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PROJECT NO.: SM 220530-G

April 14, 2023
Revised: June 14, 2024

PRIMONT (THOROLD/WELLAND) INC.
9130 Leslie Street, Suite 301
Richmond Hill, Ontario
L4B 0B9

Attention: Ian MacPherson, P.Eng.
Vice President Land Development

GEOTECHNICAL INVESTIGATION AND HYDROGEOLOGICAL CONSIDERATIONS PROPOSED RESIDENTIAL DEVELOPMENT QUAKER ROAD AND FIRST AVENUE WELLAND, ONTARIO

Dear Mr. MacPherson,

Further to your authorisation, SOIL-MAT ENGINEERS & CONSULTANTS LTD. has completed the fieldwork, laboratory testing, and report preparation in connection with the above noted project. The scope of work was completed in general accordance with our proposal P220530, dated October 25, 2022. Our comments and recommendations based on our findings at the thirteen [13] borehole locations are presented in the following paragraphs.

1. INTRODUCTION

We understand that the project will involve the construction of a residential development consisting of low-rise buildings [townhouse and single family dwellings], as well as possibly a number of mid-rise buildings up to perhaps 8 to 12 stories and 1 to 2 basement levels. The development will involve regrading of the site, including placement of engineered fill, installation of municipal services and roadway construction, along with associated storm water management ponds. It is noted that, a preliminary geotechnical report has been prepared for the site by DS Consultants Ltd [Project No. 21-339-300, dated July 22, 2022]. The information presented in that report has been referenced in the planning and reporting of this supplemental geotechnical investigation.

The purpose of this supplemental geotechnical investigation work is to further assess the subsurface soil 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 the 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 thirteen [13] sampled boreholes were advanced at the locations illustrated in the attached Drawing No. 1, Borehole Location Plan. These are in addition to nineteen [19] boreholes previously advanced and reported by DS Consultants Ltd. The current boreholes were advanced using continuous flight power auger equipment from December 6 to 9, 2022 under the direction and supervision of a staff member of SOIL-MAT ENGINEERS & CONSULTANTS LTD., to termination depths of approximately 6.7 to 20.4 metres below the existing ground surface.

Upon completion of drilling, ground water monitoring wells were installed at Borehole Nos. 5, 7, and 11 to allow for future measurements of the groundwater level. The monitoring wells consist of 50-millimetre diameter PVC pipe, screened in the lower 3.0 metres. The wells were encased in well filter sand up to approximately 0.3 metres above the screened portion, then with bentonite ‘hole plug’ up to the surface and fitted with a protective steel ‘stick up’ casing. The remainder of the boreholes were backfilled in general accordance with Ontario Regulation 903, and the grade reinstated even with the surrounding ground surface. It is noted that a total of thirteen [13] monitoring wells were installed as part of the previous investigation by DS Consultants Ltd. and are found to still be intact and have been utilized in preparation of this report.

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 the borings, with hand penetrometer testing conducted on all cohesive samples. Additionally, six [6] selected soil samples were subject to grain size analysis.

The boreholes were located in the field by representatives of SOIL-MAT ENGINEERS & CONSULTANTS LTD., based on accessibility over the site and clearance of underground utilities. The ground surface elevation at the borehole locations has been referenced to the geodetic elevations of existing monitoring wells, installed by DS consultants Ltd., during their preliminary site investigation.
Details of the conditions encountered in the boreholes, together with the results of the field and laboratory tests, are presented in Log of Boreholes Nos. 1 to 13 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 while 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 the north-west of the intersection of Quaker Road and First Avenue, in Welland, Ontario. The subject site is bounded to the North by wetlands, to the east by First Avenue, to the south by Quaker Road and to the west by Rice Road and some residential properties. The subject site has relatively flat and even topography, with an overall relief of approximately 2 to 3 metres across the site. The property is largely vacant agricultural land, with a large woodlot present over the northern portion. There are two natural drainage courses crossing east-west across the property.

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

Topsoil

A surficial veneer of topsoil approximately 150 to 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 ability to support plant life. Given the current use of the property is for agricultural purposes the upper levels of the soils would be expected to have a reworked nature with a variable topsoil depth based on historical working of the field, ranging from undiscernible to greater depths of topsoil. 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 veneer at all the borehole locations. The native cohesive soil was brown to reddish brown in colour, transitioning to grey below about 2.5 to 5 metres depth in most locations, contained occasional gravel, and was firm to very stiff in consistency. Some organics were noted in upper levels of silty clay/clayey silt soils, likely associated with historical tilling of the agricultural field. The silty clay was proven to depths of between approximately 2.2 and 8.6 metres below the existing ground surface at all borehole locations, and to termination in Borehole Nos. 5, 11 and 13. The silty clay exhibits the properties of a 'weathered crust' in the upper about 2.5 to 4 metres, stiff to very stiff in consistency, and good relative shear strength. With depth the silty clay deposit tends to become firm to soft, with lower shear strengths. This firm zone is variable across the site, ranging in thickness from effectively zero to as much as perhaps 3 to 4 metres, generally more over the central and eastern portion of the site. This is fairly typical of the overburden clays in the Niagara Peninsula, with the upper ‘crust’ typically being over consolidated, and the firm zone tending to be normally to only slightly over consolidated.

Sandy Silt/Silt

At all borehole locations, native sandy silt/silt soil was encountered beneath the native silty clay/clayey silt soil, with the exception of Borehole Nos. 5, 11 and 13. The native fine grained granular soil was reddish brown in colour, with occasional gravel, trace clay, and was generally in a compact state. The sandy silt/silt soil was proven to termination at depths of between approximately 6.7 and 20.4 metres at all borehole locations.

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

TABLE A – GRAIN SIZE ANALYSES

Sample ID	Depth	% Clay	% Silt	% Sand	% Gravel	Hydraulic Conductivity, k [cm/s]
BH1 SS6	4.5 m	60	39	1	0	10^{-7}
BH1 SS9	9.1 m	14	82	4	0	10^{-7}
BH3 SS5	3.0 m	11	78	11	0	10^{-6}
BH6 SS4	2.2 m	45	51	4	0	10^{-8}
BH7 SS3	1.5 m	61	38	1	0	10^{-8}
BH11 SS4	2.2 m	66	31	2	1	10^{-8}

The field and laboratory testing demonstrate the native soils within the upper few metres to predominantly consist of silty clay with traces of sand to silt to sandy silt with some clay at lower levels. According to the Unified Soil Classification System (USCS), the soils are classified as C.L. – inorganic clays of low to medium plasticity, silty clays to M.L. – Inorganic silts, with very fine sand or clayey silts with slight plasticity. The clay and silt soils would generally behave as a cohesive material with slight to medium plasticity, and low hydraulic conductivity, on the order of 10^{-7} to 10^{-8} cm/sec, and would be of low permeability to effectively impermeable.

These low permeable cohesive soils encountered would generally be considered suitable to provide an impermeable liner for the proposed stormwater management ponds, however further assessment in the area of the SWM pond at the depths of the proposed pond base would be warranted based on the increased silt content noted at depth.

A review of available published information [Quaternary Geology of Ontario, Southern Sheet Map 2556] indicate the subsurface soils to consist of fine-textured glaciolacustrine deposits of silt and clay with minor sand and gravel. This is consistent with our experience in the area, the above analyses, and our observations during drilling, as well as the conditions reported in the previous boreholes by DS Consultants.

Groundwater Observations

Borehole Nos. 2, 6, 8, 9, 10, 11, and 13 were recorded as being ‘wet’ upon completion of drilling at depths of approximately between 4.8 to 6.7 metres below existing ground surface. All other borehole locations 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, monitoring wells were installed at Borehole Nos. 5, 7 and 11 to allow for future measurements of the static groundwater level. The details of the monitoring well installation, as well as the groundwater measurements taken, have been summarised as follows:

TABLE B.1 – SUMMARY OF GROUNDWATER MEASUREMENTS
(SM 220530-G)

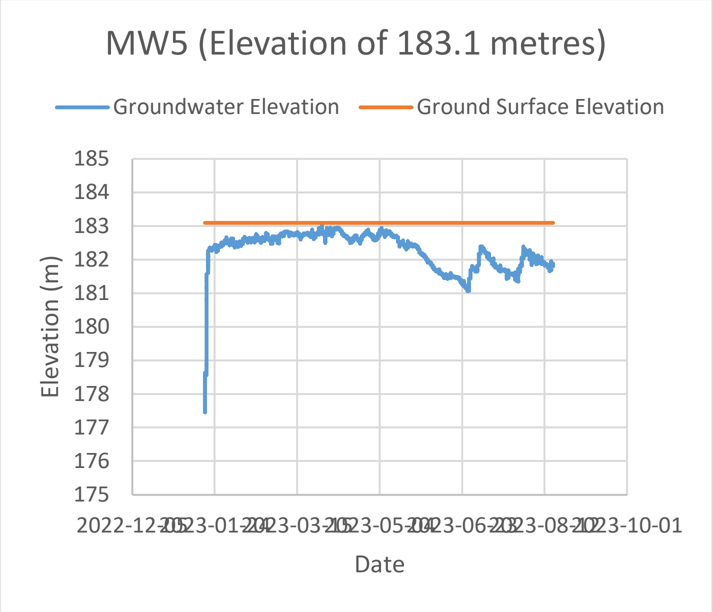
BH No.	Ground Surface Elev. (m)	Date of Observation	Groundwater Depth (m)	Groundwater Elevation (m)
BH5	183.1	Jan 18, 2023	0.80	182.32
		Feb 24, 2023	0.57	182.55
		August 17, 2023	1.22	181.88
BH7	183.5	Jan 3, 2023	1.60	181.65
		Jan 18, 2023	1.42	182.1
		Feb 24, 2023	1.28	182.24
		August 17, 2023	1.29	182.21
BH11	183.2	Jan 3, 2023	0.0	183.23
		Jan 18, 2023	**-0.22**	183.45
		Feb 24, 2023	**-0.12**	183.35
		August 17, 2023	**-0.11**	183.31

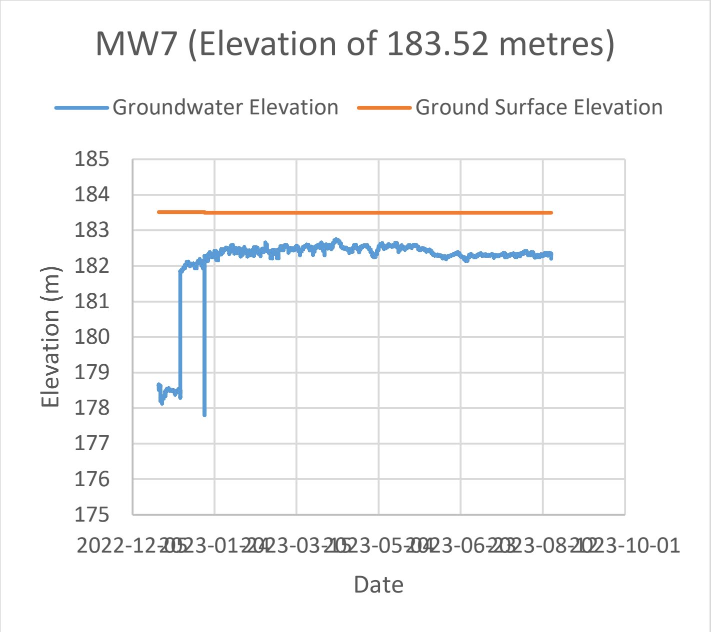
TABLE B.2 – SUMMARY OF GROUNDWATER MEASUREMENTS
(DS PROJECT NO. 21-339-300)

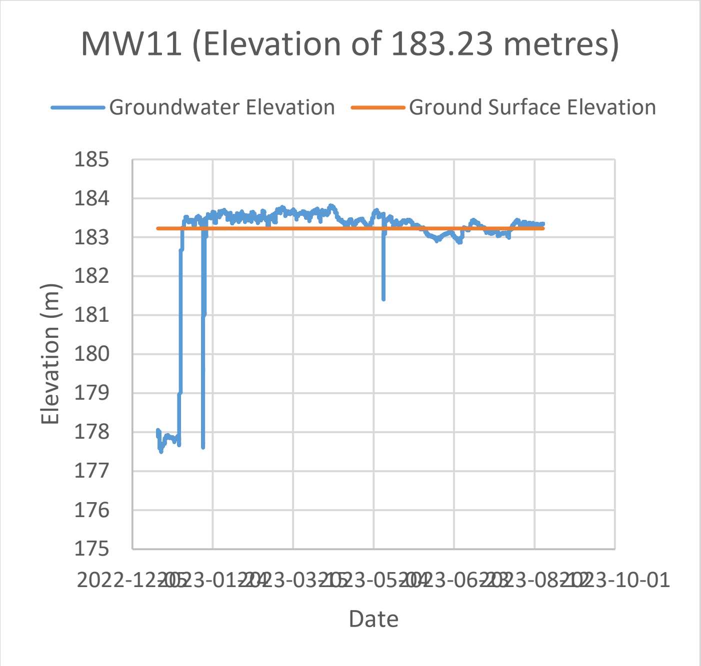
BH No.	Ground Surface Elev. (m)	Date of Observation	Groundwater Depth (m)	Groundwater Elevation (m)

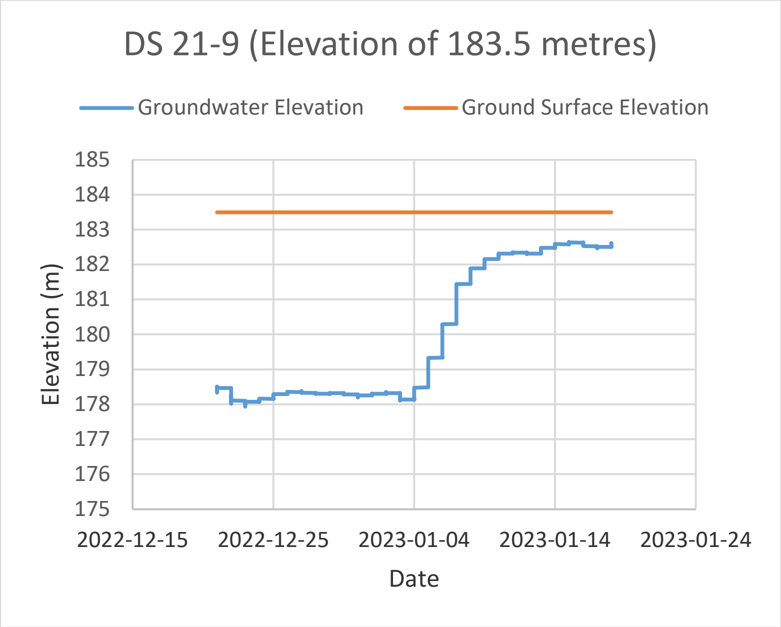
BH21-1	183.5	Nov 11, 2021	1.26	182.2
		May 10, 2022	**-0.80**	184.3
BH21-2	184.1	Nov 11, 2021	0.7	183.4
		May 10, 2022	0.68	183.4
		June 27, 2022	0.54	183.6
BH21-3	182.4	Nov 11, 2021	0.35	182.1
		May 10, 2022	0.52	181.9
BH21-6	184.1	Nov 11, 2021	0.54	183.6
		May 10, 2022	0.66	183.4
		June 27, 2022	0.78	183.3
BH21-8	183.6	Nov 11, 2021	1.37	182.2
		May 10, 2022	1.11	182.5
		June 27, 2022	1.12	182.5
BH21-9	183.5	Nov 11, 2021	0.25	183.3
		May 10, 2022	**-0.5**	184.0
		June 27, 2022	0.97	182.5
BH21-11	184.3	Nov 11, 2021	3.47	180.8
		May 10, 2022	0.77	183.5
		June 27, 2022	0.57	183.7
BH21-13	183.4	Nov 11, 2021	0.55	182.8
		May 10, 2022	0.52	182.9
BH21-14	183.6	Nov 11, 2021	0.56	183.1
		May 10, 2022	0.67	182.9
BH21-16	183.4	Nov 11, 2021	4.43	179.0
		May 10, 2022	0.54	182.9
		June 27, 2022	0.72	182.7
BH22-01	184.3	March 25, 2022	1.57	182.7
		April 12, 2022	1.33	183.0
		June 27, 2022	1.18	183.1
BH22-02	183.6	April 12, 2022	1.15	182.4
		June 27, 2022	0.17	183.4
BH22-03	184.0	March 25, 2022	0.15	183.8
		April 12, 2022	0.28	183.7
		June 27, 2022	0.87	183.1

Data loggers were also installed at selected monitoring well locations to allow for continuous measurement of the groundwater level between January 3, 2023 and January 18, 2023. Selected monitoring wells were purged dry and reinstalled with second set of data loggers on January 18, 2023 to allow continuous measurement of groundwater level between January 18, 2023 and August 17, 2023. The data obtained from these data loggers have been illustrated as follows:









The available ground water data to date indicates a groundwater level on the order of approximately 0.5 to 1.5 metres below the existing ground surface, varying with the physical topography. This corresponds to groundwater elevations of approximately 182.5 to 183.8 metres. It is noted that indication of a slight artesian condition was noted in well installed at Borehole No. 11 with ground water level noted above existing ground surface. Given the span of time and time of the year the readings have been taken, it is anticipated that the observed readings would be indicative of a 'seasonal' high during the wet spring season. Depending on the depth of the proposed excavation and timing of construction, it may be prudent to advance a series of test pits to assess first hand the effect groundwater conditions on the proposed excavations during earthworks and servicing.

4. EARTHWORKS AND GRADING CONSIDERATIONS

As noted above, the subsurface soils within the depths of construction, or influence of construction, are predominantly silty clay. The silty clay has a typical very stiff 'weathered crust' in the upper about 2.5 to 4 metres, underlain by a variable firm to soft zone ranging in thickness from effectively zero to as much as perhaps 4 metres. The very stiff 'crust' tends to be over consolidated, while the 'soft' zone tends to be normally to slightly over consolidated. The presence of the underlying normally to slightly over consolidated clay layer does present the potential for consolidation settlements as a result of stress change such as from the placement of fill to raise the grade.

Reviewing the current proposed grading plan the depth of fill placement over the site is on the order of approximately 0.5 to 3 metres, with isolated peak depths of as much as 4 metres. In general, the depth of fill placement over areas of the site where the 'soft' clay zone is present tend to be on the order of 2.5 metres and less. Such a modest raise in the grade is not considered likely to mobilise significant consolidation settlements, and can be readily accommodated through suitable planning and staging of the earthworks.

The degree of potential settlements associated with the proposed grading would be relatively low, though not zero. However, any such minor settlements would occur over a wide area, based on a wide area of fill placement, such that there would be essentially negligible potential for acute or significant differential settlements over a short distance. This further reduces the degree of concern for potential consolidation settlements that would affect the support of services, roads or foundations.

A further consideration with respect to potential for consolidation settlement of the underlying soft to firm clay, is the timeline of such settlements to occur. While larger potential settlements can take several months or even years to manifest, considering the degree of load change [i.e. raise in grade] any such minor consolidation settlements would be likely to occur within a timeframe on the order of perhaps 3 to 9 months. As such, it would be prudent to consider the schedule of earthworks and site development to further minimize the potential for settlements to impact the site development. In this case, the greatest depth of fill placement should be conducted at the outset of earthworks. Where possible the fill works should be conducted to pregrade level sufficiently in advance of site servicing, ideally allowing a delay of 3 to 6 months. This will allow the majority of any potential settlements to occur prior to the completion of site servicing and roadway construction, such that support for proposed houses would be unaffected.

As noted above, the static groundwater level tends to be relatively shallow across much of the site, on the order of 0.5 to 1.5 metres below the existing grade, in the range of 182.5 to 183.8 metres elevation. In this regard, raising the grade of the site as much as possible will be helpful to reduce the potential for interaction with the groundwater during development. It is recommended that the design basement elevations be a minimum of 0.5 metres, and preferably greater as much as possible, above the establish groundwater level. The current preliminary grading plan indicates the grade to be rising by approximately 0.5 to as much as 3 metres. This should effectively raise the level of proposed foundations for low-rise residential buildings such that there would be no long-term interaction with the groundwater. For any proposed mid-rise buildings with underground parking levels it would be recommended to conduct a more detailed specific review the grading and groundwater conditions as part of the detailed design for a given building.

5. EXCAVATIONS

Excavations for the installation of foundations and underground services are anticipated to extend to depths of up to approximately 1 to 6 metres below the existing grade. Excavations through the native silty clay/clayey silt and sandy silt/silt soils above the groundwater level should be relatively straightforward, with the sides remaining stable for the short construction period at slopes of up to 45 to 60 degrees to the horizontal, respectively. However, where excavations extend below the static groundwater level, during periods of extended precipitation or during ‘wet’ times of the year, increased excavation instability should be anticipated, which may cause excavations to ‘slough in’ to as flat as 3 horizontal to 1 vertical, and as such, wider excavations should be anticipated, and the contractor should be prepared to work in the ‘wet’. Nevertheless, all excavations must comply with the current Occupational Health and Safety Act and Regulations for Construction Projects. Excavation slopes steeper than those required in the Safety Act must be supported or a trench box must be provided, and a senior geotechnical engineer from this office should monitor the work. With respect to the Act, the majority of the soils would be considered as Type 3 soil, with the stiff native silty clay soils considered as Type 2 soil. Nonetheless, considering the variable depths of materials and ground water conditions across the site, the onsite soils should be conservatively be considered Type 3 soils for the purposes of excavation planning.

Excavation bases will be prone to disturbance and localized instability, largely as a function of the prevailing weather conditions, depth of excavation, and moisture condition of the subsurface soils. It should be anticipated that it may be necessary to provide base stabilization with additional bedding or ballast stone, or a layer of coarse crushed stone. This is best assessed in the field at the time of construction.

As noted above, the static groundwater level is estimated at a depth of approximately 0.5 to 1.5 metres below existing ground surface, elevation 182.5 to 183.8 metres, with excavations likely extending to or below this level. As noted above, where feasible, it would be prudent to raise the grade with engineered fill to raise dwelling foundations and roadways, and reduce the scale of the excavations which may be affected by shallow groundwater conditions.

Based on the preliminary grading plans provided to our office, the grade will be raised such that excavations for watermain and storm sewer installation will extend to depths on the order of 1.0 to 1.5 metres below the existing grade, at to slightly below the groundwater level. Excavations for sanitary sewers will extend as much as approximately 5 to 6 metres below the existing grade, well below the groundwater level.

Excavations should begin at the ‘low end’ of the sewer alignment to allow drainage away from the work area. Work should be coordinated so that a section of pipe is installed as quickly as possible after excavation, and is provided with an initial cover of at least 0.6 to 0.9 metres of backfill within the same day it is installed, in particular for sanitary sewer pipe in deeper excavations. Surface water should be directed away from the excavation.

The initial volume of infiltration may be greater, but would tend to reduce with time and pumping, depending on weather conditions during construction. The generally low permeability silty clay/clayey silt and sandy silt/silt soils should yield a relatively low rate of groundwater infiltration such that it should be possible to adequately control groundwater infiltration for the short construction period using conventional construction dewatering techniques for excavations extending near to as much as perhaps 1 to 3 metres below the static groundwater level. More water should be expected when connections are made to existing services. Surface water should be directed away from the excavations.

It is anticipated that typical temporary construction dewatering volumes would be below a rate of 50,000 L/day. For greater excavation depths, or lengths, the volume of dewatering may be greater, up to 400,000 L/day, such that an EASR notification may be warranted. The need for a Permit to Take Water [PTTW] is not expected to be required for site servicing. Buildings with basement levels to greater depth may have increased dewatering requirements, however these are best assessed during the design stage on a case by case basis for specific buildings.

Additionally, it is noted that the final grading of the site relative to the existing grade will affect the required depth of excavation below the existing grade and groundwater level, with an overall increase in the site grade being generally beneficial, tending to reduce the potential and extent of groundwater infiltration. This is particularly relevant with respect to establishing the founding level and basement level of proposed dwellings, to be above the established static groundwater level and avoid the potential for frequent or ongoing operation of sump pumps.

The base of the excavations in the native soils, above the groundwater level, encountered in the boreholes should generally remain firm and stable. As such, standard pipe bedding material as specified by the Ontario Provincial Standard Specification [OPSS] should be satisfactory, however as noted some base stabilisation may be required where excavations extend deeper, or where shallow groundwater conditions are encountered. 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.

For service trenches extending below the groundwater level, consideration should be made for the provision of clay ‘cut-offs’ within the trench backfill. In particular within the deeper sanitary sewer trenches. The clay cut-offs would typically be installed just beyond manholes for a given section of sewer, and could consist of suitably plastic silty clay soil available on site and/or the use of a bentonite clay material mixed with granular. This later option is often more effective for the replacement of bedding and initial cover over the pipe, before switching to suitable clay soil fill.

6. SEISMIC DESIGN CONSIDERATIONS

The structure shall be designed according to Section 4.1.8 of the Ontario Building Code, Ontario Regulation 332/12. Based on the subsurface soil conditions encountered in this investigation the applicable Site Classification for the seismic design is Site Class D, stiff soil, based on the average soil characteristics for this site. It is noted that a seismic site class of C may be available, however would need to be confirmed via site specific shear wave velocity testing.

The seismic data from Supplementary Standard SB-1 of the Ontario Building Code for Welland are as follows;

$S_a(0.2)$	$S_a(0.5)$	$S_a(1.0)$	$S_a(2.0)$	$S_a(5.0)$	$S_a(10.0)$	PGA	PGV
0.308	0.150	0.069	0.0310	0.0074	0.0028	0.199	0.115

7. BACKFILL CONSIDERATIONS

The excavated materials will primarily consist of the silty clay/clayey silt and sandy silt/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, debris, or other deleterious material, and that their moisture contents can be controlled to within 3 percent of their standard Proctor optimum moisture content. Some selective sorting to remove organics, debris, and other unsuitable materials should be expected.

It is noted that the fine grained to cohesive soils encountered are not considered to be free draining, and should not be used where this characteristic is required. It is also noted that these soils present difficulties in achieving effective compaction where access with compaction equipment is restricted. The silty clay/clayey silt and sandy silt/silt soils are generally considered to be near to slightly 'wet' of their standard Proctor Optimum moisture content. Some moisture conditioning may be required depending upon the weather conditions at the time of construction. It is noted that these 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.

The use of free draining, well-graded granular material, such as Ontario Provincial Standard Specification [OPSS] Granular 'B' Type II (crushed limestone bedrock), is recommended for backfill against the foundation walls or to raise the interior grade to the design subgrade level. This material is more readily compacted in restricted access areas, and generally presents a more positive support condition for interior floor slabs and exterior concrete sidewalks.

We note that where the 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 the fill structure is reduced. Correspondingly, the shear strength of the 'wet' backfill material is also lowered, thereby reducing its ability to support construction traffic and therefor impacting 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 fine grained to cohesive soils 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 placement moisture content of the backfill soils be within 3 percent of their standard Proctor optimum moisture content during placement and compaction to minimise 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 percent 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 compacted to a minimum of 98 percent of its 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.

8. MANHOLES, CATCH BASINS AND THRUST BLOCKS

Properly prepared bearing surfaces for manholes, valve chambers, etc. in the native competent soils, stabilised 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 compaction of the fill around these structures is not adequate, causing 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 100 per cent of its standard Proctor maximum dry density.

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 150 kPa [~3,000 psf]. Any backfill required behind the blocks should be a well-graded granular product and should be compacted to 100 per cent of its standard Proctor maximum dry density.

9. STORM WATER MANAGEMENT POND CONSIDERATIONS

It is understood that multiple Storm Water Management [SWM] ponds are proposed for the proposed site. The base of the proposed ponds within the native silty clay/clayey silt soils should generally remain firm and stable. However, depending on the proposed depth of the pond the base may potentially become locally unstable as a function of the pond base elevation versus the groundwater level and prevailing weather conditions. Such instability would be exacerbated by repeated travel of heavy construction equipment. These conditions will be made worse during wet weather, and so it is recommended that site works be conducted during the dry summer months of the year, where possible. It would be reasonable to conduct the initial grading of the SWM pond to or slightly above the final base contours. These initial 'pre-grade' contours could then be maintained during construction of site grading and servicing and then the pond completed near the end of site servicing works. This would have the benefit of providing a demonstration of how the pond can be expected to perform in the long-term and allow any necessary changes to be made to the design prior to completion of construction.

Another design consideration in the long-term performance of the SWM pond will be the need to accommodate the infiltration/exfiltration of natural groundwater to allow the pond to provide the maximum storage volume for storm water detention. Given the observed static groundwater levels it is anticipated that groundwater movement will be either infiltration into the pond or exfiltration from the pond as a function of the design base elevation, permanent pool elevation and seasonal fluctuation in groundwater levels. The low permeable silty clay soils will yield a low rate of infiltration in the short-term, in the long-term [over yearly cycles] the groundwater must be expected to stabilize near the levels as estimated above.

Based on information available to date, it would appear that the most appropriate approach to the seepage conditions and storm water management on this site would be to provide a low permeability layer over the base of the pond to resist the infiltration or exfiltration of groundwater, and of sufficient weight to resist any hydrostatic uplift pressures. This could be readily accomplished through the use of a re-compacted clay liner or with a weighed down proprietary liner system, etc. The weight of the liner system would have to exceed the uplift pressure of the ground water during the most severe periods of the year, likely when maximum storage is required. In approximate terms for example, one metre of clay liner, or equivalent, would be required for about every two meters of water storage below static ground water level, i.e., when the water level [permanent pool elevation] in the pond is 2 metres below the static ground water table, the clay liner would have to be at least 1 metre thick; if 3 metres below the static level, then 1.5 metres thick, etc.

An impermeable compacted clay liner would consist of a sufficiently plastic clay soil, with a recommended minimum clay content of 20 per cent and plasticity index of 7 or more. Based on the grain size analyses presented above, the on-site silty clay soils would be considered suitable for use in the construction of a low permeable or impermeable liner at the base of the SWM pond to resist the infiltration/exfiltration of groundwater. This may be readily accomplished by working the silty clay in the base of the pond to a depth of perhaps 0.5 metres, such as with a heavy disc, to break apart any natural structure or layering. The liner material should be moisture conditioned to be within 2 per cent below to 4 per cent above optimum moisture content and compacted in place to 95 per cent of standard Proctor maximum dry density [SPMDD].

Alternatively, weighed down proprietary liners could be considered, however the material suppliers of such materials (such as Layfield, Terrafix, Suprema) would have to be consulted for recommendations on the appropriate product and installation methods for the site conditions. Such artificial liners would not require compaction efforts and could be weighed down with practically any available soil or granular material.

The final design interior pond slopes in the native overburden or constructed using the on-site silty clay should be at 4 horizontal to 1 vertical, or flatter, and the exterior slopes of any berms, where required, at 3 horizontal to 1 vertical, or flatter. Should steeper slopes be required it will be necessary to provide some form of stabilization, such as with the placement of coarse 'rip-rap' stone, or proprietary product such as Turfstone or Cable-Crete, or constructed as a reinforced earth embankment. It is recommended that all interior pond slopes be provided with at least some form of nominal stabilization/protection to control erosion/loss of ground. Above the extended pond level this may consist of appropriate vegetation.

Material utilised in construction of pond slopes must be free of significant organic deposits, or any other deleterious materials which would affect stability of the pond walls. Our office should be retained to review any imported material to the site, as well as to provide quality control services during construction.

It is also noted that appropriate care and effort will be required by the contractor around inlet and outlet structures to ensure the impermeable liner is continuous and avoid the potential of 'piping'. In this regard the clay liner should be completely constructed prior to the installation of inlet/outlet structures. If necessary, a bentonite clay material could be utilized within the fill around any structures to provide a continuous impermeable seal.

10. PAVEMENT DESIGN CONSIDERATIONS

All areas to be paved should be stripped of all organic or otherwise unsuitable materials. The exposed subgrade should be 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 must be sub-excavated and replaced with suitable backfill material. Alternatively, the soft areas may be stabilized by placing coarse crushed stone and 'punching' it into the soft areas. Where the subgrade condition is poorer it may be necessary to implement more aggressive stabilization methods, such as the use of coarse aggregate [50-millimetre clear stone, 'rip rap', etc.] 'punched' into the soft areas, or the use of stabilizing geogrid and a geofabric separator. The need for the treatment of softened subgrade will be reduced if construction is undertaken during the dry summer months and careful attention is paid to the compaction operations. The fill over shallow utilities cut into or across paved areas such as telephone, hydro, gas, etc. must also be compacted to 100 per cent of its SPMDD.

Good drainage provisions will optimize 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 mitigate 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 may have to 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 during the Fall and Spring months, or during colder winter weather, it should be anticipated that additional subgrade preparation will be required, such as additional depth of Ontario Provincial Standard Specification [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 confirm to the appropriate municipal standard. The suggested pavement structures outlined in Table D below may also be considered. These are based on 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 D – 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.

Depending on the anticipated traffic, a reduced light duty asphalt structure consisting of 65 millimetres of HL3 surface course may also perform sufficiently. This would be reasonable in areas subjected only to light vehicles such as cars for parking. Such a structure may have a reduced lifespan if subjected to heavier vehicles, and would also not allow for ‘mill and pave’ type operations for future rehabilitation.

To minimize segregation of the finished asphalt mat, the asphalt temperature must be maintained uniform throughout the mat during placement and compaction. All too 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 contractor 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.

11. FOUNDATION CONSIDERATIONS

11.1 HOUSE AND TOWNHOUSE CONSTRUCTION

It is anticipated that the design founding level for residential dwellings and townhouse blocks will extend to depths of up to approximately 0.5 to 1 metres below the existing grade. The construction of foundations at or above this depth should be relatively straightforward when above the static groundwater level. The static groundwater level, as noted above, is anticipated to be at depths ranging from 0.5 to 1.5 metre below the existing grade, roughly elevation 182.5 to 183.8 metres. Depending on the final grading of the property, and final founding elevations of the proposed residences, it would be prudent to raise the finish grade and/or founding level of the proposed structures to avoid potential interaction with the static groundwater level. It is noted that our office has been provided with the preliminary cut-fill plan of the proposed development, which indicates the grading to be rising such that the founding levels for townhouse blocks will be above the static groundwater level. This should be further reviewed as part of detailed design for the development.

The native soils encountered at these depths 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. Spread footings in the native silty clay/clayey silt soils, may be conservatively designed on the basis of bearing values of 150 kPa [~3,000 psf] SLS and 225 kPa [~4,500 psf] ULS. The founding surfaces must be hand cleaned of any loose or disturbed material, along with any ponded water, immediately prior to placement of foundation concrete.

In the event that site grading work results in engineered fill below founding elevations, the general recommendations presented in the Backfill Considerations above should be strictly adhered to, with compaction to 100 percent standard Proctor maximum dry density, verified by monitoring and testing by a representative of SOIL-MAT ENGINEERS present on a full time 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 a more thorough evaluation of the engineered fill works. If there is a short fall in the volume of fill required, then the source of imported fill should be checked for gradation, Proctor value, and compatibility with existing fill and approved by this office.

If there is a short fall in the volume of suitable fill required, then the source(s) 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. Soil import would need to be conducted in accordance with Ontario Regulation 406/19, including the preparation of a Fill Management Plan and associated tracking, analytical testing, etc.

It is noted that the SLS value represents the Serviceability Limit State, which is governed by the tolerable deflection [settlement] based on the proposed building type, using unfactored load combinations. The ULS value represents the Ultimate Limit State and is intended to reflect and upper limit of the available bearing capacity of the founding soils in terms of geotechnical design, using factored load combinations. There is no direct relationship between ULS and SLS; rather they are a function of the soil type and the tolerable deflections for serviceability, respectively. Evidently, the bearing capacity would be lower for very settlement sensitive structures and larger for more flexible buildings.

The support conditions afforded by the native soils and/or engineered fill are generally not uniform across the building footprint, nor are the loads on the various foundations 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 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 minor settlements, heaving, shrinkage, etc. and will assist in resisting the pressures generated against the foundation walls by the backfill. Such nominal reinforcement is an economical approach to the reduction and prevention of costly foundation repairs after completion and later in the life of the buildings. This 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 millimeters from the top of the foundation walls at a minimum, depending on 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 continuous tensile capacity of the reinforcement. Where footings are founded on, or partially on, engineered fill the above provision for nominal reinforcement would be required.

All basement foundation walls should be suitably damp proofed, 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 positive sump pit a minimum of 150 millimetres below the basement floor slab. The clear stone material surrounding the weeping tile should be encased with a geotextile material to prevent the migration of fines from the foundation wall backfill into the clear stone product. In the event that sump pit systems are required we would recommend that 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 meters of earth or equivalent insulation to protect against frost penetration. This frost protection would also be required if construction were undertaken during the winter months. All footings must be proportioned to satisfy the requirements of the Ontario Provincial Building Code.

In areas where it will be necessary to provide adjacent footings at different founding elevations, the lower footing should be constructed before the higher footing is constructed, if possible, and the higher footing should be set below and imaginary line drawn up from the lower footing at 10 horizontal to 7 vertical. This practice will limit stress transfer from the higher footings to lower footings.

With foundations designed as outlined above and as required by the Ontario Building Code, and with careful attention paid to construction detail, total and differential settlements should be well within normally tolerated limits of 25 and 20 millimetres respectively, for the type of building and occupancy expected.

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.

11.2 MID-RISE BUILDING CONSTRUCTION

It is understood that the project may involve the construction of mid-rise residential buildings with 1 to 2 basement parking levels on east side of the site. Given the potential for up to two basement levels, is it anticipated that foundations will be on the order of approximately 3 to 6 metres below the existing grade. These depths are such that it would be expected to be below the static groundwater level. As such it is recommended that basement levels would be designed to be water tight, pending more detail building specific review.

On a preliminary basis the following design considerations are provided for foundations, noting that building specific geotechnical evaluation, including additional investigations as warranted based on building details and location on the site, and updated geotechnical reporting should be undertaken.

Spread footings in the native soils may be conservatively designed on the basis of bearing values of 100 kPa [~2,000 psf] SLS and 150 kPa [~3,000 psf] ULS. Raft slabs founded on the native sandy silt/silt soils may be designed considering an allowable bearing pressure of 75 kPa [~1,500 psf] SLS, and 100 kPa [~2,00 psf] ULS. However, it is anticipated that these values would not be sufficient for the proposed structure, without being used in some combination with deep foundation schemes, or ground improvement methods, discussed below. Nonetheless, for lightly loaded accessory structures, these values may be acceptable.

Based on the proposed building and subsurface conditions, it is likely that a foundation design making use of ground improvement or deep foundation systems would be preferred. This would be a function of the height of the proposed buildings and is best evaluated on a building specific basis.

12. SOIL IMPORT CONSIDERATIONS

Ontario Regulation 406/19 has come into effect, which regulates the management of surplus soil generated as part of construction projects. The Regulation is volume based, requiring site specific environmental assessments and considerable background analytical testing of surplus soils to be exported from, or imported to, the site. In this case it is understood that a significant volume of fill import will be required for the project. With a fill import of greater than 10,000 m3, this would require the filling of a Notice in the Excess Soil Registry, along with proper planning documents and tracking as required by the Regulation. Soil-Mat Engineers can assist with the preparation of a formal Fill Management Plan to provide direction on the plan and requirements for managing the fill import, including review and approval of fill source sites, managing the soil registry notice, etc.

13. 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.

Chauhan

Ishan Chauhan, B.Eng., EIT.
Junior Engineer

Ian Shaw, P. Eng.
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
June 20/24
I. D. SHAW
100042315
IS
PROVINCE OF ONTARIO

Enclosures: Drawing No.1, Borehole Location Plan
Log of Borehole Nos. 1 to 13, inclusive

Distribution: Primont (Thorold/Welland) Inc. [1, plus pdf]

LEGEND

⊕ BH#	Borehole Location
⊕ BH#	Borehole Location of DS Consultants Investigation.

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Report No. SM 220530-G.

2. Borehole locations are approximate.

SOIL-MAT

ENGINEERS & CONSULTANTS LTD.

Proposed Residential Development
Quaker Road and First Avenue, Welland, Ontario

Borehole Location Plan

Project No. SM 220530-G

Date: December 2022

Drawn: IC | Checked: IS

SM 220530-G
Borehole Location Plan

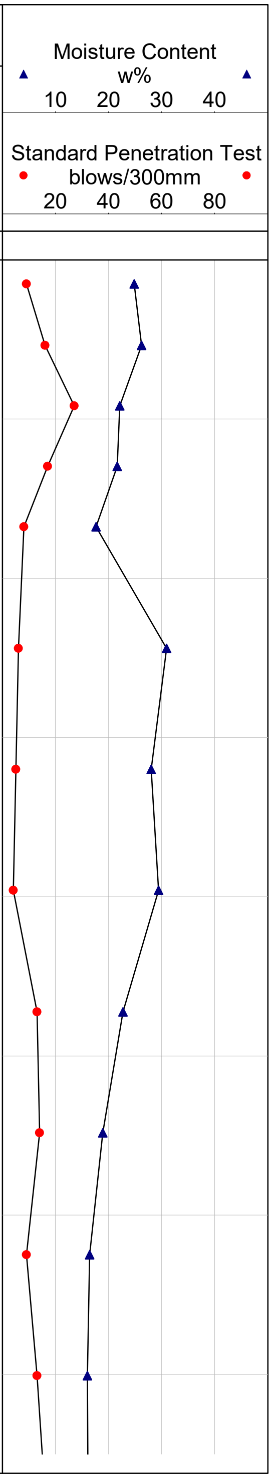
Drawing No. 1

Log of Borehole No. 1

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765186
E: 641731

Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	183.32		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	3,3,6,8	9	■	<1.0	
			Silty Clay/Clayey Silt Brown to reddish brown, some organics in upper levels, firm to very stiff.		SS	2	7,7,9,13	16	■	>4.5	
					SS	3	7,11,16,19	27	■	>4.5	
					SS	4	5,7,10,13	17	■	2.5	
	179.82		Transition in colour to grey.		SS	5	4,3,5,6	8	■	1.5	
					SS	6	3,2,4,5	6	■	<1.0	
					SS	7	2,2,3,4	5	■	<1.0	
					SS	8	1,2,2,4	4	■	<1.0	
	174.64		**Sandy Silt/Silt** Reddish brown, occasional gravel, loose to very dense.								
					SS	9	6,6,7,8	13	■		
					SS	10	6,7,7,6	14	■		
					SS	11	3,3,6,7	9	■		
					SS	12	4,6,7,10	13	■		



Drill Method: Hollow Stem Augers
Drill Date: December 07, 2022
Hole Size: 200 Millimetres
Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.
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Datum: Geodetic
Field Logged by: IC
Checked by: IS
Sheet: 1 of 2

Log of Borehole No. 1

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765186
E: 641731

Depth: 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
					SS	13	4,6,10,12	16	■		
					SS	14	6,6,8,8	14	■		
					SS	15	5,7,13,16	20	■		
	162.90				SS	16	9,24,48,50/5"	72	■		

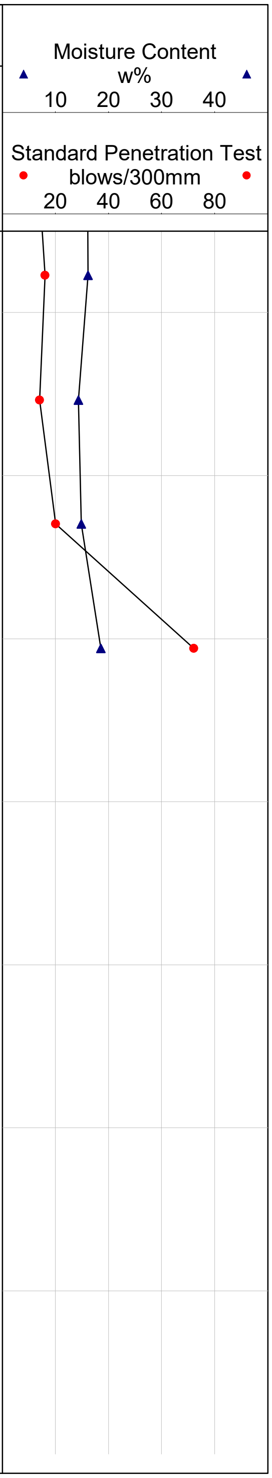
End of Borehole

NOTES:

1. Borehole was advanced using solid stem auger equipment on December 07, 2022 to termination at a depth of 20.4 metres.

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

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



Drill Method: Hollow Stem Augers
Drill Date: December 07, 2022
Hole Size: 200 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic
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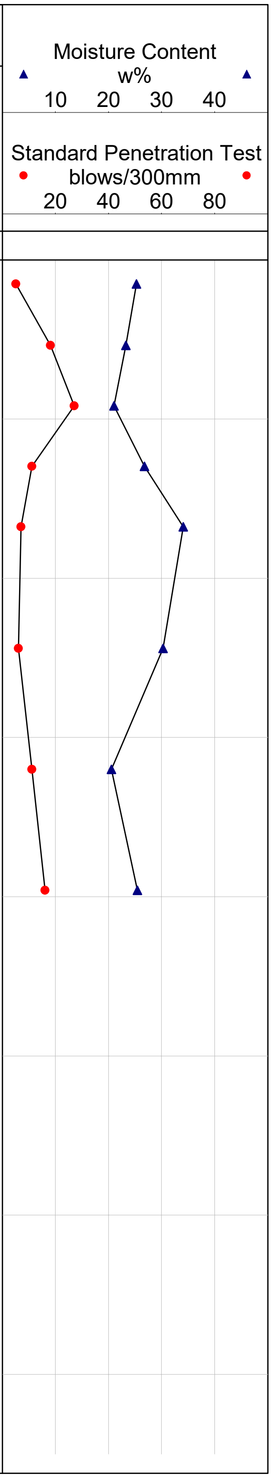
Checked by: IS
Sheet: 2 of 2

Log of Borehole No. 2

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.
Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765226
E: 641680

Depth (m)	Elevation (m)	Description
0	183.26	Ground Surface
0.3	182.96	**Topsoil** Approximately 300 millimetres of topsoil.
		Silty Clay/Clayey Silt Brown, occasional gravel, firm to very stiff.
2.4	180.83	Transition in colour to grey.
5.3	177.93	**Sandy Silt/Silt** Reddish brown, compact.
8.2	175.04	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,2,3,5	5	▨	2.0	
SS	2	5,7,11,14	18	▨	>4.5	
SS	3	6,11,16,21	27	▨	>4.5	
SS	4	4,5,6,7	11	▨	1.0	
SS	5	4,3,4,6	7	▨	1.5	
SS	6	2,3,3,5	6	▨	<1.0	
SS	7	5,5,6,10	11	▨		
SS	8	4,7,9,9	16	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.

2. Borehole was recorded as caved to 6.0 metres and 'Wet' at a depth of 4.8 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

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

Drill Method: Solid Stem Augers
Drill Date: December 06, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic
Field Logged by: IC
Checked by: IS
Sheet: 1 of 1

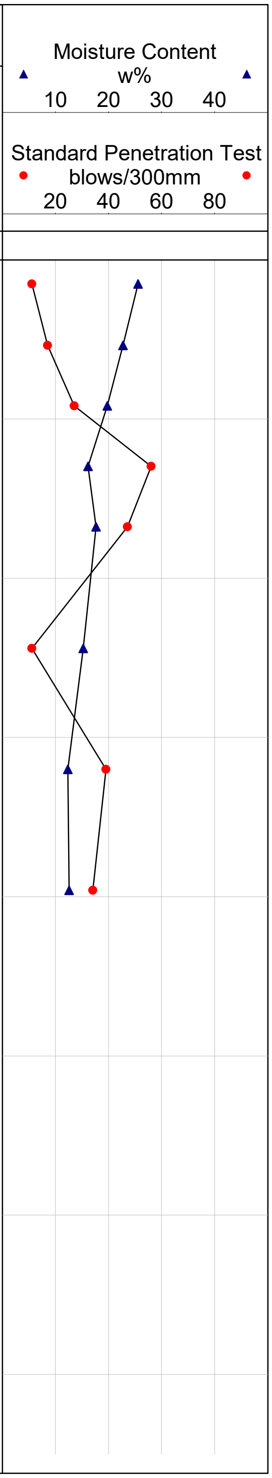
Log of Borehole No. 3

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765364
E: 641633

Depth	Elevation (m)	Description
0	183.80	Ground Surface
0		**Topsoil** Approximately 200 millimetres of topsoil.
		Silty Clay/Clayey Silt Brown, occasional gravel, firm to very stiff.
2	181.60	**Sandy Silt/Silt** Reddish brown, more silt content with depth, trace clay, compact to dense.
8	175.58	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	3,4,7,5	11	▨	>4.5	
SS	2	5,7,10,12	17	▨	>4.5	
SS	3	8,11,16,22	27	▨	>4.5	
SS	4	22,26,30,44	56	▨		
SS	5	21,23,24,20	47	▨		
SS	6	5,6,5,8	11	▨		
SS	7	7,17,22,22	39	▨		
SS	8	13,16,18,23	34	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.

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

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

Drill Method: Solid Stem Augers
Drill Date: December 06, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic
Field Logged by: IC
Checked by: IS
Sheet: 1 of 1

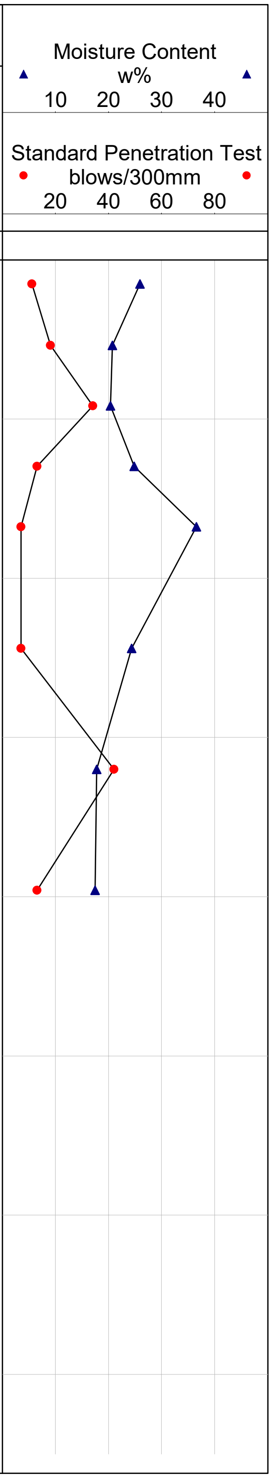
Log of Borehole No. 4

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765208
E: 641522

Elevation (m)	Description
183.54	Ground Surface
	Topsoil Approximately 200 millimetres of topsoil.
	Silty Clay/Clayey Silt Brown, firm to hard.
180.65	Transition in colour to grey.
177.30	**Sandy Silt/Silt** Reddish brown, trace clay, compact to dense.
175.32	End of Borehole

Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
	SS	1	4,5,6,8	11	■	>4.5	
	SS	2	5,7,11,16	18	■	>4.5	
	SS	3	8,15,19,25	34	■	>4.5	
	SS	4	5,6,7,10	13	■	2.0	
	SS	5	3,3,4,5	7	■	<1.0	
	SS	6	2,3,4,4	7	■	<1.0	
	SS	7	5,20,22,28	42	■		
	SS	8	6,6,7,7	13	■		



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.

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

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

Drill Method: Solid Stem Augers
Drill Date: December 06, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

Datum: Geodetic
Field Logged by: IC
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 5

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765091
E: 641718

Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
ft m 0	183.12		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	1,1,1,4	2	■	>4.5	
			Silty Clay/Clayey Silt Brown to reddish brown, firm to very stiff.		SS	2	6,8,11,17	19	■	>4.5	
					SS	3	5,8,11,17	19	■	>4.5	
					SS	4	5,6,8,10	14	■	>4.5	
					SS	5	3,3,4,4,	7	■	<1.0	
	179.01		Transition in colour to grey.								
					SS	6	3,2,3,3	5	■	<1.0	
					SS	7	2,2,2,4	4	■	<1.0	
	176.42		End of Borehole								

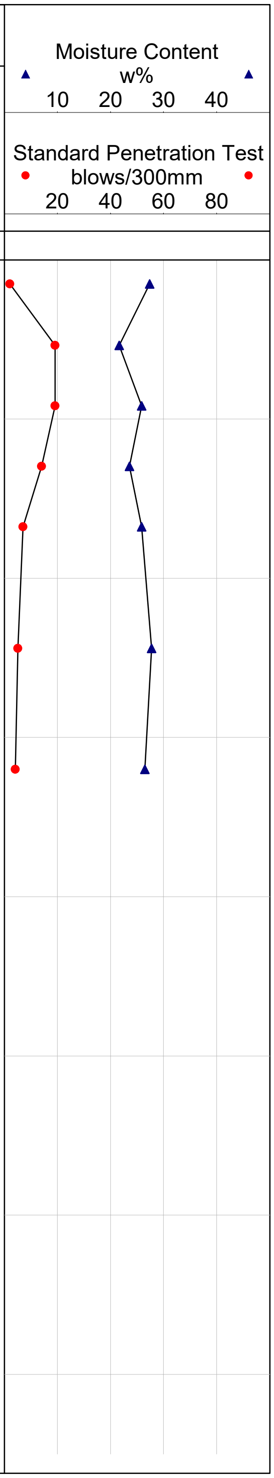
NOTES:

1. Borehole was advanced using solid stem auger equipment on December 07, 2022 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 and the following groundwater level readings have been measured:
January 3 2023 : 0.83 metres



Drill Method: Solid Stem Augers
Drill Date: December 07, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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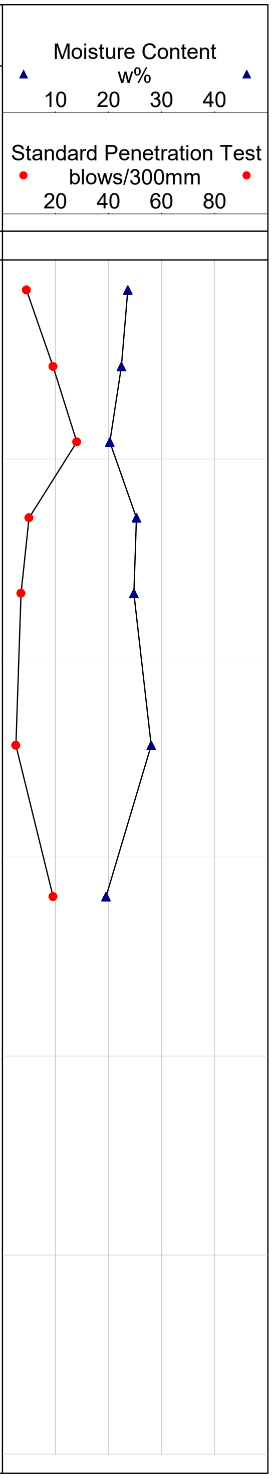
Log of Borehole No. 6

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765198
E: 641374

Elevation (m)	Description
183.83	Ground Surface
	Topsoil Approximately 200 millimetres of topsoil.
	Silty Clay/Clayey Silt Brown, firm to very stiff.
181.09	Transition in colour to grey.
177.59	**Sandy Silt/Silt** Reddish brown, compact.
177.13	End of Borehole

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,4,5,7	9	▨	>4.5	
SS	2	5,8,11,14	19	▨	>4.5	
SS	3	6,9,19,22	28	▨	>4.5	
SS	4	4,5,5,6	10	▨	1.0	
SS	5	2,3,4,5	7	▨	<1.0	
SS	6	2,2,3,5	5	▨	<1.0	
SS	7	5,7,12,17	19	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'Wet' at a depth of 5.9 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

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

Drill Method: Solid Stem Augers
Drill Date: December 08, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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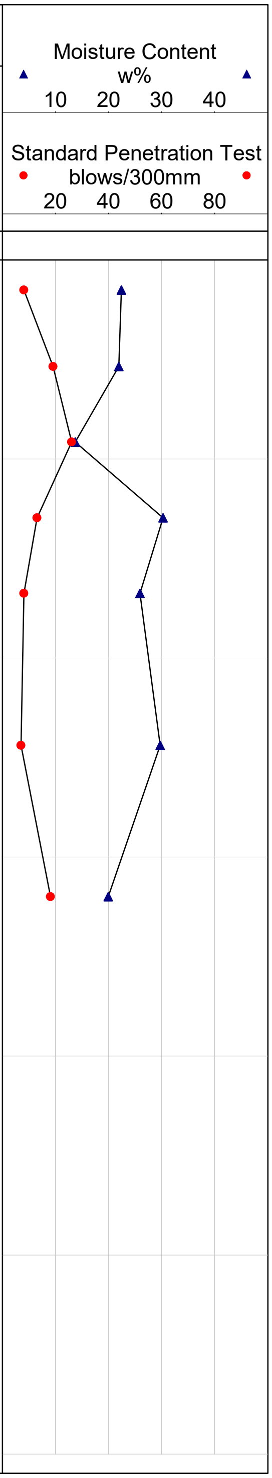
Log of Borehole No. 7

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765042
E: 641421

Depth (m)	Elevation (m)	Description	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0	183.52	Ground Surface							
	183.27	**Topsoil** Approximately 250 millimetres of topsoil.	SS	1	1,3,5,6	8		>4.5	
		Silty Clay/Clayey Silt Brown, firm to very stiff.	SS	2	5,7,12,18	19		>4.5	
			SS	3	6,12,14,18	26		>4.5	
			SS	4	5,6,7,10	13		2.0	
			SS	5	3,4,4,7	8		2.0	
4	179.41	Transition in colour to grey.							
			SS	6	2,3,4,5	7		<1.0	
6	177.43	**Sandy Silt/Silt** Reddish brown, compact.	SS	7	8,9,9,9	18			
	176.82	End of Borehole							



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as caved to 5.9 metres 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 and the following groundwater level readings have been measured:
January 3 2023 : 1.6 metres

Drill Method: Solid Stem Augers
Drill Date: December 08, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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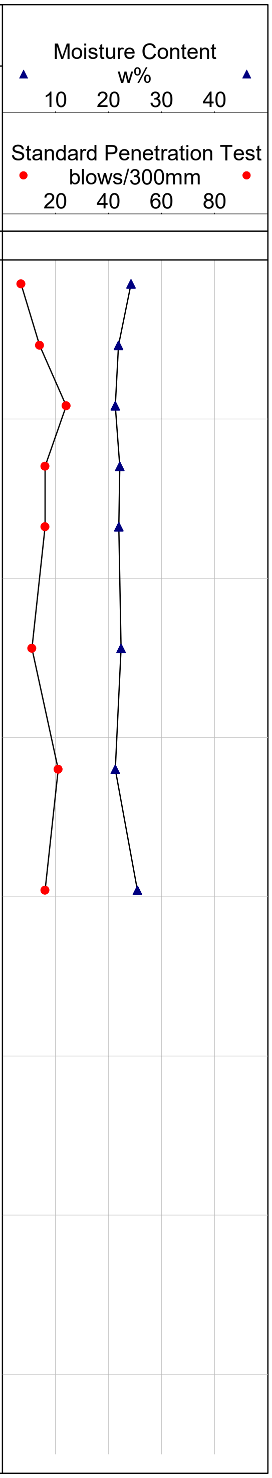
Log of Borehole No. 8

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765199
E: 641192

Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
ft m 0	184.94		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	2,3,4,6	7	▇	2.0	
			Silty Clay/Clayey Silt Brown, occasional gravel, firm to very stiff.		SS	2	4,7,7,12	14	▇	4.0	
					SS	3	5,9,15,20	24	▇	>4.5	
					SS	4	4,6,10,15	16	▇	>4.5	
					SS	5	6,7,9,10	16	▇	4.0	
	180.83		Transition in colour to grey.								
					SS	6	4,4,7,11	11	▇	1.5	
	179.76		**Sandy Silt/Silt** Reddish brown, compact.								
					SS	7	4,9,12,17	21	▇		
					SS	8	6,7,9,9	16	▇		
	176.72		End of Borehole								



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 8.2 metres.

2. Borehole was recorded as caved to 7.3 metres and 'Wet' at a depth of 6.7 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

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

Drill Method: Solid Stem Augers
Drill Date: December 08, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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Log of Borehole No. 9

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765253
E: 641229

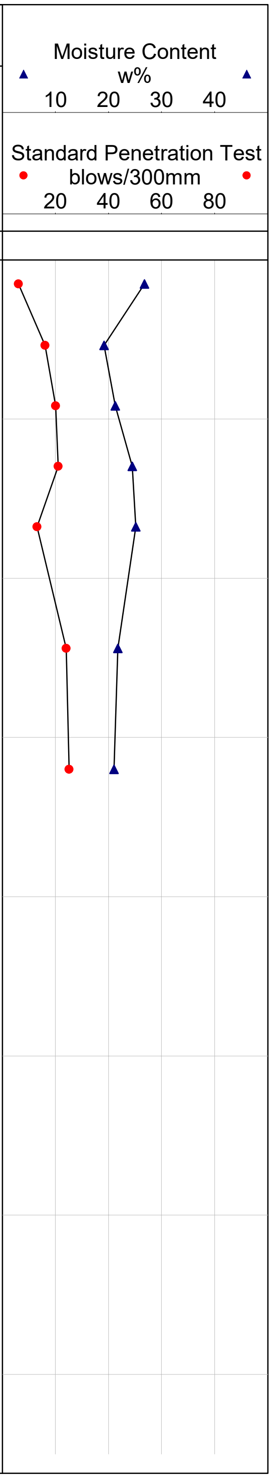
Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	184.05		Ground Surface								
	183.75		**Topsoil** Approximately 300 millimetres of topsoil.		SS	1	2,2,4,6	6	▇	4.0	
			Silty Clay/Clayey Silt Brown, firm to very stiff.		SS	2	6,7,9,11	16	▇	>4.5	
					SS	3	7,9,11,14	20	▇	>4.5	
					SS	4	5,9,12,17	21	▇	>4.5	
					SS	5	4,6,7,8	13	▇	<1.0	
	180.40		Transition in colour to grey.								
	179.94		**Sandy Silt/Silt** Reddish brown, compact.								
					SS	6	5,11,13,16	24	▇		
					SS	7	7,11,14,21	25	▇		
	177.35		End of Borehole								

NOTES:

1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as caved to 5.4 metres and 'Wet' at a depth of 5.3 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

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



Drill Method: Solid Stem Augers
Drill Date: December 08, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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Log of Borehole No. 10

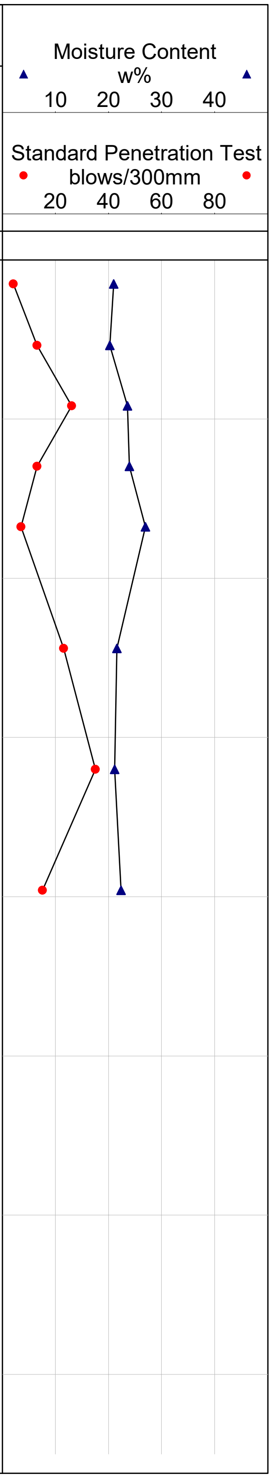
Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765588
E: 641174

Elevation (m)	Description
184.23	Ground Surface
	Topsoil Approximately 200 millimetres of topsoil.
	Silty Clay/Clayey Silt Brown, some organics in upper levels, firm to very stiff.
180.73	Transition in colour to grey.
180.12	**Sandy Silt/Silt** Reddish brown, compact to dense.
176.01	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,1,3,4	4	■	1.5	
SS	2	4,6,7,11	13	■	>4.5	
SS	3	5,11,15,18	26	■	>4.5	
SS	4	5,6,7,9	13	■	2.5	
SS	5	2,3,4,5	7	■	1.0	
SS	6	6,11,12,14	23	■		
SS	7	10,16,19,24	35	■		
SS	8	6,6,9,10	15	■		



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.

2. Borehole was recorded as caved to 6.4 metres and 'Wet' at a depth of 5.7 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

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

Drill Method: Solid Stem Augers
Drill Date: December 09, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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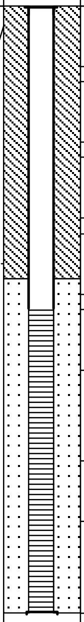
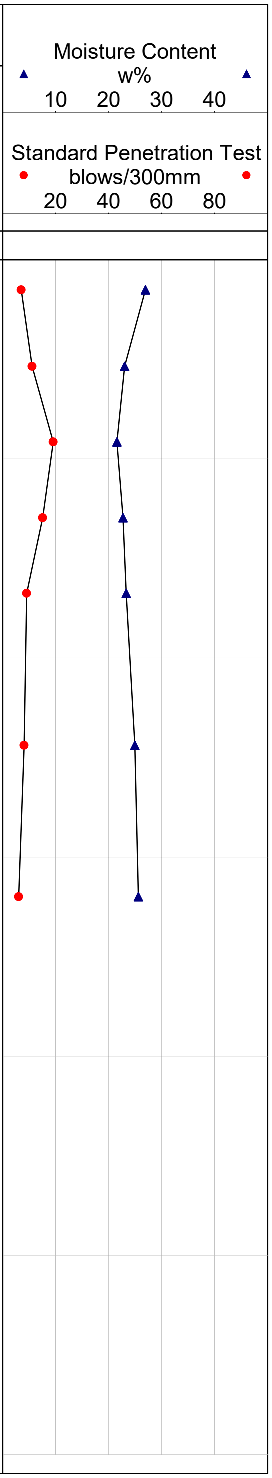
Log of Borehole No. 11

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.

Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765518
E: 641270

Elevation (m)	Description	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
183.23	Ground Surface							
	Topsoil Approximately 200 millimetres of topsoil.	SS	1	2,2,5,5	7	■	2.0	
	Silty Clay/Clayey Silt Brown, some organics in upper levels, firm to very stiff.	SS	2	3,4,7,11	11	■	>4.5	
		SS	3	4,7,12,16	19	■	>4.5	
180.64	Transition in colour to grey.	SS	4	4,7,8,10	15	■	2.5	
		SS	5	3,4,3,7	9	■	2.0	
		SS	6	3,3,5,7	8	■	1.5	
		SS	7	2,3,3,4	6	■	<1.0	
176.53	End of Borehole							





NOTES:

1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'Wet' at a depth of 5.4 metres upon completion and backfilled as per Ontario Regulation 903.

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

4. A monitoring well was installed and the following groundwater level readings have been measured:
January 3 2023 : 0.0 metres

Drill Method: Solid Stem Augers
Drill Date: December 09, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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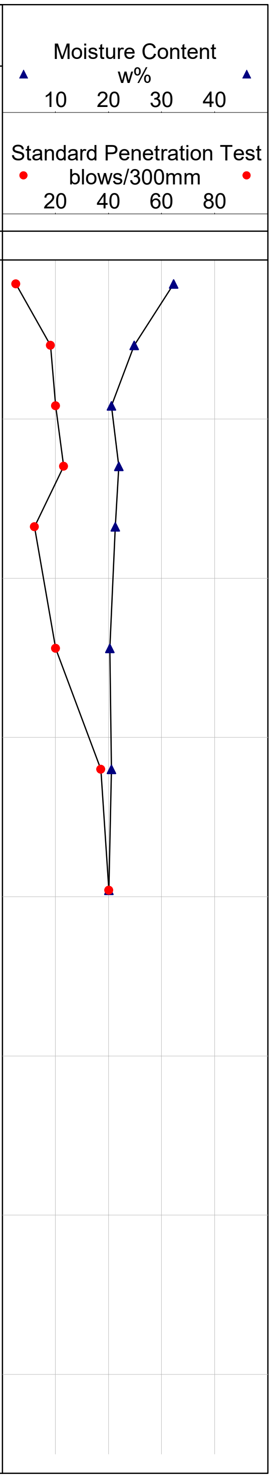
Log of Borehole No. 12

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.
Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4765409
E: 641213

Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	184.19		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	0,2,3,5	5	▨	1.5	
			Silty Clay/Clayey Silt Brown, firm to very stiff.		SS	2	5,8,10,13	18	▨	>4.5	
					SS	3	5,8,12,16	20	▨	>4.5	
					SS	4	6,10,13,16	23	▨	>4.5	
	180.84		Transition in colour to grey.		SS	5	4,5,7,7	12	▨	1.5	
	179.32		**Sandy Silt/Silt** Reddish brown, compact to dense.		SS	6	3,5,15,19	20	▨	1.5	
					SS	7	12,16,21,25	37	▨		
	175.97				SS	8	12,14,26,28	40	▨		
			End of Borehole								



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.

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

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

Drill Method: Solid Stem Augers
Drill Date: December 09, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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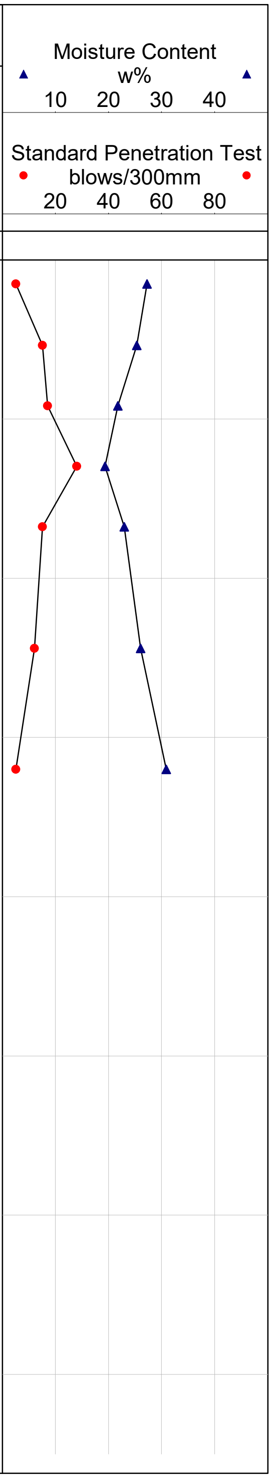
Log of Borehole No. 13

Project No: SM 220530-G
Project: Proposed Residential Development
Location: Quaker Road & First Avenue, Welland
Client: Primont (Thorold/Welland) Inc.
Project Manager: Ian Shaw, P.Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4764871
E: 641196

Depth (m)	Elevation (m)	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0	183.94		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	0,2,3,6	5	■	1.5	
1			**Silty Clay/Clayey Silt** Brown, firm to very stiff.		SS	2	5,7,8,11	15	■	>4.5	
2					SS	3	7,7,10,15	17	■	>4.5	
					SS	4	6,12,16,19	28	■	>4.5	
3					SS	5	4,7,8,11	15	■	3.0	
5	178.76				SS	6	3,4,8,8	12	■	<1	
			Transition in colour to grey.								
	177.24				SS	7	2,2,3,4	5	■	<1	
			End of Borehole								



NOTES:

1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'Wet' at a depth of 5.6 metres upon completion and backfilled as per Ontario Regulation 903.

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

Drill Method: Solid Stem Augers
Drill Date: December 09, 2022
Hole Size: 150 Millimetres
Drilling Contractor: Elements Drilling Ltd.

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