2481 Barton Street East, Hamilton, ON

Barton Street Developments Inc.

Type of Document:
Geotechnical Investigation Report

Project Name:
Proposed Mid-Rise Apartment Building
2481 Barton Street East
Hamilton, Ontario

Project Number:
HAM-00802036-A0

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1. Introduction and Background

This report presents the results of the geotechnical investigation carried out at the site of the proposed development at 2481 Barton Street East in Hamilton, Ontario. The investigation was authorized by Mr. Rajan Banwait on behalf of Barton Street Developments Inc. (Client).

At the time of the investigation, the site was occupied by a single-family dwelling and garage structure with associated gravel driveway and parking areas. Brush and mature trees were also present throughout the property and were dense on the west and north sides. Details of the proposed development were not finalized at the time of the investigation, but it is expected that the existing structures will be demolished to make way for the construction of an apartment building with 12 to 17 storeys and 1 or 2 levels of underground parking.

The purpose of this investigation was to determine the subsoil and groundwater conditions at the site by advancing ten (10) boreholes and based on an assessment of the factual subsurface data, provide an engineering report containing general geotechnical recommendations pertinent to the proposed construction. This report does not address the environmental aspects of the development. Additional fieldwork and testing was carried out at the site by EXP as part of the hydrogeological investigation, the results of which are presented under separate cover.

The comments and recommendations given in this report assume that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or the requirement of additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2. Field Investigation

As requested, EXP advanced a total of ten (10) boreholes at the site, numbered BH-01 to BH-10. The approximate borehole locations are shown on Drawing No. 1 in Appendix A. The boreholes were advanced to depths ranging from approximately 5.8 to 11.1 m below existing grade.

The fieldwork for this investigation was carried out on November 9, 10, and 11, 2020. Drilling and sampling operations were completed by a combination of auger and split-spoon techniques using track mounted drilling equipment owned and operated by specialist drilling subcontractor. Prior to the commencement of the drilling, the public and private-owned underground services were located to minimize the risk of contacting any such services during the investigation.

Soil samples were obtained using a 51 mm (2 inch) outside diameter split-spoon sampler driven in conjunction with Standard Penetration Test procedure (ASTM D1586) at the depths noted graphically on the borehole logs. The retained soil samples were logged in the field and then carefully packaged and transported to our Hamilton laboratory for detailed visual, textural and olfactory classification. The Standard Penetration Test (SPT) N values and pocket penetrometer measurements were recorded and used to provide an assessment of the consistency of the in-situ soils.

Groundwater levels within the boreholes were measured prior to backfilling. Three (3) 50 mm diameter monitoring wells were installed to allow for stabilized groundwater level measurements and hydrogeological testing. The remaining boreholes were backfilled upon completion of drilling in accordance with O.Reg. 903.

Ground surface elevations at the borehole locations were surveyed by EXP and referenced to a temporary benchmark (TBM), described as follows:

TBM:	Top of catch basin, in the north curb of Barton Street East and approximately 25 m east of the west property line of 2481 Barton Street East
Elevation:	85.23 m (as per the topographical survey provided by the client dated September 24, 2020 by A.T. McLaren Ltd.)

3. Subsurface Conditions

Details of the subsurface conditions encountered during the drilling program are summarized on the borehole logs in Appendix A.

The logs include textural descriptions of the subsoil and groundwater conditions and indicate the soil boundaries inferred from non-continuous sampling and observations during drilling. These boundaries reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Description" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

3.1 Soil Stratigraphy

The boreholes each encountered surficial topsoil, granular fill, and/or fill, extending to depths ranging from approximately 0.8 to 2.6 m below grade. The underlying native silty clay till extended to the bedrock surface or borehole termination depth. Where encountered, the bedrock was contacted at depths ranging from approximately 6.3 to 11.0 m below grade. Details of the encountered materials are provided in the following subsections.

3.1.1 Topsoil

Surficial topsoil was encountered at Boreholes BH-01, BH-03, BH-04, BH-07, and BH-08 and was noted to have a thickness ranging from approximately 100 to 175 mm. It is noted that topsoil thicknesses may further vary across the site.

3.1.2 Granular Fill

Boreholes BH-05, BH-09, and BH-10 were advanced in the area of the existing gravel parking lot/driveway and encountered approximately 200 to 600 mm of granular fill. The granular fill consisted of crusher-run limestone.

3.1.3 Fill

A layer of fill was encountered at the ground surface or below the topsoil/granular fill in each of the borehole locations, extending to depths of 0.8 to 2.6 m. The fill consisted of silty clay, sand and gravel, or sandy silt, and was brown, dark brown, greyish brown or grey. The fill was noted to contain rootlets, glass, asphalt, and construction debris. The fill was in a moist to very moist, with moisture contents ranging from 6 to 20%. Trace black organic staining and odour was also noted at Boreholes BH-02, BH-08, and BH-09.

3.1.4 Silty Clay Till

Native silty clay till was encountered in each of the borehole locations, extending to the borehole termination depth or bedrock surface. The silty clay till contained some sand and occasional gravel and was brown, reddish brown, greyish brown, or grey. The stratum was generally in a moist state, becoming damp at depth, with moisture contents ranging from 5 to 23%. SPT N values ranged from 16 to over 50 blows per 305 mm penetration. Based on estimated undrained shear strengths from 125 to greater than 225 kPa as determined by pocket penetrometer measurements, the silty clay till is classified as very stiff to hard in consistency. Borehole BH-02 was terminated at a depth of 5.8 m below grade due to auger refusal on possible cobbles or boulder within the till.

Three (3) grain size analysis were conducted with the results included in Appendix B and summarized in the table below.

Table 3-1: Summary of Grain Size Analyses

Sample	Clay (%)	Silt (%)	Sand (%)	Gravel (%)
BH-01 SS9	18	60	22	0
BH-05 SS6	35	50	15	0
BH-09 SS7	15	60	25	0

Atterberg limits testing was also conducted on the above samples, indicating the stratum is of intermediate plasticity. The results of this testing are also included in Appendix B.

3.1.5 Bedrock

The weathered shale bedrock surface was encountered at depths ranging from 6.3 to 11.0 m below grade, corresponding to Elev. 79.4 to 74.6 m. The bedrock was not confirmed by coring and was inferred based on drilling observations. However, based on Map 2343, Paleozoic Geology, Grimsby, the bedrock in the site vicinity consists of red shale of the Queenston Formation. The upper portion of the bedrock is typically highly weathered to weathered to a depth of 600 mm to 1.5 m. Hard limestone lenses are common within the shale.

The bedrock surface depths and elevations are summarized in the table below.

Table 3-2: Depths and Elevations of Bedrock Surface

Borehole No.	Depth of Bedrock Surface (m)	Elevation of Bedrock Surface (m)
BH-01	9.3	76.2
BH-03	8.2	77.1
BH-04	9.3	76.1
BH-06	7.7	77.7
BH-07	10.9	74.6

Borehole No.	Depth of Bedrock Surface (m)	Elevation of Bedrock Surface (m)
BH-08	7.8	77.9
BH-09	7.9	77.7
BH-10	6.3	79.4

3.2 Groundwater Conditions

Groundwater conditions were monitored in the open boreholes during and upon completion of the investigation. Upon borehole completion, groundwater was encountered at 10.2 m at Borehole BH-09 and at 9.2 m at Borehole BH-10 with no free water encountered at the remaining locations, but groundwater levels are not anticipated to have stabilized during the short term of the investigation. 50 mm diameter groundwater monitoring wells were installed at three (3) borehole locations with the groundwater depths and elevations summarized in the table below.

Table 3-3: Groundwater Level Measurements at Monitoring Well Locations

Borehole No.	Groundwater Depth/Elevation (m)		
	Upon Completion	November 23, 2020	November 30, 2020
BH-01	no free water	4.5/81.0	5.5/80.0
BH-03	no free water	2.3/83.0	2.4/82.9
BH-09	10.2/75.4	2.9/82.7	2.6/83.0

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions. Reference should be made to the hydrogeological report for additional groundwater comments.

4. Discussion and Recommendations

Details of the proposed development were not finalized at the time of the investigation, but it is expected to consist of an apartment building with 12 to 17 storeys and 1 or 2 levels of underground parking. We offer the following comments and recommendations for the proposed construction.

4.1 Site Grading

The proposed site grading was not available at the time of this report. However, based on the presence of fill and existing structures, it is expected that regrading (cut and fill operations) will be carried out at the site. The following procedures are recommended for the construction of building and pavement areas at the site, where required:

- All existing topsoil, fill, disturbed soils, foundations, services, and organic/deleterious materials should be removed from the proposed building and pavement areas. Fill materials in pavement areas may remain in place, subject to being proof-rolled and replaced as directed by a geotechnical representative, but pavements constructed over fill may require more frequent maintenance and experience a reduced service life.

- The exposed subgrade surface should be proof-rolled with a heavy roller or partially loaded truck and reviewed by a geotechnical representative. Any soft areas detected during the proof-rolling process should be sub-excavated and replaced with approved material compacted to 100 percent Standard Proctor Maximum Dry Density (SPMDD).

- Low areas can then be brought up to final subgrade level with approved on-site or imported material placed in lifts not exceeding 200 mm. Fill placed in building floor slab areas must be compacted to 100 percent of SPMDD. Fill placed in pavement areas should be compacted to at least 95 percent SPMDD, with the upper 600 mm compacted to at least 98 percent SPMDD. The moisture content of the fill should be at or near its optimum moisture content to ensure the specified densities can be achieved with reasonable compactive effort.

- Re-use of the on-site fill should be at the discretion of the geotechnical consultant during construction. Some adjustment of moisture content may be required to facilitate compaction of re-used materials. Re-used materials must also be free from organics and deleterious materials.

- All imported borrow fill material from local sources should be free from organic material and foreign objects (trees, roots, debris, etc.) and should be approved by EXP prior to transport to the site. In addition, the chemical quality of the borrowed fill material should be assessed by EXP in accordance with the current applicable MECP regulations and guidelines.

- All excavation, backfilling and compaction operations should be monitored on a full-time basis by EXP's geotechnical staff to approve materials and to ensure the specified degrees of compaction have been obtained.

4.2 Building Foundation Recommendations

It is understood that the building will consist of a 12 to 17 storey structure with 1 or 2 levels of underground parking (corresponding to a founding level in the order of 4 to 7 m below grade).

Based on the subsurface conditions encountered at the site, the proposed building may be supported on conventional spread and strip footings founded on silty clay till. Alternatively, caissons bearing on the shale bedrock may be a preferred option.

4.2.1 Conventional Footings

Conventional spread and strip footing foundations constructed on the undisturbed silty clay till can be designed with a geotechnical resistance of 300 kPa at Serviceability Limit State (SLS) or 450 kPa at ULS at or below the depths provided in the table below, subject to review by EXP during construction. A capacity of 1,000 kPa at SLS/ULS may be used for foundations constructed in the weathered shale.

Table 4-1: Available Geotechnical Resistance

Borehole No.	Available Geotechnical Resistance (kPa)	Founding Soils	Recommended Minimum Founding Depth / Elevation (m)
BH-01	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	1.8 / 83.7 9.6 / 75.9
BH-02	300 SLS / 450 ULS	Native Silty Clay Till	2.6 / 82.7
BH-03	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	1.2 / 84.1 8.5 / 76.8
BH-04	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	1.5 / 83.9 9.6 / 75.8
BH-05	300 SLS / 450 ULS	Native Silty Clay Till	1.4 / 84.0
BH-06	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	2.9 / 82.5 8.1 / 77.3
BH-07	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	1.4 / 84.1 11.3 / 74.2
BH-08	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	2.1 / 83.6 8.1 / 77.6
BH-09	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	2.6 / 83.0 8.2 / 77.4
BH-10	300 SLS / 450 ULS 1,000 SLS/ULS	Native Silty Clay Till Shale Bedrock	1.1 / 84.6 6.6 / 79.1

Prior to placement of foundation concrete, all existing fill, organics, and other deleterious material must be removed down to the competent native soils or, if founding on bedrock, all loose rock must be removed. The exposed founding surface is to be reviewed by EXP.

4.2.2 Caissons

Alternatively, a deep foundation scheme consisting of caissons may be considered. Caissons founded in the shale bedrock below any highly weathered/fractured rock can be designed for an end-bearing resistance of 1,000 kPa at the approximate depths provided in Table 4-1 above. The actual founding depth of the caissons are subject to verification by EXP during construction.

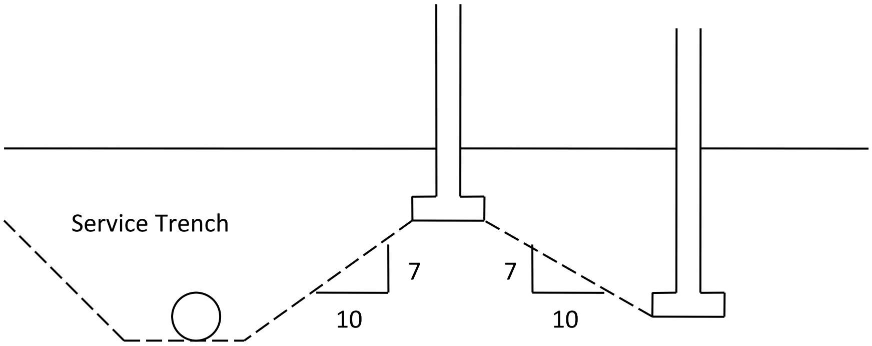
The use of temporary liners may be required for caisson installation to prevent the soil from caving and thus minimize the possible formation of voids below the floor slab, and to help control any water seepage into the caissons. The liners should be tightly sealed into the bedrock to prevent the infiltration of groundwater into the hole. Once the caissons have been drilled to the final founding elevation and the rock conditions confirmed by EXP, it is recommended that the base be cleaned by placing about 0.3 to 0.5 m of concrete into the final base and mixing it with any loose material present at the base. All concrete and loose soil should then be removed prior to placing the reinforcing cage and the structural concrete.

Prior to withdrawal of the liner, the contractor should be prepared to place concrete by tremie method if the liner cannot form a seal to prevent groundwater infiltration. An experienced contractor should be employed to ensure the above procedures are followed and no necking or voids in the concrete occurs in the caisson shaft during the concrete pour.

Concrete being placed into the caissons should have a slump of about 150 mm in order to minimize the risk of necking in the shaft. Once the method of construction is established the concrete mix must be reviewed by this office.

4.3 General Foundation Recommendations

Conventional foundations in soil at different elevations should be located such that higher footings are set below a line drawn up at 10:7, horizontal to vertical from the near edge of the lower footing. This requirement is not applicable for foundations in sound bedrock. This concept should also be applied to excavations for new foundations in relation to existing foundations or underground services.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

All foundations and grade beams for caissons exposed to freezing conditions must be provided with a minimum of 1.2 m of earth cover or equivalent insulation for frost protection, depending on the final grade requirements.

The recommended geotechnical resistances have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, it should be appreciated that modifications to bearing levels may be required if unforeseen subsoil conditions are revealed after the excavation is exposed to full view or if final design decisions differ from those assumed in this report. For this reason, this office should be retained to review final foundation drawings and to provide field inspections during the construction stage.

4.4 Excavations

Excavations for 1 to 2 underground levels are expected to extend to depths of approximately 4 to 7 m below existing grade. Excavations within the encountered overburden may be undertaken with a sufficiently sized hydraulic excavator. Bedrock was encountered as high as 6.3 m below grade at the borehole locations and varied between borings. Excavations proceeding into the weathered bedrock (Queenston Shale) will likely require the excavator be equipped with rock teeth. Limestone lenses are commonly encountered in the shale and so may be encountered during construction. The use of rock breaking equipment, e.g. rippers or pneumatic rock hammers, should be anticipated in the sound shale or where thicker limestone interbedding is encountered.

The silty clay till is a non-sorted sediment and cobbles and boulders should be anticipated in the stratum, as was encountered in Borehole BH-02. Consequently, provisions should be made in the contract documents to cover any delays caused by limestone interbedding, boulders, obstructions, etc.

All excavations must be completed in accordance with the most recent regulations of the Ontario Occupation Health and Safety Act (OHSA). The encountered fill may generally be classified as Type 3 Soil above the groundwater level. The very stiff to hard silty clay may generally be classified as Type 2 Soil. In accordance with the OHSA regulations if the excavation contains more than one type of soil, the soil shall be classified as the type with the highest number.

The OHSA requires that unsupported excavation slopes be cut at predetermined inclinations, based on the soil types encountered. The bedrock excavations can be sloped at near vertical (1 horizontal to 6 vertical) provided any loose rock is scaled from the face. The need to excavate flatter side slopes if excessively wet or soft/loose materials, or concentrated seepage zones are encountered, should not be overlooked. Water (i.e. surface water runoff) should not be permitted to enter and/or pond within the construction area.

It is important to note that soils encountered in the construction excavations may vary significantly across the site. Our preliminary soil classifications are based solely on the materials encountered in the boreholes advanced at the site. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, we recommend that EXP be contacted immediately to evaluate the conditions encountered.

4.5 Temporary Shoring

If required, the shoring method chosen by the structural engineer and/or contractor will depend on the settlement tolerance of the surrounding structures and infrastructure. Where settlement sensitive structures or services are located within a distance from the excavation equal or less than the overburden excavation depth, the use of a rigid retaining structure will be required.

Properly designed shoring may be used to reduce the lateral extent of the excavations. The lateral earth pressure acting on the shoring may be computed using the following equation, assuming a rectangular pressure distribution and dewatering will be carried out:

$$p = K(\gamma h + q)$$

where p = lateral earth pressure intensity at depth h (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth to point of interest (m)
q = surcharge load acting adjacent to the shoring at the ground surface (kPa)

In general, an earth pressure coefficient, K, of 0.45 may be used where movements must be minimized and 0.25 where minor movements can be tolerated. A unit weight of 21 kN/m^3 may be used for the encountered soils.

4.6 Lateral Earth Pressure

The lateral earth pressure acting on the foundation walls may be calculated using the following equation:

$p = K(\gamma h + q)$

where p = lateral earth pressure intensity at depth h (kPa)
K = earth pressure coefficient (assume 0.40)
γ = unit weight of retained soil, assume 21.0 kN/m^3 for granular backfill
h = depth to point of interest (m)
q = surcharge load acting adjacent to the wall at the ground surface (kPa)

If the building is constructed as a tank without drainage, lateral hydrostatic and uplift pressures below the slab will need to be accounted for using the expression below.

$p = K[(\gamma h_w) + (\gamma' (h - h_w))] + (\gamma_w (h - h_w)) + K q$

where p = lateral earth pressure and hydrostatic pressure in kPa acting at depth h (kN/m^2)

K = active earth pressure coefficient, assume 0.30

γ_w = unit weight of water, 9.8 kN/m^3

γ = unit weight of soil surrounding the structure, assume 21.0 kN/m^3

γ' = effective unit weight of retained soil, assume 11.2 kN/m^3

h = depth to point of interest (m)

q = equivalent value of surcharge on the ground surface (kPa)

4.7 Groundwater Control

Groundwater levels in the monitoring wells on site ranged from 2.3 to 5.5 m below grade. For excavations above these levels, perched water from the fill as well as minor seepage from the native soils should be anticipated. Groundwater should be anticipated during construction, but is expected to be controllable using conventional construction sump pumping techniques. However, if two levels of basement are included and excavations extend below approximately 3 to 4 m then more significant dewatering should be anticipated, and a reference should be made to the EXP hydrogeological investigation report for the subject site for additional groundwater control comments. Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather.

Dewatering requirements will be governed by the time of year the construction is performed. It is the responsibility of the contractor to propose a suitable dewatering system based on the time of construction and the groundwater levels. The method used should not undermine adjacent structures.

4.8 Building Floor Slab-on-Grade and Permanent Drainage

The basement floor slab-on-grade can be supported on the native soil. It is recommended that the exposed subgrade be examined by a geotechnical engineer prior to constructing the floor slab-on-grade. Any loose or disturbed material encountered during the review should be sub-excavated and replaced with approved fill placed in lifts not exceeding 200 mm and compacted to 100 percent Standard Proctor Maximum Dry Density (SPMDD) within 2 percent of the optimum moisture content. The floor slab should be cast on a moisture barrier consisting of 19 mm clear stone with a thickness of at least 200 mm. The clear stone layer will minimize the capillary rise of moisture from the subgrade to the floor slab (moisture barrier). Adequate saw cuts should be provided in the floor slab as directed by the structural engineer to help control cracking. The installation of a perimeter drainage is required for buildings with basements and underfloor drainage system at 3 m intervals is recommended for the groundwater levels encountered on site. The exterior grade should be sloped to ensure positive drainage of surface water away from the structure and reduce groundwater infiltration adjacent to the foundations.

4.9 Backfill

Backfill used to satisfy under slab requirements and service trenches, etc., should be compactible fill, i.e. inorganic soil with its moisture content close to its optimum moisture content as determined in the standard Proctor test. Fill placed below concrete slab areas should be compacted to 100 percent Standard Proctor Maximum Dry Density (SPMDD) in lifts not exceeding 200 mm.

To minimize potential problem, any trench backfilling operations should follow closely after excavation so that only minimal length of trench slope is exposed. This will minimize wetting of the subgrade material. Should construction extend to the winter season, particular attention should be given to ensure that frozen material is not used as backfill.

The majority of excavated material will likely consist of silty clay fill or native silty clay till. In general, the excavated material may be reused for backfill subject to the removal of any organics or other obviously unsuitable material. However, moisture content adjustment of re-used soils might be required.

In general, the overburden soils are not free draining and therefore should not be used where this characteristic is required, or in confined areas. Imported granular material conforming to OPSS Granular B Type I or II would be suitable for these purposes.

All backfilling and compaction operations must be closely examined by a qualified geotechnical consultant to ensure uniform compaction to specification requirements, especially in the vicinity of manholes and catch basins, and in all areas that are not readily accessible to compaction equipment.

4.10 Earthquake Considerations

The recommendations for the geotechnical aspects to determine the earthquake loading are presented in the subsections below.

4.10.1 Subsoil Conditions

The subsoil and groundwater information at this site have been examined in relation to Section 4.1.8.4 of the OBC 2012. Conventional foundations are anticipated to be founded on the encountered silty clay till whereas caisson foundations are anticipated to be founded on the encountered shale bedrock.

There have been no shear wave velocity measurements carried out at this site and therefore, N values and EXP's knowledge of the soil conditions in the area have been used to determine the site classification.

4.10.2 Site Classification

Based on the above assumptions and interpretations and the known soil conditions, the Site Class for this site is "C" as per Table 4.1.8.4.A, Site Classification for Seismic Site Response, OBC 2012. It should be noted that, depending on the founding level, an improved site classification may be achievable if shear wave velocity testing is carried out. EXP can be contacted to provide this service if required.

4.11 Roadway and Parking Lot Construction

It is understood that paved areas will be constructed at the site. The proposed development is anticipated to include medium duty parking/driveway areas as well as heavy duty truck routes.

The recommended pavement structures are provided in table below and are based on an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples and traffic requirements. Consequently, the recommended pavement structures should be considered for preliminary design purposes only.

Table 4-2: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Medium-Duty Parking	Truck Routes & Heavy-Duty Parking
Asphaltic Concrete (OPSS 1150)	Min 92.0% Maximum Relative Density (MRD)	40 mm HL3 50 mm HL8	40 mm HL3 80 mm HL8
Granular A Crusher Run Limestone (OPSS 1010)	100% SPMDD	150 mm	150 mm
Granular B Type II (OPSS 1010)	100% SPMDD	250 mm	350 mm

The granular base and sub-base must be placed in maximum 200 mm lifts and compacted to 100 percent of the Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within 2 percent of the optimum moisture content. The subgrade should be compacted to 98 percent SPMDD for at least the upper 600 mm. The recommended pavement structures outlined assume adequate provision for drainage.

The foregoing design assumes construction is carried out during dry periods and the subgrade is prepared according to Section 4.1 of this report. If construction is carried out during wet weather, and heaving or rolling of the subgrade is experienced, additional thickness of sub-base course material may be required.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be sloped to provide effective surface drainage toward catch basins. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Subdrains should be installed to intercept excess subsurface moisture and prevent subgrade softening.

Additional comments on the construction of the paved areas are as follows:

- The location and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed site grading. In view of the fine-grained nature of the subgrade soils, subdrains should be installed on both sides of roadways and radially to catch basins in parking areas.

- To minimize problems of differential movement between the pavement and catch basins/manholes due to frost action, the backfill around the structures should consist of free draining granular fill.

- The most severe loading conditions on pavement areas and the subgrade may occur during construction. Consequently, special provisions such as half loads during paving, etc. may be required, especially if construction is carried out during unfavourable weather.

- The subgrade should be properly shaped, crowned, and then proof-rolled in the full-time presence of a representative of this office. Soft or spongy subgrade areas should be sub-excavated and properly replaced with suitable approved backfill compacted to at least 98 percent SPMDD.

5. General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions of the subject property. The conclusions presented in this report reflect site conditions existing at the time of the investigation.

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

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

More specific information, with respect to the conditions between samples, or the lateral and vertical extent of materials, may become apparent during excavation operations. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required. EXP Services Inc. has qualified personnel to provide assistance in regard to future geotechnical and environmental issues related to this property.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Dilsher Bhangal

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Jeff Golder

Jeffrey Golder, P.Eng.
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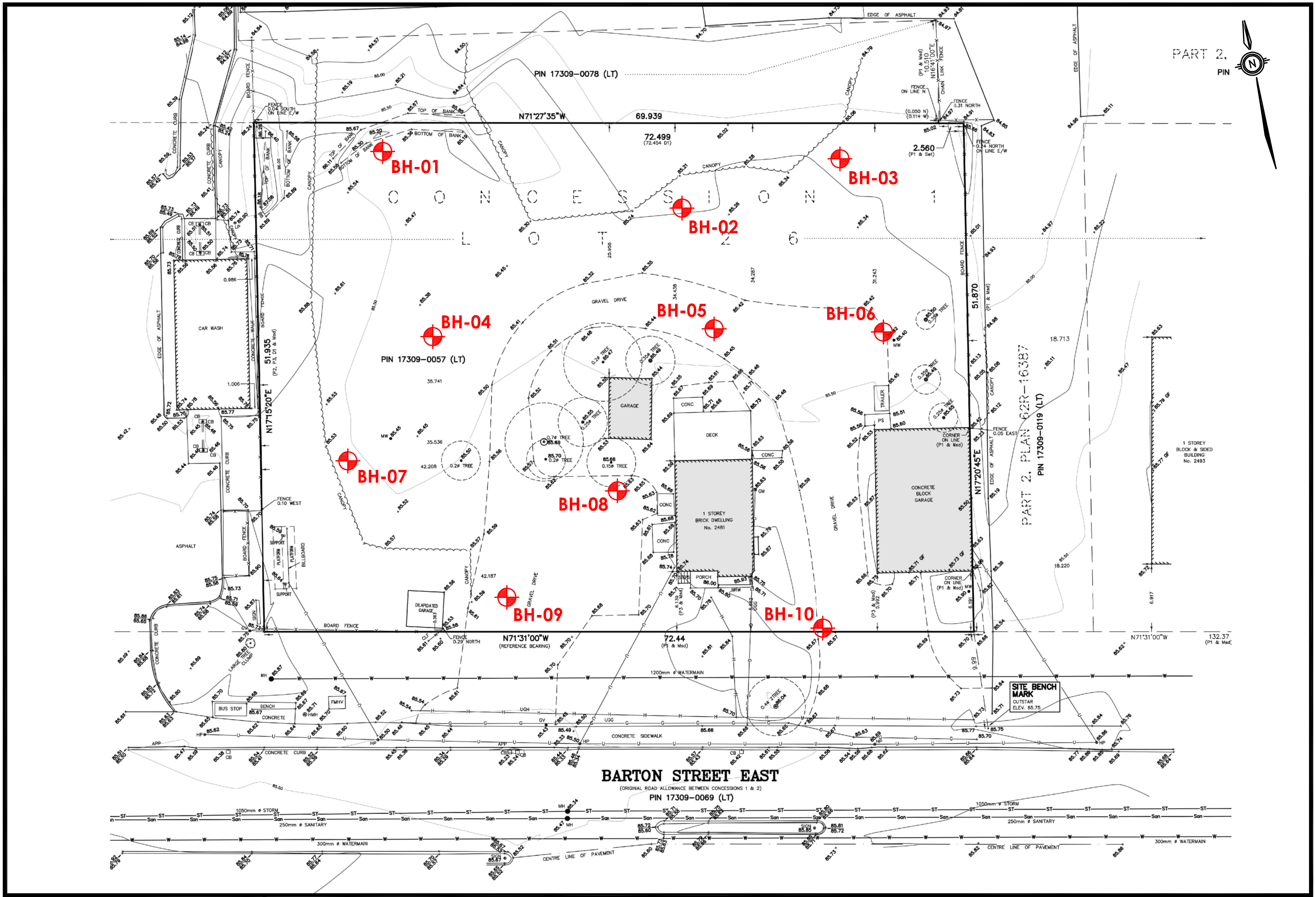
Appendix A

Drawings & Borehole Logs



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LEGEND:

⊕ APPROXIMATE BOREHOLE LOCATION

TITLE AND LOCATION:

BOREHOLE LOCATION PLAN
PROPOSED MID-RISE APARTMENT BUILDING
2481 BARTON STREET EAST, HAMILTON, ON

JOB NO.: HAM-00802036-A0	DRAWN BY: DB
SCALE: NTS	CHECKED BY: JG
DATE: DECEMBER 2020	DWG NO.: 1

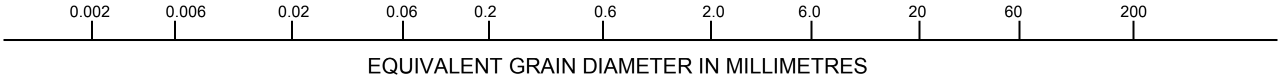
Drawing 2A

Notes on Sample Descriptions

1. All sample descriptions included in this report follow the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), as outlined in the Canadian Foundation Engineering Manual. Note, however, that behavioral properties (i.e. plasticity, permeability) take precedence over particle gradation when classifying soil. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

UNIFIED SOIL CLASSIFICATION

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



ISSMFE SOIL CLASSIFICATION

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

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

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Drawing 2B

Notes On Soil Descriptions

4. The following table gives a description of the soil based on particle sizes. With the exception of those samples where grain size analyses have been performed, all samples are classified visually. The accuracy of visual examination is not sufficient to differentiate between this classification system or exact grain size.

Soil Classification		Terminology	Proportion
Clay and Silt	<0.060 mm	"trace" (e.g. Trace sand)	1% to 10%
Sand	0.060 to 2.0 mm	"some" (e.g. Some sand)	10% to 20%
Gravel	2.0 to 75 mm	adjective (e.g. sandy, silty)	20% to 35%
Cobbles	75 to 200 mm	"and" (e.g. and sand)	35% to 50%
Boulders	>200 mm		

The compactness of Cohesionless soils and the consistency of the cohesive soils are defined by the following:

Cohesionless Soil		Cohesive Soil		
Compactness	**Standard Penetration Resistance "N" Blows / 0.3 m**	**Consistency**	**Undrained Shear Strength (kPa)**	**Standard Penetration Resistance "N" Blows / 0.3 m**
Very Loose	0 to 4	Very soft	<12	<2
Loose	4 to 10	Soft	12 to 25	2 to 4
Compact	10 to 30	Firm	25 to 50	4 to 8
Dense	30 to 50	Stiff	50 to 100	8 to 15
Very Dense	Over 50	Very Stiff	100 to 200	15 to 30
		Hard	>200	>30

5. **ROCK CORING**

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundless of the rock mass. It is obtained from the rock cores by summing the length of the core covered, counting only those pieces of sound core that are 100 mm or more length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

$$\text{Recovery Designation \% Recovery} = \frac{\text{Length of Core Per Run}}{\text{Total Length of Run}} \times 100$$

Log of Borehole BH-01

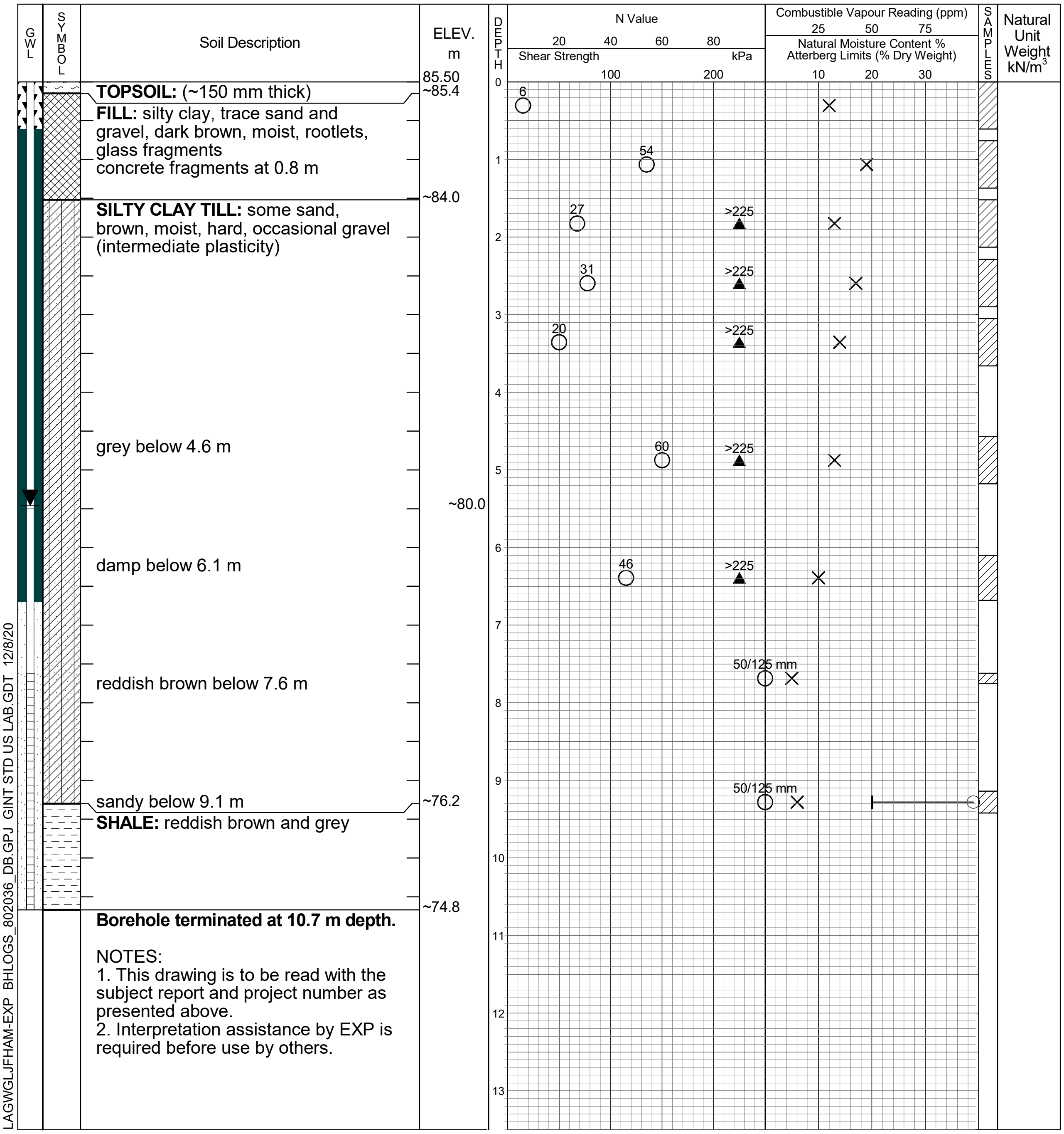
Project No.	HAM-00802036-A0	Drawing No.	3
Project:	Proposed Mid-Rise Apartment Building	Sheet No.	1 of 1
Location:	2481 Barton Street E, Hamilton, ON		

Date Drilled: November 10, 2020

Drill Type: CME-55 Track Mount. Solid Stem

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├—○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL: (~150 mm thick)

FILL: silty clay, trace sand and gravel, dark brown, moist, rootlets, glass fragments
concrete fragments at 0.8 m

SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel (intermediate plasticity)

grey below 4.6 m

damp below 6.1 m

reddish brown below 7.6 m

sandy below 9.1 m

SHALE: reddish brown and grey

Borehole terminated at 10.7 m depth.

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	10.7
November 23, 2020	4.5	N/A
November 30, 2020	5.5	N/A

Log of Borehole BH-02

Project No. HAM-00802036-A0

Drawing No. 4

Project: Proposed Mid-Rise Apartment Building

Sheet No. 1 of 1

Location: 2481 Barton Street E, Hamilton, ON

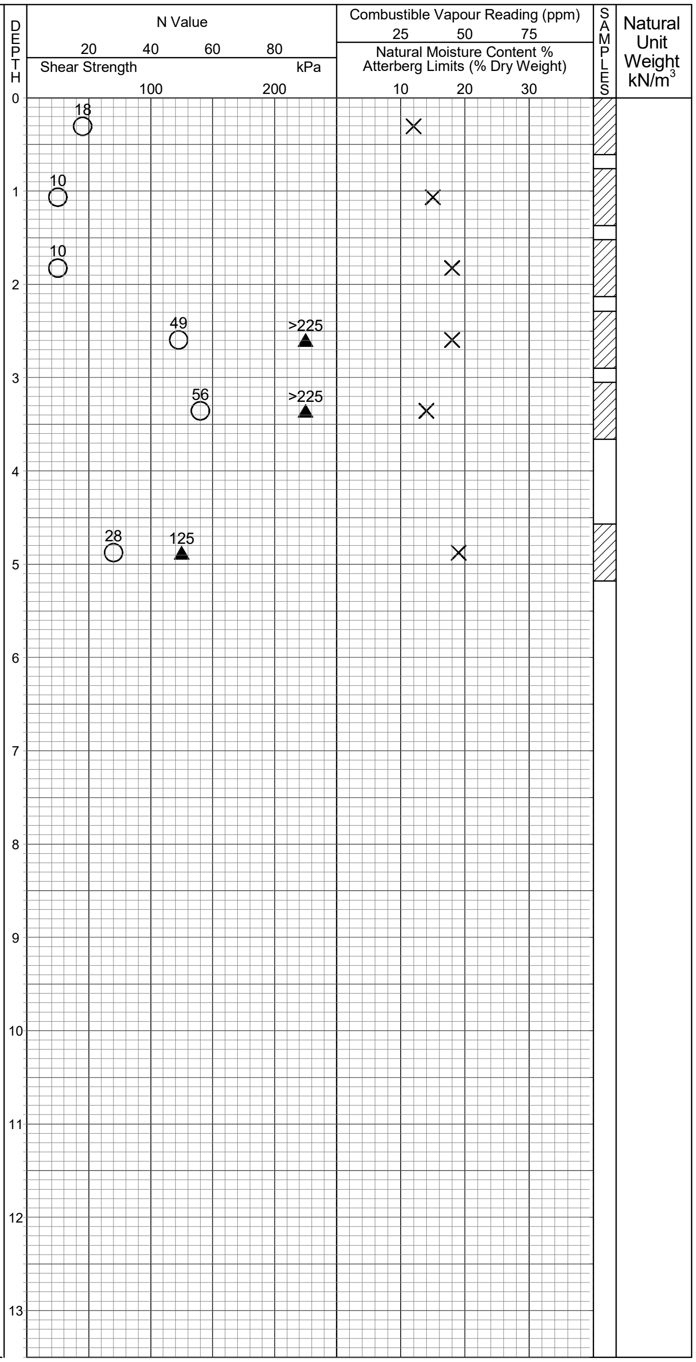
Date Drilled: November 10, 2020

Drill Type: CME-55 Track Mount. Solid Stem

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
	▩	**FILL:** silty clay, some sand and gravel, dark brown, moist, rootlets, brick fragments	85.26
	▩	**FILL:** sandy silt, some clay, brown, very moist, trace black organic staining and odour	~84.2
	▨	**SILTY CLAY TILL:** some sand, brown, moist, hard, occasional gravel grey, very stiff below 4.6 m	~83.0
		Borehole terminated at 5.8 m depth due to auger refusal on obstruction. NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others.	~79.5



EXP Services Inc.
Hamilton, ON
Telephone: 905.573.4000
Facsimile: 905.573.9693

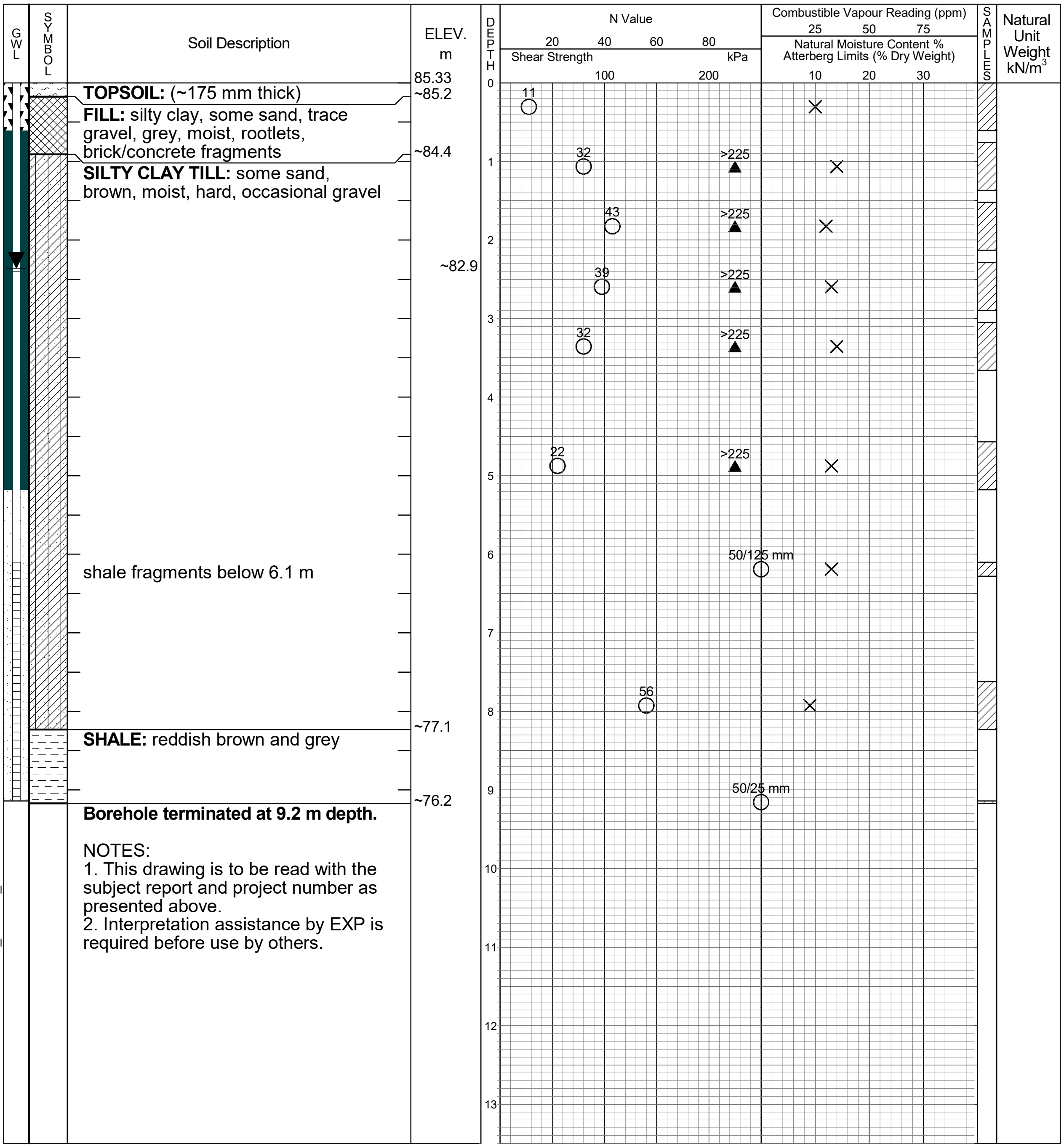
Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	5.8

Log of Borehole BH-03

Project No. HAM-00802036-A0
Drawing No. 5
Project: Proposed Mid-Rise Apartment Building
Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 9, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL: (~175 mm thick)

FILL: silty clay, some sand, trace gravel, grey, moist, rootlets, brick/concrete fragments

SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel

shale fragments below 6.1 m

SHALE: reddish brown and grey

Borehole terminated at 9.2 m depth.

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	9.2
November 23, 2020	2.3	N/A
November 30, 2020	2.4	N/A

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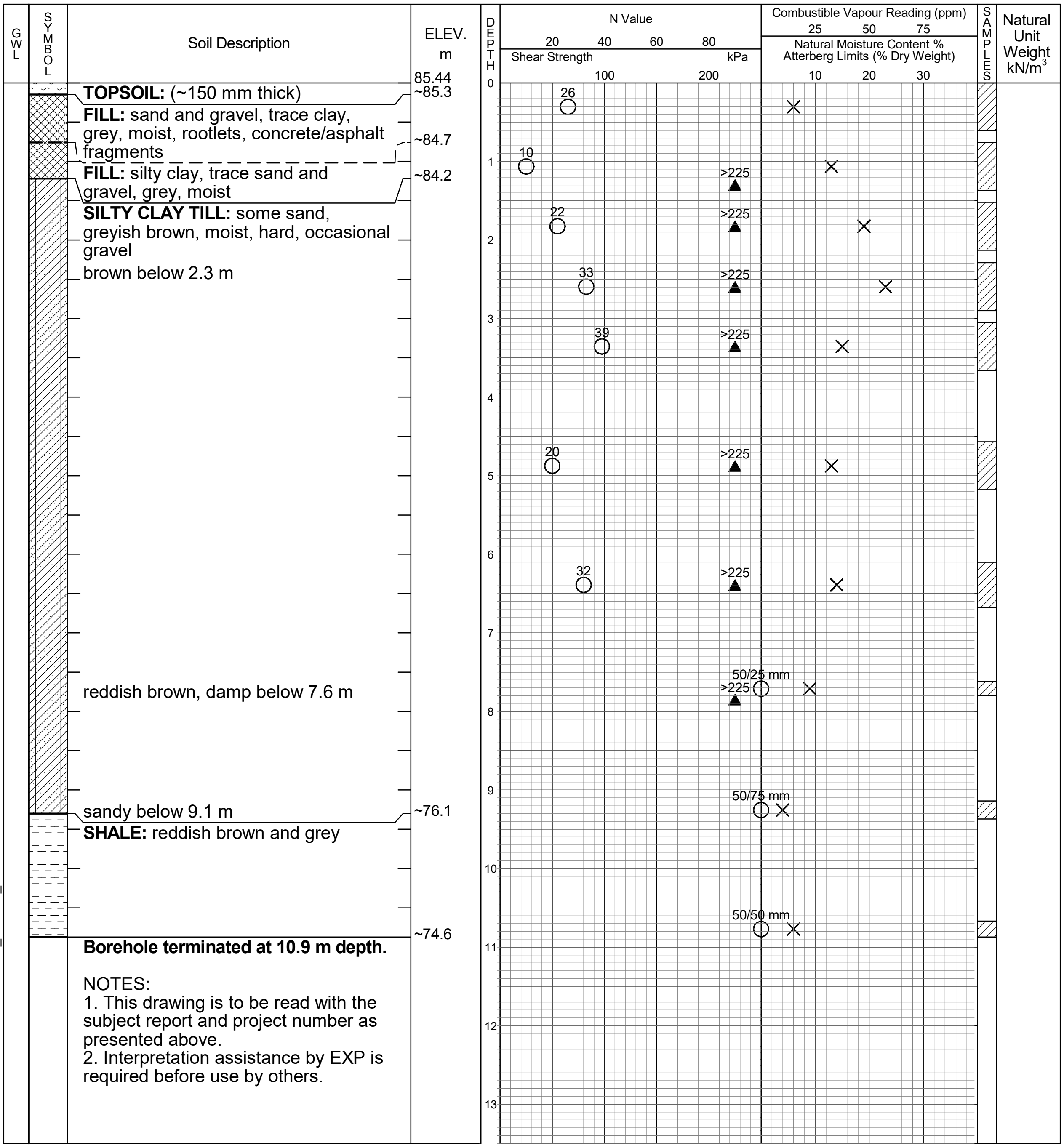
Telephone: 905.573.4000
Facsimile: 905.573.9693

Log of Borehole BH-04

Project No. HAM-00802036-A0
Drawing No. 6
Project: Proposed Mid-Rise Apartment Building
Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 10, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒
SPT (N) Value	○ ▨
Dynamic Cone Test	—
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	☐
Natural Moisture	×
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲



Soil Description	ELEV. m
	85.44
TOPSOIL: (~150 mm thick)	~85.3
FILL: sand and gravel, trace clay, grey, moist, rootlets, concrete/asphalt fragments	~84.7
FILL: silty clay, trace sand and gravel, grey, moist	~84.2
SILTY CLAY TILL: some sand, greyish brown, moist, hard, occasional gravel	
brown below 2.3 m	
reddish brown, damp below 7.6 m	
sandy below 9.1 m	~76.1
SHALE: reddish brown and grey	
Borehole terminated at 10.9 m depth.	~74.6

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	10.1

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Facsimile: 905.573.9693

Log of Borehole BH-05

Project No. HAM-00802036-A0

Drawing No. 7

Project: Proposed Mid-Rise Apartment Building

Sheet No. 1 of 1

Location: 2481 Barton Street E, Hamilton, ON

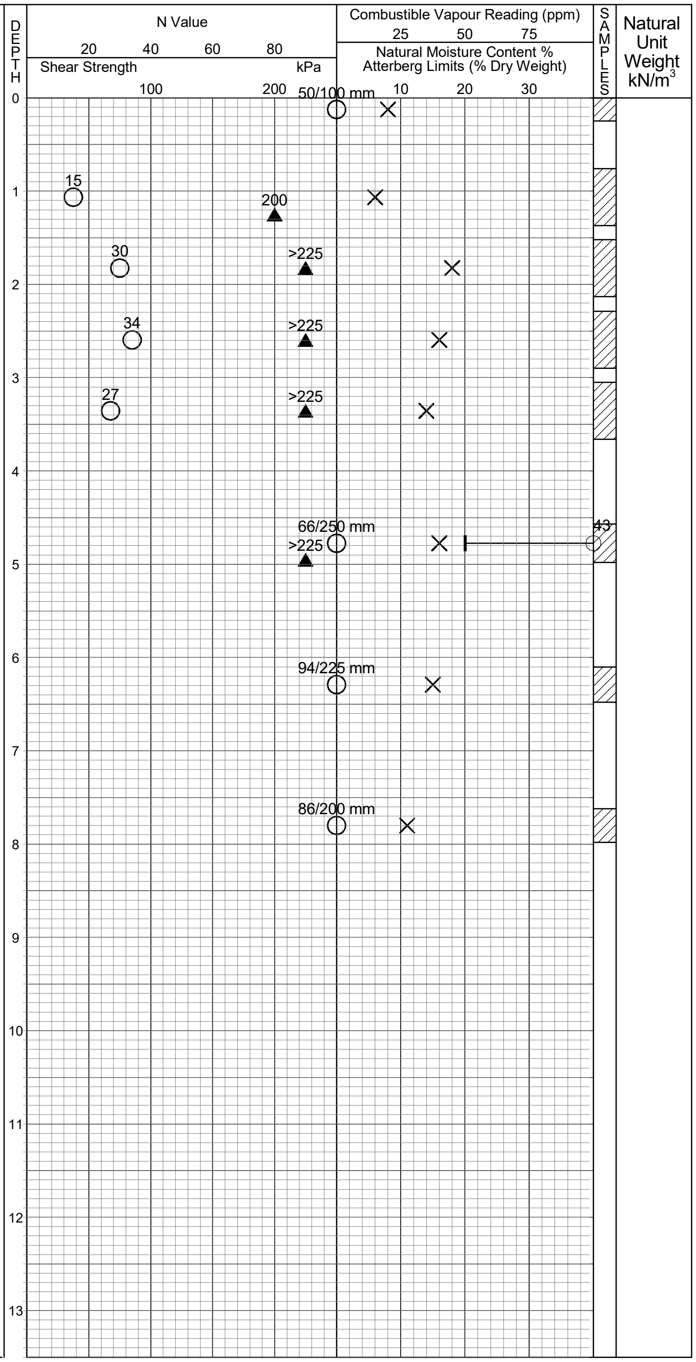
Date Drilled: November 11, 2020

Drill Type: CME-55 Track Mount. Solid Stem

Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
			85.44
		GRANULAR FILL: (~600 mm thick)	~84.8
		FILL: silty clay, trace sand and gravel, greyish brown, moist	~84.4
		SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel (intermediate plasticity) limestone inclusions below 4.6 m sandy below 6.1 m reddish brown, damp below 7.6 m	~77.5
		Borehole terminated at 8.0 m depth. NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others.	



LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

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Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	7.3

Log of Borehole BH-06

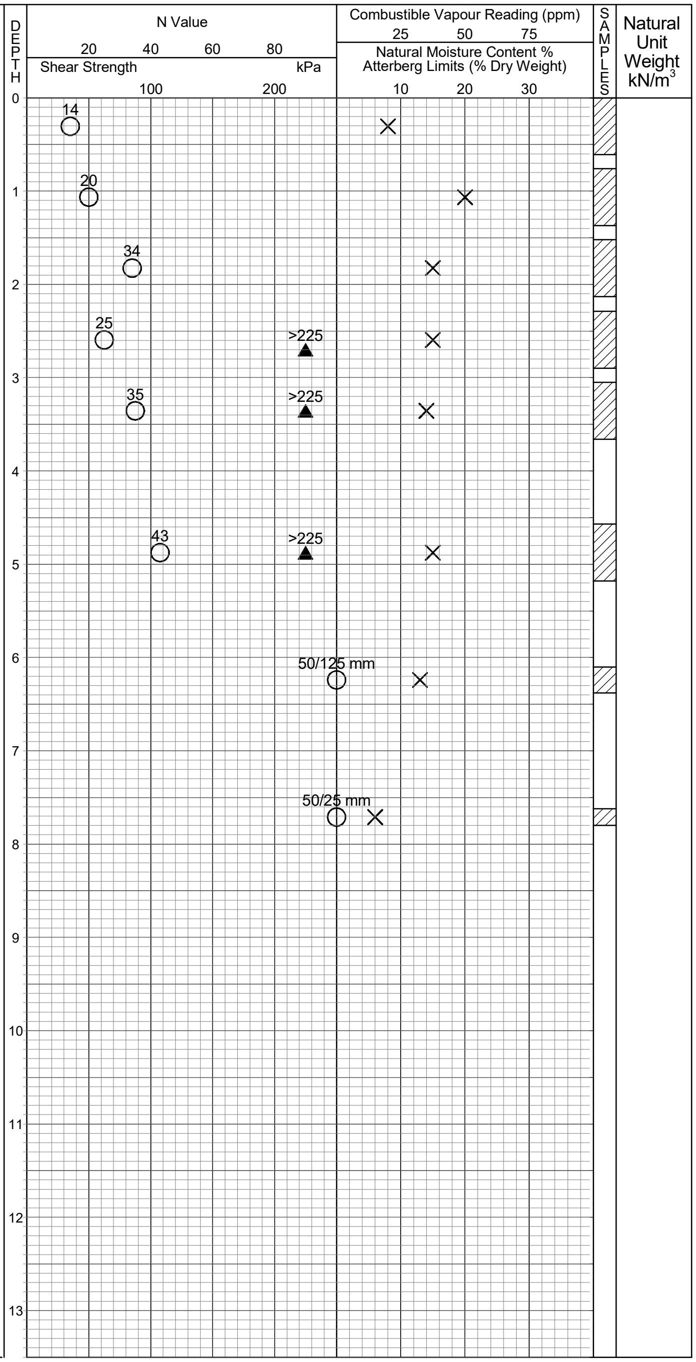
Project No. HAM-00802036-A0
Drawing No. 8
Project: Proposed Mid-Rise Apartment Building
Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 9, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒
SPT (N) Value	○ ▨
Dynamic Cone Test	—
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	☐
Natural Moisture	×
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
			85.42
		FILL: silty clay, trace sand and gravel, brown, moist, rootlets, concrete/asphalt fragments	
		SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel	~82.8
		shale fragments at 5.2 m	
		sandy, limestone inclusions below 6.1 m	
		SHALE: reddish brown and grey	~77.7
		Borehole terminated at 7.8 m depth.	~77.6

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	7.8

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Log of Borehole BH-07

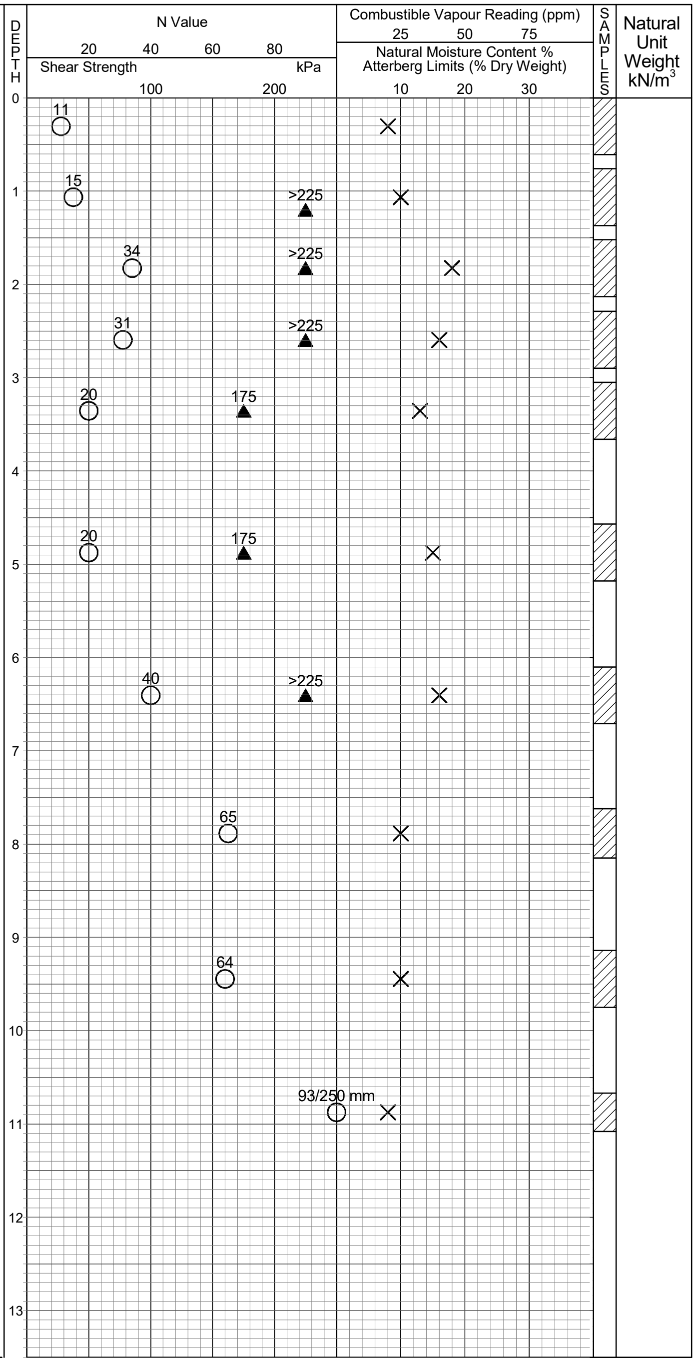
Project No. HAM-00802036-A0
Drawing No. 9
Project: Proposed Mid-Rise Apartment Building
Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 11, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├──○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲

Soil Description	ELEV. m
	85.54
TOPSOIL: (~150 mm thick)	~85.4
FILL: silty clay, some sand, trace gravel, grey, moist, asphalt/glass fragments	~84.5
SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel	
grey, very stiff below 3.1 m	
reddish brown, hard below 6.1 m	
sandy, damp below 7.6 m	~74.6
SHALE: reddish brown and grey	~74.5
Borehole terminated at 11.1 m depth.	

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	10.5

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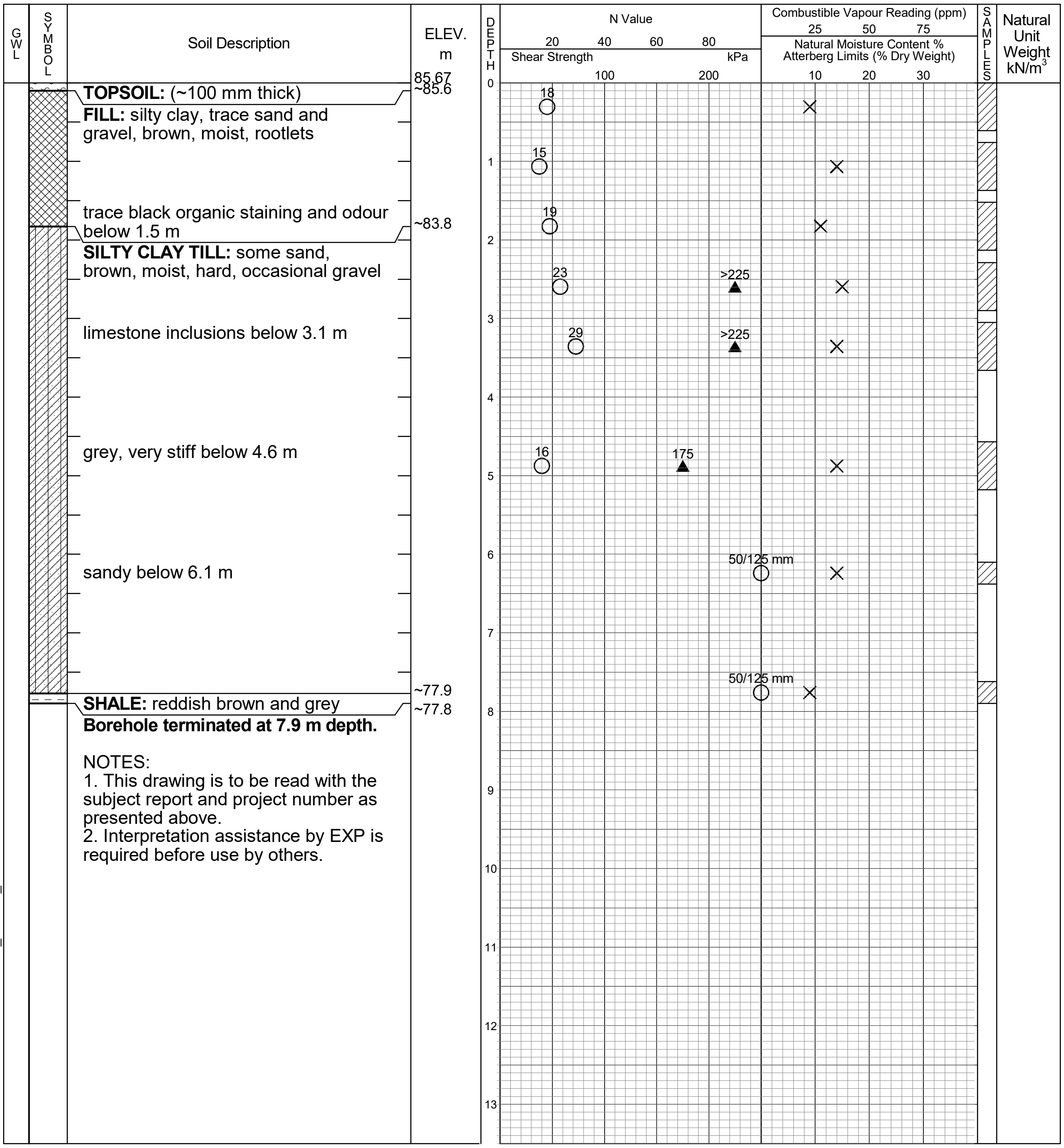
Log of Borehole BH-08

Project No. HAM-00802036-A0 Drawing No. 10
Project: Proposed Mid-Rise Apartment Building Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 11, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├─○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚ S	Penetrometer	▲



TOPSOIL: (~100 mm thick)

FILL: silty clay, trace sand and gravel, brown, moist, rootlets

trace black organic staining and odour below 1.5 m

SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel

limestone inclusions below 3.1 m

grey, very stiff below 4.6 m

sandy below 6.1 m

SHALE: reddish brown and grey

Borehole terminated at 7.9 m depth.

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

Time	Water Level (m)	Depth to Cave (m)
on completion	no free water	7.5

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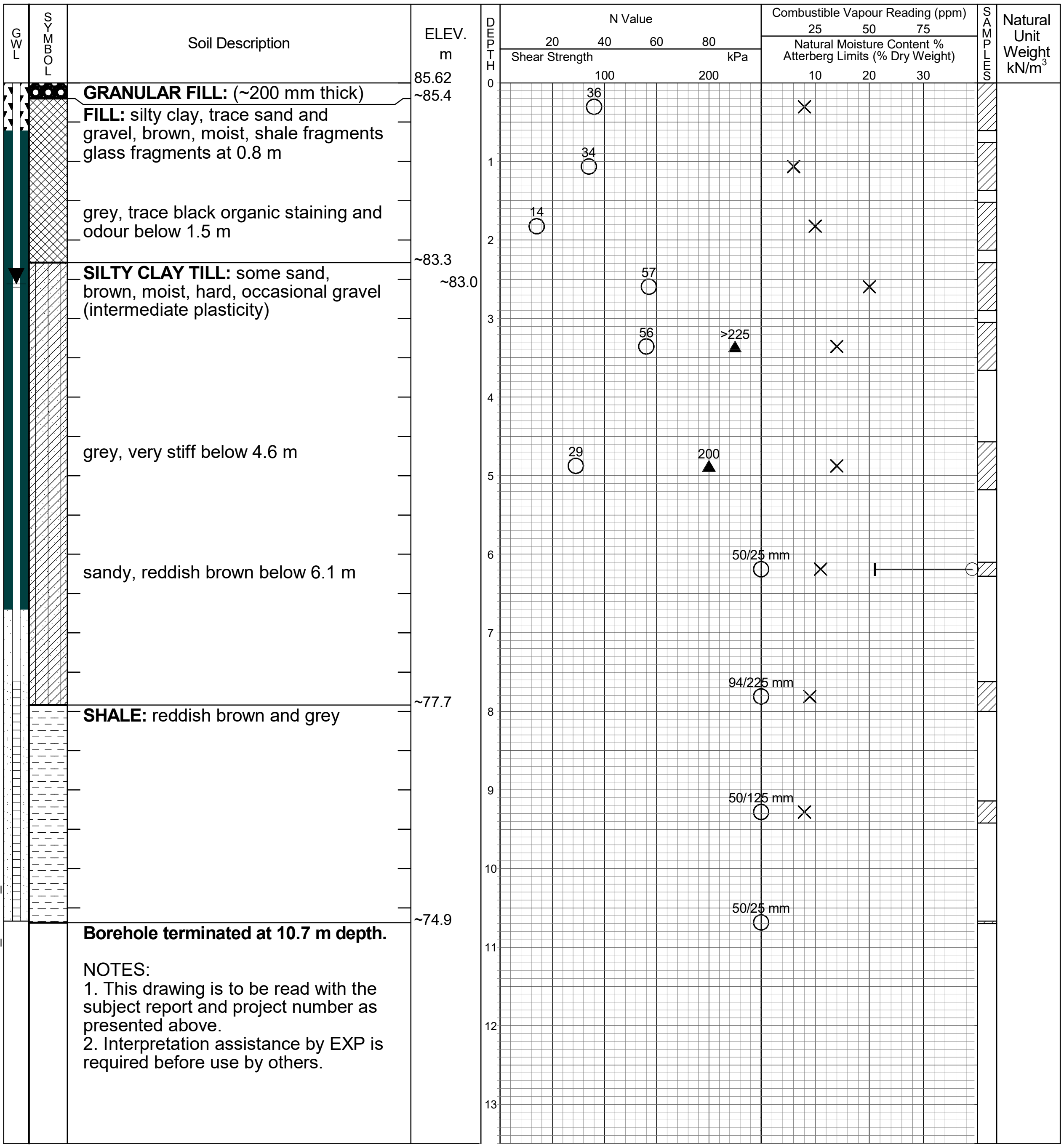
Facsimile: 905.573.9693

Log of Borehole BH-09

Project No.	HAM-00802036-A0	Drawing No.	11
Project:	Proposed Mid-Rise Apartment Building	Sheet No.	1 of 1
Location:	2481 Barton Street E, Hamilton, ON		

Date Drilled: November 11, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒	Combustible Vapour Reading	☐
SPT (N) Value	○ ▨	Natural Moisture	×
Dynamic Cone Test	—	Plastic and Liquid Limit	├─○
Shelby Tube	■	Undrained Triaxial at % Strain at Failure	⊕
Field Vane Test	✚S	Penetrometer	▲



Soil Description	ELEV. m
	85.62
GRANULAR FILL: (~200 mm thick)	~85.4
FILL: silty clay, trace sand and gravel, brown, moist, shale fragments glass fragments at 0.8 m grey, trace black organic staining and odour below 1.5 m	
SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel (intermediate plasticity) grey, very stiff below 4.6 m sandy, reddish brown below 6.1 m	~83.3 ~83.0
SHALE: reddish brown and grey	~77.7
Borehole terminated at 10.7 m depth.	~74.9

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BHLOGS_802036_DB.GPJ GINT STD US LAB.GDT 12/8/20

Time	Water Level (m)	Depth to Cave (m)
on completion	10.2	10.5
November 23, 2020	2.9	N/A
November 30, 2020	2.6	N/A

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Facsimile: 905.573.9693

Log of Borehole BH-10

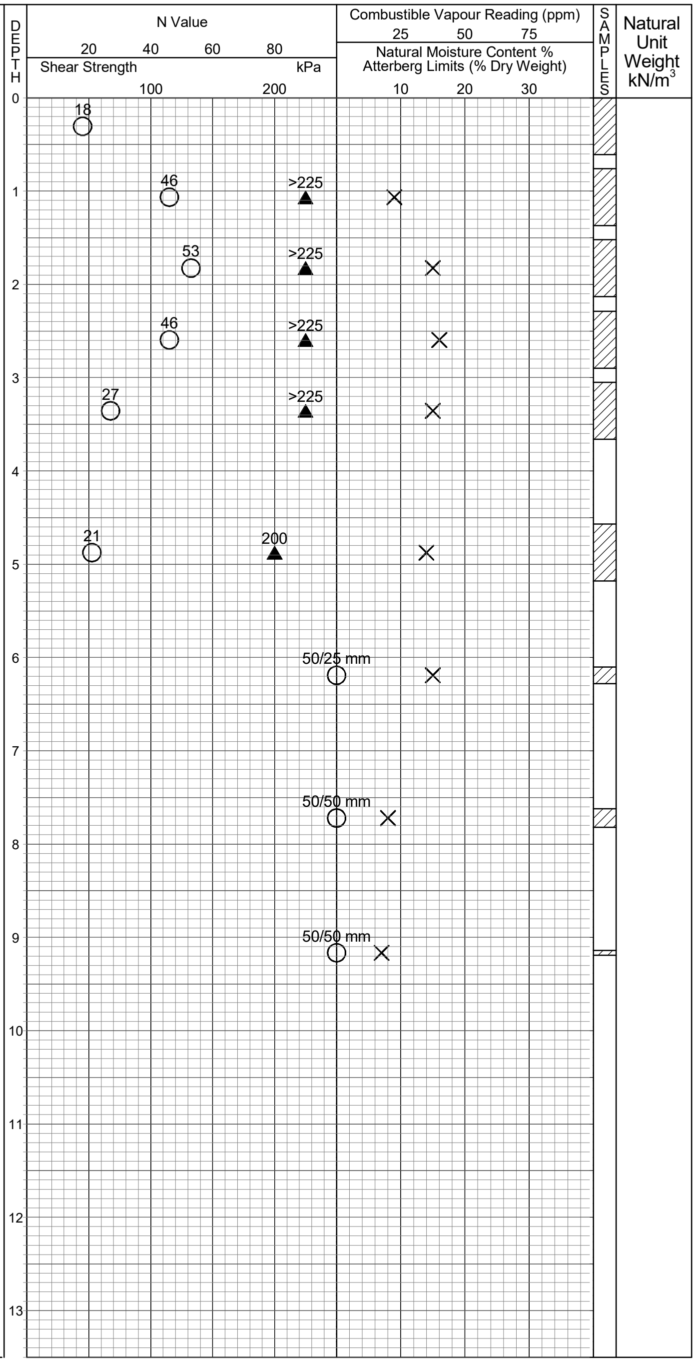
Project No. HAM-00802036-A0
Drawing No. 12
Project: Proposed Mid-Rise Apartment Building
Sheet No. 1 of 1
Location: 2481 Barton Street E, Hamilton, ON

Date Drilled: November 9, 2020
Drill Type: CME-55 Track Mount. Solid Stem
Datum: Geodetic

Auger Sample	☒
SPT (N) Value	○ ▨
Dynamic Cone Test	───
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	☐
Natural Moisture	×
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲

GWL	SYMBOL	Soil Description	ELEV. m
			85.66
		GRANULAR FILL: (~300 mm thick)	~85.4
		FILL: silty clay, trace sand and gravel, brown, moist	~84.9
		SILTY CLAY TILL: some sand, brown, moist, hard, occasional gravel grey, very stiff, limestone inclusions below 4.6 m	~79.4
		SHALE: reddish brown and grey	~76.5
		Borehole terminated at 9.2 m depth.	

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



Time	Water Level (m)	Depth to Cave (m)
on completion	8.9	9.2

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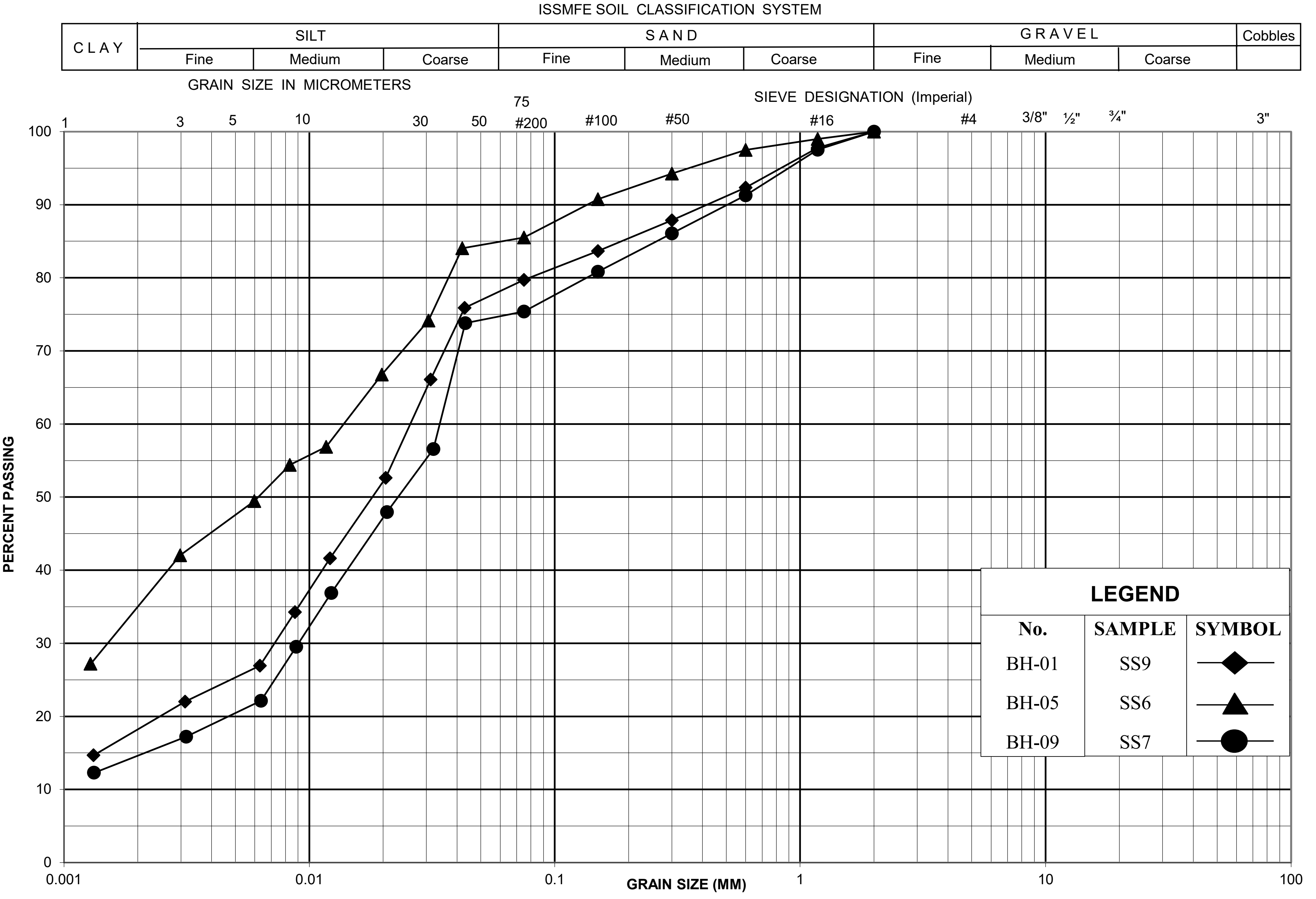
Facsimile: 905.573.9693

Appendix B

Laboratory Test Results



GRAIN SIZE DISTRIBUTION

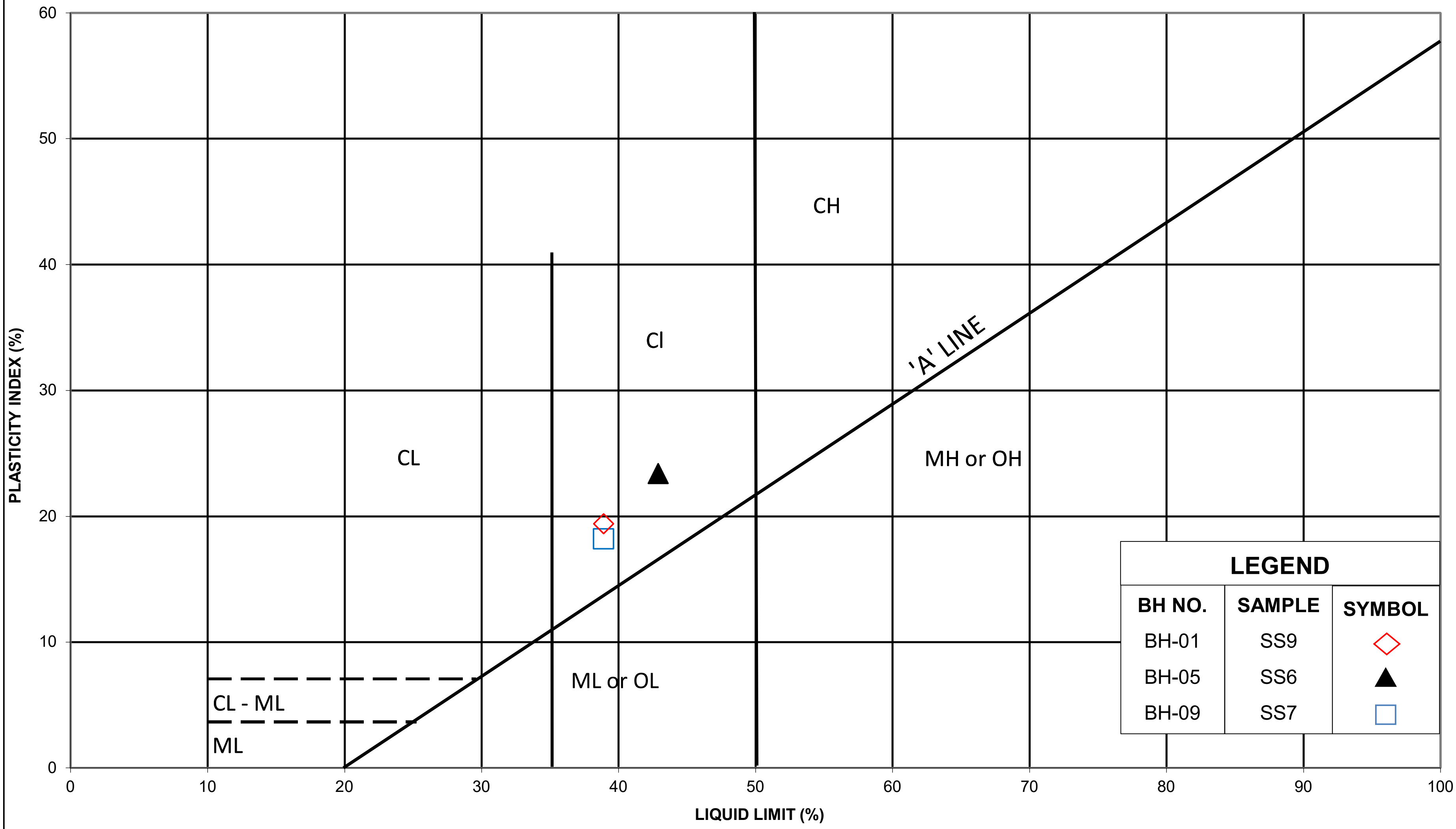
DRAWING NO.: B1

PROJECT NO.: HAM-00802036-A0

DATE: DECEMBER 2020

Proposed Mid-Rise Apartment Building

2481 Barton Street East, Hamilton, ON



exp.

PLASTICITY CHART

SILTY CLAY (CI)

DRAWING NO.:	B2
PROJECT NO.:	HAM-00802036-A0
DATE:	DECEMBER 2020