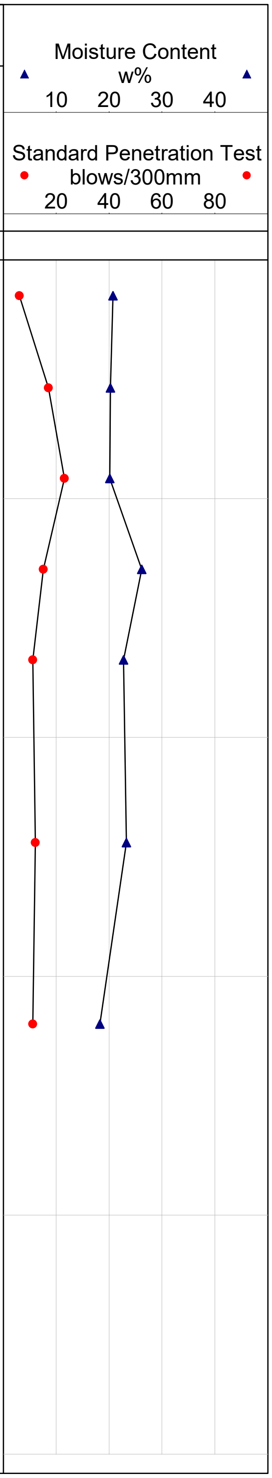
Log of Borehole No. 3

Project No: SM 230882-G
Project: Proposed Residential Development
Location: 450 Rice Road, Welland
Client: BSF Communities Inc.

Project Manager: Ian Shaw, P. Eng. QPESA
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764850
E: 641046

Elevation (m)	Description
99.20	Ground Surface
98.90	**Topsoil** Approximately 300 millimetres of topsoil.
	Silty Clay/Clayey Silt Brown to greyish brown, occasional silt seams in lower level, very stiff to stiff.
95.10	Transition to Grey
92.50	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,2,4,6	6	■		
SS	2	5,8,9,16	17	■	>4.5	
SS	3	5,9,14,21	23	■	>4.5	
SS	4	5,6,9,10	15	■	>4.5	
SS	5	3,4,7,9	11	■	4.0	
SS	6	3,5,7,7	12	■	1.5	
SS	7	3,5,6,12	11	■	0.5	



NOTES:

1. Borehole was advanced using solid stem auger equipment on November 29, 2023 to termination at a depth of 6.7 metres.

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

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

Drill Method: Solid Stem Auger
Drill Date: November 29, 2023
Hole Size: 150 millimetres
Drilling Contractor: Elements Geo

Soil-Mat Engineers & Consultants Ltd.
401 Grays Road · Hamilton, Ontario · L8E 2Z3
T: 905.318.7440 · TF: 800.243.1922 · F: 905.318.7455
www.soil-mat.ca · E: info@soil-mat.ca

Datum: Temporary Benchmark
Field Logged by: MG
Checked by: KJR
Sheet: 1 of 1

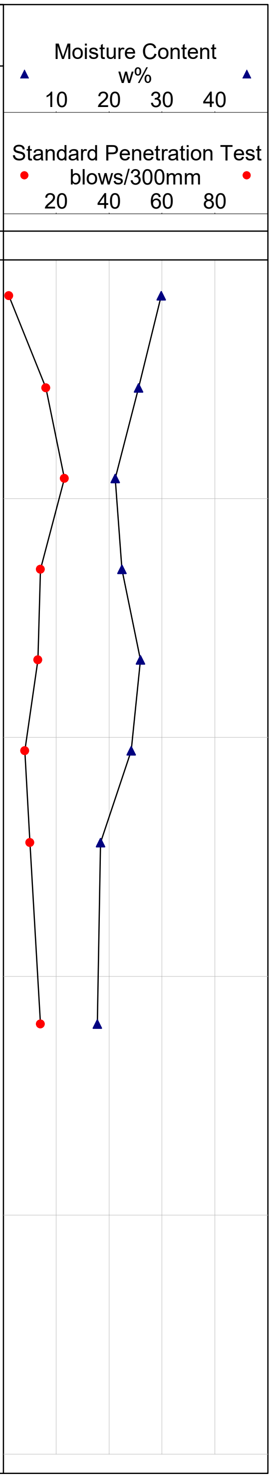
Log of Borehole No. 4

Project No: SM 230882-G
Project: Proposed Residential Development
Location: 450 Rice Road, Welland
Client: BSF Communities Inc.

Project Manager: Ian Shaw, P. Eng. QPESA
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764850
E: 641046

Depth (m)	Elevation (m)	Description
0	99.13	Ground Surface
0.3	98.83	**Topsoil** Approximately 300 millimetres of topsoil.
		Silty Clay/Clayey Silt Greyish Brown, occasional silt seams in middle layers, very stiff to stiff.
	95.80	Transition to Grey
	92.40	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	1,1,1,2	2	▨		
SS	2	4,5,11,14	16	▨	>4.5	
SS	3	5,9,14,19	23	▨	>4.5	
SS	4	4,5,9,13	14	▨	>4.5	
SS	5	4,6,7,9	13	▨	3.5	
SS	6	2,3,5,6	8	▨	1.5	
SS	7	4,4,6,9	10	▨	2.0	
SS	8	4,6,8,12	14	▨	3.5	



NOTES:

1. Borehole was advanced using solid stem auger equipment on November 29, 2023 to termination at a depth of 6.7 metres.

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

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

4 A groundwater monitoring well has been installed and the following readings have been taken:

December 15, 2023 - 1.93 metres below the existing ground surface

January 5, 2024 - 1.55 metres below the existing ground surface

Drill Method: Solid Stem Auger
Drill Date: November 29, 2023
Hole Size: 150 Millimetres
Drilling Contractor: Elements Geo

Soil-Mat Engineers & Consultants Ltd.
401 Grays Road · Hamilton, Ontario · L8E 2Z3
T: 905.318.7440 · TF: 800.243.1922 · F: 905.318.7455
www.soil-mat.ca · E: info@soil-mat.ca

Datum: Temporary Benchmark
Field Logged by: MG
Checked by: KJR
Sheet: 1 of 1

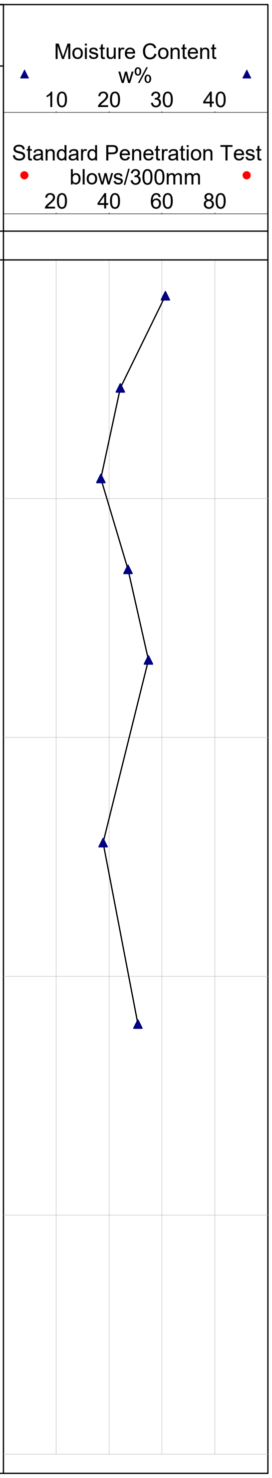
Log of Borehole No. 5

Project No: SM 230882-G
Project: Proposed Residential Development
Location: 450 Rice Road, Welland
Client: BSF Communities Inc.

Project Manager: Ian Shaw, P. Eng. QPESA
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764836
E: 641114

Elevation (m)	Description
99.80	Ground Surface
99.50	**Topsoil** Approximately 300 millimetres of topsoil.
	Silty Clay/Clayey Silt Brown, greyish brown in lower levels, very stiff to firm.
96.80	Transition to Grey
93.10	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,3,4,5	7	■		
SS	2	4,5,10,14	15	■	>4.5	
SS	3	5,8,11,17	19	■	>4.5	
SS	4	4,8,12,18	20	■	>4.5	
SS	5	3,3,5,6	8	■	1.0	
SS	6	4,4,6,6	10	■	>4.5	
SS	7	2,2,4,5	6	■		



NOTES:

1. Borehole was advanced using solid stem auger equipment on November 29, 2023 to termination at a depth of 6.7 metres.

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

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

4. A groundwater monitoring well has been installed and the following readings have been taken.

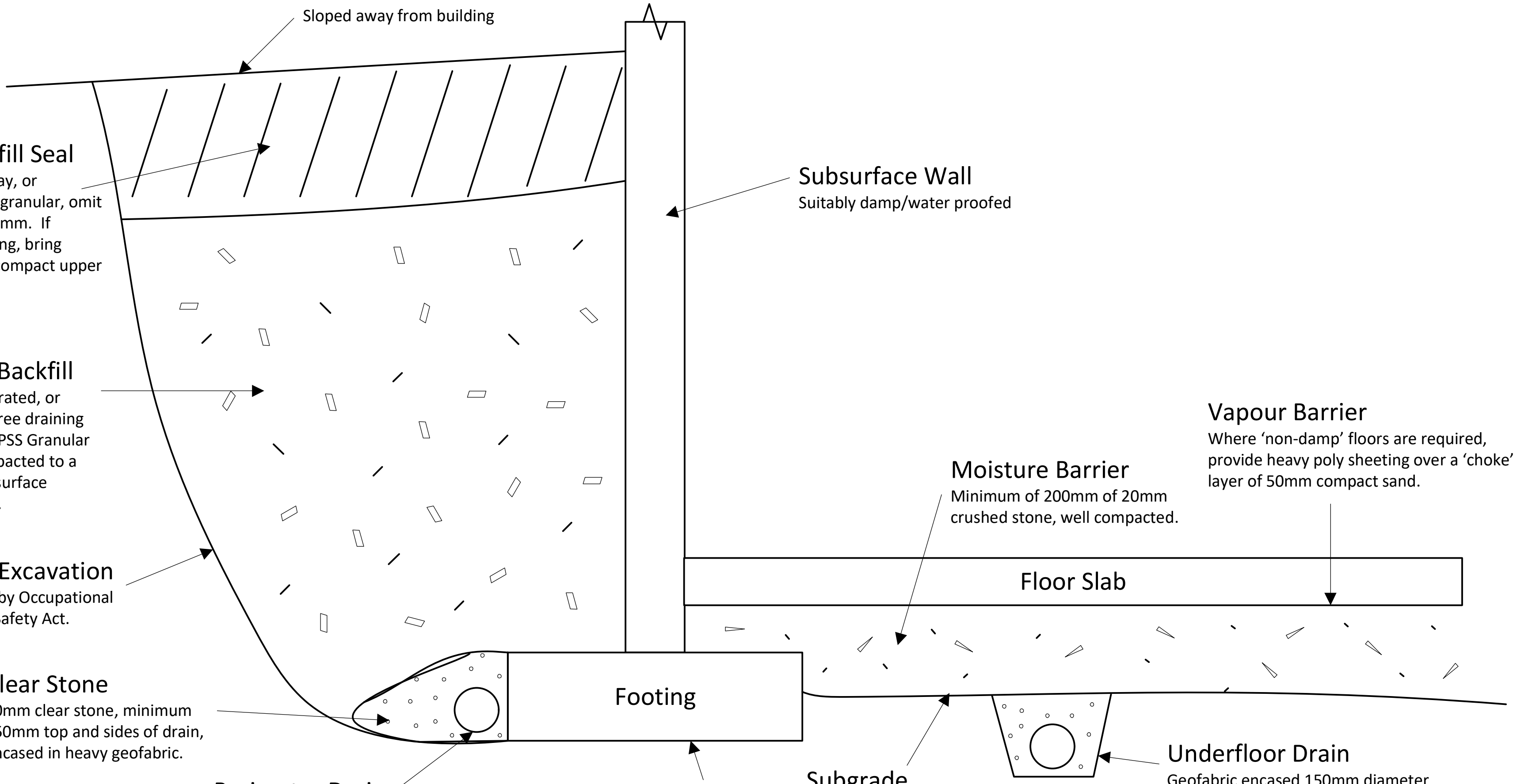
December 15, 2023 - 0.91 metres below the existing ground surface

January 5, 2024 - 1.66 metres below the existing ground surface

Drill Method: Solid Stem Auger
Drill Date: November 29, 2023
Hole Size: 150 millimetres
Drilling Contractor: Elements Geo

Soil-Mat Engineers & Consultants Ltd.
401 Grays Road · Hamilton, Ontario · L8E 2Z3
T: 905.318.7440 · TF: 800.243.1922 · F: 905.318.7455
www.soil-mat.ca · E: info@soil-mat.ca

Datum: Temporary Benchmark
Field Logged by: MG
Checked by: KJR
Sheet: 1 of 1



Ground Surface
Sloped away from building

Impermeable Backfill Seal
Well compacted clay/silty clay, or equivalent. If original soil is granular, omit seal and compact upper 600mm. If pavement adjacent to building, bring Granular ‘B’ to surface and compact upper 1 metre to 100% SPMDD.

Subsurface Wall
Suitably damp/water proofed

Select Compacted Backfill
Free of organic, frozen, saturated, or otherwise unsuitable soil. Free draining granular material, such as OPSS Granular ‘B’ (Type II) preferred. Compacted to a minimum of 95% SPMDD if surface settlement can be tolerated.

Vapour Barrier
Where ‘non-damp’ floors are required, provide heavy poly sheeting over a ‘choke’ layer of 50mm compact sand.

Moisture Barrier
Minimum of 200mm of 20mm crushed stone, well compacted.

Limit of Excavation
As required by Occupational Health and Safety Act.

Clear Stone
20mm clear stone, minimum 150mm top and sides of drain, encased in heavy geofabric.

Pour flush with original undisturbed soil.

Subgrade
Competent native soil or well compacted fill.

Underfloor Drain
Geofabric encased 150mm diameter perforated pipe or equivalent, leading to a positive sump or outlet. Invert at least 300mm below underside of floor slab. Pipe placed in parallel rows on nominal 4-6m centres.

Perimeter Drain
150mm diameter weeping tile or pipe equivalent, leading to positive sump or outlet. Invert at least 150mm below underside of floor slab.

NOT TO SCALE

Soil-Mat

Soil-Mat Engineers & Consultants Ltd.

Project No.: SM 230882-G
Date: 02/13/24

Typical Design Requirements
Drainage and Backfill for Basement Walls

Drawing No. 2