Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

GEOTECHNICAL INVESTIGATION
19 ELM STREET & 13 MOUNTAIN STREET
GRIMSBY, ONTARIO

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File No. 7-18-0051-01
Issued: May 18, 2021
Revision 1: May 26, 2021

Distribution of Report:

1 copy (pdf) – Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
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1.0 INTRODUCTION

Terraprobe Inc. was retained by Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc. (the client) to carry out a geotechnical investigation at 19 Elm Street and 13 Mountain Street in Grimsby, Ontario. The location of the site is shown on the Site Location Plan, Figure 1.

Terraprobe is in receipt of the preliminary architectural design package prepared by SvN Architects + Planners, dated May 7, 2021. Terraprobe is also in receipt of a topographic survey completed at the site by J.D. Barnes Limited, dated April 9, 2021.

The purpose of the work was to investigate and report on the subsurface soil and ground water conditions in a series of boreholes drilled at the site. Based on this information, advice is provided with respect to the geotechnical aspects of the proposed development, including the design of foundations, floor slabs-on-grade and pavements. The anticipated construction conditions pertaining to excavation, backfill and temporary ground water control are discussed also, but only with regard to how these might influence the design.

Phase One & Two Environmental Site Assessments (ESA) and a hydrogeological assessment were also carried out concurrently with the geotechnical investigation and are being reported under separate cover.

2.0 SITE AND PROJECT DESCRIPTION

2.1 Existing Site Conditions

The property consists of two contiguous parcels of land covering a total area of approximately 0.32 hectares (1.79 acres). The northern portion of the Site (13 Mountain Street) consists of a residential house which has been converted to office space. An ancillary building is located on the northeast portion of the Site that is currently used for commercial purposes. The southern portion of the Site (19 Elm Street) consists of a former church which is currently occupied by a community organization. The remainder of the site was paved and used for surface parking. The general arrangement of the site is shown on Figure 2.

2.2 Site Geology

Based on published geological information for the general area, near surface soil at and in the vicinity of the subject property generally consists of Halton Till; red to brown clayey silt till[1]. Beneath the

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[1] Quaternary Geology, Grimsby Area, Southern Ontario; Ontario Division of Mines; Map No. P.993; 1975.

overburden deposits is bedrock of the Queenston Formation.[2] The geological mapping and regional well records indicated that the bedrock beneath the site is approximately 18 meters below the existing grade.[3]

2.3 Proposed Development

The proposed development features are shown in Figures 3A and 3B, as derived from drawings prepared by SvN Architects + Planners. It is understood that the development presently under consideration would include the retention and adaptive reuse of two existing buildings on site, as well as a 7 storey residential building with two and half underground parking levels. The lowest FFE will be about 8.3 m below existing grade or at an elevation of about 85.3 ± for the lowest basement level. The excavation will extend below existing building foundations that will have to be supported during the excavation.

3.0 PROCEDURE

The field work for this investigation was carried out from March 23rd to March 31st, 2021, during which time seven (7) boreholes were drilled to depths of about 12.8 to 18.4 metres below the existing ground surface (m BGS). The locations of the boreholes are shown on the Borehole Location Plan, Figure 2. The results of the boreholes are shown on the Log of Borehole sheets presented in Appendix A.

The boreholes were drilled using track-mounted power auger drill rig supplied and operated by a specialist drilling contractor. The boreholes were advanced using conventional interval augering and sampling techniques. Soil samples were recovered by split barrel sampling in accordance with ASTM D1586. All leftover soil cuttings were disposed of in drums which were removed from the site following completion of the investigation.

Ground water observations were made in each borehole during and upon completion of drilling and sampling. In addition, monitoring wells were installed and sealed in Boreholes 1 to 6. The monitoring wells were extended to depths of about 6.1 to 9.8 m BGS and were constructed of 50 mm diameter schedule 40 PVC screen and riser with a silica sand pack, and bentonite seal. The screened sections of the wells were 3.0 m long in each installation. The remainder of the monitoring well sections were sealed with bentonite to the existing ground surface. A conventional 50 mm diameter J-plug was used to seal the top of each well and flush mount well caps were installed at the ground surface and sealed with concrete. Details of the construction of the monitoring wells are presented on the attached corresponding boreholes logs in Appendix A. The water levels were measured in the monitoring wells on several occasions between April 19th and May 6th by a member of our field staff.

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[2] Paleozoic Geology, Grimsby, Southern Ontario; Ontario Division of Mines; Map No. 2343; 1976.
[3] Bedrock Topography Series, Grimsby Area, Southern Ontario; Ministry of Natural Resources; Map No. P.2401; 1981.

Boreholes that were not equipped with a monitoring well were backfilled with bentonite pellets in accordance with Ontario Regulation 903, and sealed with nominally compacted commercial grade cold-mix asphalt patch at the pavement surface.

The field work was observed throughout by a member of our engineering staff who located the boreholes, arranged for the underground utility clearances at the borehole locations and cared for the samples obtained during the investigation. The borehole locations were located in the field in advance of drilling. The ground surface elevations at the borehole locations were inferred based on data from a topographic survey of the site provided by J.D. Barnes Limited Ltd, dated April 9, 2021. The elevations were understood to have been referred to the geodetic datum.

All of the samples recovered in the course of the investigation were brought to our Stoney Creek laboratory for further examination and water content determinations. The laboratory testing program consisted of the determination of the natural moisture content of all samples as well as grain size analysis on four (4) select soil samples. The results of grain size analysis are shown on the log of borehole sheets in Appendix A.

4.0 SUBSURFACE CONDITIONS

The subsurface soil and ground water conditions encountered in the boreholes are presented on the attached Log of Borehole in Appendix A. The stratigraphic boundaries indicated on the borehole are inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil type to another. These boundaries should not be interpreted to represent exact planes of geological change. The subsurface conditions have been confirmed in seven (7) generally evenly spaced boreholes, and may vary between and beyond the borehole locations.

4.1 Stratigraphy

The following discussion has been simplified in terms of the major soil strata encountered in the boreholes for the purposes of geotechnical design. In general, the boreholes drilled at the site penetrated asphalt and concrete pavements or pea gravel at the ground surface, overlying existing fill a clayey silt till stratum and bedrock of the Queenston Formation.

4.1.1 Existing Pavements and Surficial Materials

All boreholes with the exception of BH6 penetrated asphaltic concrete ranging in thickness from approximately 25 to 55 mm. A granular base layer varying in thickness from 50 to 360 mm was encountered below the asphaltic concrete. Borehole BH6 encountered approximately 100 mm of pea gravel at the surface.

4.1.2 Fill

Underlying the surficial materials at all borehole locations, a layer of earth fill was encountered, extending to depths of 2.3 to 4.0 m below existing grade (Elev. 89.8 to 91.5 masl). The earth fill was variable but typically consisted of sand and gravel with varying amounts of silt and clay. Trace brick fragments were observed within the fill material at BH3 and BH4. The earth fill was typically brown in colour. Standard Penetration Testing within the earth fill indicated N values ranging from 4 to greater than 50 blows per 0.3 m, indicating a loose to very dense state of compaction. The in-situ water content of the fill ranged from about 5 to 40 percent.

4.1.3 Clayey Silt Till

Underlying the earth fill, all boreholes encountered a native stratum of clayey silt with gravel, some sand, extending to depths of 12.6 to 18.3 m below existing grade (Elev. 74.8 to 82.4 masl). Boreholes BH1, BH3, BH5, and BH7 encountered trace red shale fragments between 7.6 and 9.1 m below existing grade. All boreholes with the exception of BH5 were terminated within the clayey silt. The clayey silt was typically brown to grey. Standard Penetration Testing carried out within the clayey silt indicated N values ranging from 20 to greater than 50 blows per 0.3 m, indicating a very stiff to hard consistency. The in-situ water content of the samples of clayey silt ranged from about 11 to 18 percent.

4.1.4 Weathered Shale Bedrock

As best as could be practically determined, weathered shale bedrock was encountered in Borehole 5 at a depth of about 18.3 m BGS, or at about elevation 74.8 masl. Standard Penetration Testing of the weathered shale indicated a single N value of greater than 50 blows per 0.3 m, indicating a hard consistency. The in-situ water content of the sample of weathered shale was approximately 10 percent.

Detailed exploration of the bedrock was not carried out as part of this assignment; however the bedrock beneath the site is known to consist of the Queenston Formation which is comprised of predominantly thinly bedded reddish brown shale of Ordovician age. The shale contains interbeds of green calcareous shale, limestone, sandstone and siltstone.

There is typically a horizontal zone of weathering at the contact between the weak rock of the Queenston Formation and the glacial soil overburden. In the Ontario Ministry of Transportation and Communications document RR229, *Evaluation of Shales for Construction Projects,* there is reproduced from Skempton, Davis and Chandler, a typical weathering profile of low durability shale, that characterizes the shale surface into three grades of weathering and four zones described as follows:

	Zone	Description	Notes
Fully Weathered	IVb	soil like matrix only	indistinguishable from glacial drift deposits, slightly clayey, may be fissured

	Zone	**Description**	**Notes**
Partially Weathered	IVa	soil like matrix with occasional pellets of shale less than 3 mm dia.	little or no trace of rock structure, although matrix may contain relic fissures
	III	soil like matrix with frequent angular shale particles up to 25 mm dia.	moisture content of matrix greater than the shale particles
	II	angular blocks of unweathered shale with virtually no matrix separated by weaker chemically weathered but intact shale	spheroidal chemical weathering of shale pieces emanating from relic joints and fissures, and bedding planes
Unweathered (Sound)	I	shale	regular fissuring

The augered borehole method used at this site is conventionally accepted investigative practise, however the interval sampling method does not define the bedrock surface with precision, particularly where the surface of the rock is weathered, weaker and easily penetrated by the auger. The change in resistance to augering in between Zones III and II in the shale profile is not profound. The top of rock as indicated on the Borehole Logs from this investigation is to be consistently interpreted as the surface of Zone II in the profile.

4.2 Ground Water

Unstabilized ground water level observations were made in the open boreholes during and after drilling, as noted on the borehole logs. A 50 mm diameter monitoring well was installed in Boreholes 1 to 6 to facilitate long-term ground water monitoring. The water levels measured within the installed wells are shown on the corresponding log of borehole sheets and are summarized below.

Borehole No.	**Elevation of Well Screen (m)**	**Stratum Captured by Well Screen**	**Depth / Elevation of Water Level in Well (m)**				
			March 31/21	**April 19/21**	**April 27/21**	**May 3/21**	**May 6/21**
1	86.1 to 83.0	Clayey Silt Till	1.6/91.2*	1.6/91.2*	1.6/91.2*	1.6/91.2*	1.6/91.2*
2	86.4 to 83.3	Clayey Silt Till	Dry	8.6/84.5	8.0/85.1	7.3/85.8	8.7/84.4
3	88.3 to 85.2	Clayey Silt Till	Dry	9.2/85.8	8.6/86.4	8.3/86.7	9.2/85.8
4	91.7 to 88.6	Fill/Clayey Silt Till	3.1/91.6	3.2/91.5	3.2/91.5	3.2/91.5	3.2/91.5
5	89.9 to 86.8	Clayey Silt Till	Dry	Dry	6.2/86.9	6.0/87.1	5.9/87.2
6	89.9 to 86.8	Clayey Silt Till	Dry	5.7/87.4	5.4/87.7	5.2/87.9	5.1/88.0

* Groundwater elevations from the monitoring well installation at Borehole 1 were not consistent with those observed at the remainder of the monitoring wells, and is considered anomalous for a monitoring well screened within clayey silty till. It is considered likely that the well was compromised on installation and as such ground water information is not available from the monitoring location Borehole 1. Comments herein relating to groundwater within native glacial till soils are based on the observed groundwater elevations from BH4.

5.0 GEOTECHNICAL DESIGN

The following discussion and recommendations are based on the factual data obtained from this investigation and are intended for use by the owner and the design engineer. Comments made regarding the construction aspects are provided only in as much as they may impact on design considerations. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

This report is based on the assumption that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards and guidelines of practice. If there are any changes to the site development features, or there is any additional information relevant to the interpretations made of the subsurface information with respect to the geotechnical analyses or other recommendations, then Terraprobe should be retained to review the implications of these changes with respect to the contents of this report.

It is understood that the development presently under consideration would include seven (7) storeys above grade with two and a half underground parking levels. It is understood that portions of the existing historic buildings will remain. The lowest FFE will be about 8.3 m below existing grade or at an elevation of about 85.3 ± for the lowest basement level. The excavation will extend below existing building foundations that will have to be supported during the excavation.

5.1 Foundation Design Parameters

Based on the subsurface conditions encountered at the site, and the expected foundation loading, consideration has been given to supporting the proposed building on conventional spread footing foundations, bearing within the clayey silt till stratum. The following table summarizes the bearing resistance at serviceability limit states (SLS) and factored geotechnical resistance at ultimate limit states (ULS) for design purposes possible for conventional spread footing foundations by borehole location at the highest permissible elevations.

Bearing Pressure Possible for Spread Footing Foundations

Borehole No.	Minimum Depth Below Existing Grade (m)	Geodetic Elevation (m)	Allowable Bearing Pressure SLS (kPa)	Factored Bearing Capacity at ULS (kPa)	Bearing Stratum
BH 1	3.3	89.5	300	450	Clayey Silt Till
	6.1	86.7	500	750	Clayey Silt Till
BH 2	2.6	90.5	300	450	Clayey Silt Till

Borehole No.	Minimum Depth Below Existing Grade (m)	Geodetic Elevation (m)	Allowable Bearing Pressure SLS (kPa)	Factored Bearing Capacity at ULS (kPa)	Bearing Stratum
	9.2	83.9	500	750	Clayey Silt Till
BH 3	4.3	90.7	300	450	Clayey Silt Till
	7.6	87.4	500	750	Clayey Silt Till
BH 4	4.1	90.6	300	450	Clayey Silt Till
	7.6	87.1	500	750	Clayey Silt Till
BH 5	2.6	90.5	300	450	Clayey Silt Till
	6.1	87.0	500	750	Clayey Silt Till
BH 6	2.6	90.5	300	450	Clayey Silt Till
	7.6	85.5	500	750	Clayey Silt Till
BH 7	2.6	90.9	300	450	Clayey Silt Till
	7.6	85.9	500	750	Clayey Silt Till

Higher design bearing resistances are feasible within the clayey silt till; however, any change to the design bearing resistances given above should be discussed with our office. A minimum footing width of 500 mm is recommended for strip footings and a minimum footing width of 900 mm should be considered for spread footings. The total and differential settlement (short term and long term) of spread footings established on the clayey silt till stratum at the above design bearing pressures is expected to be less than 25 mm.

Some variability in the consistency and depth of the native undisturbed strata is expected. Deeper excavations may be required locally and for this reason, it is important that all of the foundation excavations be inspected by the geotechnical engineer to confirm that any fill or soft/loose surficial soil has been fully penetrated and to identify any preparatory work required prior to placing the footing concrete. Where deeper excavations are required, the footings should be lowered in a series of steps with maximum vertical increments of 600 mm and with a rise to run ratio of 1:2.

5.2 Earthquake Design Parameters

Under Ontario Regulation 88/19, the ministry amended Ontario’s Building Code (O. Reg 332/12) to further harmonize Ontario’s Building Code with the 2015 National Codes. These changes are intended to help reduce red tape for businesses and remove barriers to interprovincial trade throughout the country. The amendments are based on code change proposals the ministry consulted in 2016 and 2017. The majority of the amendments came into effect on January 1, 2020, which includes structural sufficiency of buildings to withstand external forces and improve resilience.

Seismic hazard is defined in the 2012 Ontario Building Code (OBC 2012) by uniform hazard spectra (UHS) at spectral coordinates of 0.2 s, 0.5 s, 1.0 s and 2.0 s and a probability of exceedance of 2% in 50 years. The OBC method uses a site classification system defined by the average soil/bedrock properties (e.g. shear wave velocity (vs), Standard Penetration Test (SPT) resistance, and undrained shear strength (su)) in the top 30 meters of the site stratigraphy below the foundation level, as set out in Table 4.1.8.4A of the Ontario Building Code (2012). There are 6 site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote problematic soils (e.g. sites underlain by thick peat deposits and/or liquefiable soils). The site class is then used to obtain peak ground acceleration (PGA), peak ground velocity (PGV) site coefficients Fa and Fv, respectively, used to modify the UHS to account for the effects of site-specific soil conditions.

Based on the above noted information, it is recommended that the site designation for seismic analysis be ‘Site Class D’, as per Table 4.1.8.4.A of the Ontario Building Code (2012). Consideration may be given to conducting a site specific Multichannel Analysis of Surface Waves (MASW) at this site to determine the average shear wave velocity in the top 30 metres of the site stratigraphy. An improved seismic site designation (Site Class C) may be possible.

The values of the site coefficient for design spectral acceleration at period T, F(T), and of similar coefficients F(PGA) and F(PGV) shall conform to Tables 4.1.8.4.B. to 4.1.8.4.I of the OBC 2012, as amended January 1, 2020, using linear interpolation for intermediate values of PGA.

5.3 Slab on Grade Design Parameters

It is expected that the elevation of the lowest finished floors will be within the very stiff to hard silty clay to clayey silt stratum, which is capable of supporting a conventional lightly loaded slabs on grade. The moduli of subgrade reaction appropriate for slab on grade design in the above noted overburden soils and weathered shale is shown in the following table.

Stratum	Modulus of Subgrade Reaction k_s (kN/m^3)
Silty Clay to Clayey Silt Till (Very Stiff to hard)	40,000

It is recommended that when the grade for the slab areas is cut to the design elevation, that the subgrade be inspected while it is proof rolled with a smooth drum compactor. Any weak areas exposed by this activity can then be remediated by replacement of fill, or recompaction of the existing subgrade prior to placing the underfloor fill materials. Final construction beneath slabs on grade should consist of 200 mm of Granular A uniformly compacted to 98 percent of standard Proctor maximum dry density (SPMDD).

It is understood that the underground levels will be used primarily for parking. On this basis it is anticipated that moisture sensitive floor coverings are not proposed for this level and it may not be necessary to incorporate a vapour barrier into the design of the floor slabs on grade. If moisture sensitive floor finishes are proposed, a capillary moisture barrier and drainage layer will be required beneath the slab. This can be achieved by providing a minimum 200mm thick layer of clear crushed stone compacted to a dense state. Where slabs on grade are constructed on a sand and gravel subgrade, filter cloth should be used to separate the subgrade and clear stone to prevent in the ingress of fine particles into the drainage layer. General drainage recommendations for the below grade levels of the proposed development are discussed in the following Section 5.4.

5.4 Basement Drainage

The highest ground water level was measured in monitoring well BH4 at a depth of about 3.2 m BGS. Terraprobe is completing a separate Hydrogeological Investigation which will be provided under separate cover. On this basis, foundation drainage is not a major design constraint. It is considered however that substructure walls should be provided with a conventional perimeter foundation drain. To assist in maintaining dry basements and preventing seepage, it is recommended that exterior grades around the building be sloped away at a minimum 2 percent gradient, for a distance of at least 1.2 m.

Foundation walls must be damp-proofed in conformance with Section 5.8.2 of the Ontario Building Code (2012). Prefabricated drainage composites, such as Miradrain 2000 (Mirafi) or Terradrain 200 (Terrafix), should be incorporated between the shoring wall and the cast-in-place concrete foundation wall to make a drained cavity. Drainage from the cavity must be collected at the base of the wall in non-perforated pipes and conveyed directly to the sumps. The flow to the building storm water sump from the subsurface drainage will be governed largely by the building perimeter drainage collection during rainfall and runoff events. Typical shored excavation drainage details are provided in Appendix B.

The elevator pits can be drained separately with an independent lower pumping sump or can be designed as water proof structures which are below the drainage level.

If the municipality does not allow for long-term discharge of ground water to the municipal storm sewer system, the underground parking levels will have to be constructed as a waterproofed structure.

5.5 Earth Pressure Design Parameters

The appropriate values for use in the design of structures subject to unbalanced earth pressures at this site are tabulated as follows:

Stratum/Parameter	φ (deg.)	γ (kN/m^3)	K_a	K_o	K_p
Compact Granular Fill Granular 'B' (OPSS 1010)	32	21.0	0.31	0.47	3.25
Existing Earth Fill	29	19.0	0.35	0.52	2.88

Stratum/Parameter	φ (deg.)	γ (kN/m³)	K_a	K_o	K_p
Clayey Silt TIII	32	21.0	0.31	0.47	3.25

Walls subject to unbalanced earth pressures must be designed to resist a pressure that can be calculated based on the following equation:

$$\mathbf{P = K[\gamma(h - h_w) + \gamma' h_w + q] + \gamma_w h_w}$$

where,
P = the horizontal pressure at depth, **h** (m)
K = the earth pressure coefficient
h_w = the depth below the groundwater level (m)
γ = the bulk unit weight of soil, (kN/m^3)
γ' = the submerged unit weight of the exterior soil, (γ - 9.8 kN/m^3)
q = the complete surcharge loading (kPa)

The above equation pertains to a horizontal grade condition behind a retaining structure. Values of earth pressure against retaining structures for an inclined retaining grade condition will vary.

Where the wall backfill can be drained effectively to eliminate hydrostatic pressures on the wall that would otherwise act in conjunction with the earth pressure, this equation can be simplified to:

$$\mathbf{P = K[\gamma h + q]}$$

To ensure that there is no hydrostatic pressure acting in conjunction with the earth pressure, where the structure is made directly against a shored excavation, drainage is provided by forming a drained cavity with prefabricated drain core material covering the excavation face and designed to discharge collected water into a perimeter/underfloor drainage system. Where the structure is built by open cut excavation methods, this equation assumes that free-draining granular backfill such as Granular B (OPSS 1010) is used and effective drainage is provided.

Consideration must also be given to the possible effects of frost on structures retaining earth. Pressures induced by freezing in frost-susceptible soils are effectively irresistible.

5.6 Site Servicing

It is expected that site services may consist of new watermain and sanitary main connections, as well as new storm sewers and catch basins with relatively shallow inverts (i.e., less than 3 m). Excavations for underground services should be made as outlined in Section 6.1 of this report. The invert elevations are expected to be within the undisturbed clayey silt. Care will be required to ensure that any soft/loose or disturbed soil is removed from beneath the pipes. Over-excavated trenches may be restored to the invert elevation using lean concrete or additional bedding material. The need for additional excavation can best be determined by the geotechnical engineer during construction.

5.6.1 Bedding

The bedding materials should be adequately compacted to provide support and protection to the service pipes. Pipe bedding should comply with a Class B bedding configuration as per the requirements of OPSD 802.030 (rigid pipe) and/or OPSD 802.010 (flexible pipe). Bedding should consist of a well graded granular material such as Granular A which is compatible with the size and type of pipe. All bedding must be uniformly compacted to a minimum of 95 percent of standard Proctor maximum dry density.

5.6.2 Backfill

Service trench backfill should consist of clean earth, free of excessively wet or frozen soil and should be placed in lifts of 300 mm thickness or less and uniformly compacted to at least 95 percent of standard Proctor maximum dry density at placement water contents within 2 percent of the corresponding laboratory optimum water content for compaction. The upper 1m of the backfill should be uniformly compacted to 98 percent of standard Proctor maximum dry density.

It may be difficult to consistently achieve the degree of compaction specified above using the native excavated soil as trench backfill, particularly in narrow trenches. For this reason, consideration could be given to using free draining granular material, such as Type I Granular B (OPSS 1010) to allow for adequate, uniform compaction.

5.7 Pavement Design

5.7.1 Subgrade Preparation

It is recommended that the subgrade be cut as cleanly as possible to minimize disturbance and be proof rolled with a static roller to identify any loose or disturbed areas. The preparation of the subgrade and the compaction of all fills should be monitored at the time of construction.

If fill is required to raise the grade, there may by some select on-site fill which could be used, provided it is free of topsoil and other deleterious material, and is at suitable placement water content. If imported fill is used, the fill should consist of clean earth materials (not excessively wet), free of organics and topsoil, and free of deleterious materials such as building rubble, wood, plant materials and at a suitable placement water content. The fill should be placed in large areas where it can be uniformly compacted in 300 mm thick lifts with each lift uniformly compacted to at least 95 percent of SPMDD. The upper 1 m of fill beneath areas to be developed as pavements should be compacted to 98 percent of SPMDD.

The final subgrade should be free of depressions and sloped (preferably at a minimum grade of two percent) to promote subgrade drainage. Effective drainage of the granular base and subbase should be achieved by properly filtered subgrade drains at the catchbasin locations and along curb lines.

5.7.2 Asphaltic Concrete Pavement Design

The following pavement component thicknesses are recommended for flexible pavements which will be subjected to ‘heavy duty’ use (ie main site accesses and drive thru aisles) and ‘light duty’ use (ie car parking) constructed on a properly prepared clayey silt subgrade.

Minimum Asphaltic Concrete Pavement Structure

Pavement Layer	Compaction Requirements	Car Traffic Minimum Component Thickness	Truck Traffic Minimum Component Thickness
Surface Course Asphaltic Concrete HL3 (OPSS 1150)	92% MRD	40 mm	50 mm
Base Course Asphaltic Concrete HL8 (OPSS 1150)	92% MRD	50 mm	60 mm
Base Course: Granular A (OPSS 1010) or 19mm Crusher Run Limestone	98% standard Proctor Maximum Dry Density (ASTM-D1557)	150 mm	150 mm
Subbase Course: Granular B Type II (OPSS 1010) or 50mm Crusher Run Limestone	98% standard Proctor Maximum Dry Density (ASTM-D1557)	300 mm	400 mm

Some adjustment to the thickness of the granular subbase material may be required depending on the condition of the subgrade at the time of the pavement construction. The need for such adjustments can be best assessed by the geotechnical engineer during construction.

Consideration should be given to delaying the placement of the final wearing surface for at least one year after construction of the binder course in order to minimize the effects of post construction settlement. Prior to placing the wearing surface, the binder course should be evaluated by the geotechnical engineer and remedial work carried out as required in preparation for final construction.

5.7.3 Drainage

Control of surface water is a significant factor in achieving good pavement life. Grading adjacent to pavement areas must be designed so that water is not allowed to pond adjacent to the outside edges of the pavement or curb. The subgrade must be free of depressions and sloped (preferably at a minimum grade of two percent) to provide effective drainage toward subgrade drains or swales and/or ditches.

Continuous perimeter subdrains should be provided in paved areas and short perforated sub drains should be provided at all catch basins locations. The subdrain invert elevations should be maintained at least 0.3 metres below subgrade level.

It should be noted that in addition to a strict adherence to the above pavement design recommendations, a close control on the pavement construction process will be required in order to obtain the desired pavement life. It is therefore recommended that regular inspection and testing should be conducted during the construction to confirm material quality, thickness, drainage, and to ensure adequate compaction.

6.0 DESIGN CONSIDERATIONS FOR CONSTRUCTABILITY

6.1 Excavations

Excavations must be carried out in accordance with the Occupational Health and Safety Act, Ontario Regulation 213/91 (as amended), Construction Projects, Part III – Excavations, Sections 222 through 242. These regulations designate four (4) broad classifications of soils for specifying appropriate measures for excavation safety. Within this context and for excavations of not greater than 3m in depth, the following table summarizes the recommended soil classification for each of the encountered soil strata in the boreholes, provided that ground water seepage is controlled and surface water is directed away from open excavations.

Soil Description	Soil Type (OHSA Classification)
Fill (All fill)	Type 3
Clayey Silt Till (Undisturbed)	Type 2

Where workers must enter a trench or excavation the soil must be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. The regulation stipulates safe slopes of excavation by soil type as follows:

Soil Type	Base of Slope	Steepest Slope Inclination
1	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
2	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
3	from bottom of trench	1 horizontal to 1 vertical
4	from bottom of trench	3 horizontal to 1 vertical

Minimum support system requirements for steeper excavations are stipulated in Sections 235 through 238 and 241 of the Act and Regulations and include provisions for timbering, shoring and moveable trench boxes.

The need for shoring to support adjacent property will depend on the proximity of the building footprint to the property lines and adjacent structures. For preliminary consideration temporary unsupported excavations should be cut to an overall inclination of 1 horizontal to 1 vertical or flatter and a buffer of 1 to 3m should be provided between the top of the excavation and the property lines. If this minimum geometry cannot be achieved then consideration will need to be given to the use of shoring. The requirement for shoring will need to be examined when the actual building footprints and the number of basement levels have been finalized. Preliminary shoring design recommendations are discussed in Section 6.2.

It should be noted that surplus excavated soil resulting from the construction that is to be disposed of off-site, will require chemical analyses to assess the disposal site requirements. Chemical analyses of soil was carried out as part of the concurrent Phase Two ESA, which will be provided under separate cover. It should be noted that sites accepting fill usually have aesthetic, or engineering property requirements, as well as chemical requirements for soil acceptance. Such requirements are site specific, so assessment of the appropriateness of the soil from this site for use at other locations was beyond the scope of the investigation.

6.2 Preliminary Shoring Design Recommendations

Where excavations cannot be sloped, they can be supported using conventional soldier pile and lagging walls. The west wall of the excavation is expected to adjoin an adjacent building structure. Depending on whether adjacent structures need to be supported, a rigid shoring system to preserve the integrity and support of the soil beneath the existing foundations of the adjacent buildings in a state approximating the at-rest condition may be required.

6.2.1 Earth Pressure Distribution

If the shoring is supported with a single level of earth anchor or bracing, a triangular earth pressure distribution similar to that used for the basement wall design is appropriate. Where multiple supports are used to support the excavation, research has shown that a distributed pressure diagram more realistically approximates the earth pressure on a shoring system of this type, when restrained by pre-tensioned anchors. In the clayey silt, multi-level supported shoring can be designed based on an earth pressure distribution consisting of a trapezoidal pressure distribution with a maximum pressure defined by:

$$\boldsymbol{P = 0.8\,K[\gamma H + q]}$$

In this distribution, the earth pressure is taken as zero at the grade level, uniformly increasing to a maximum pressure within 1/4H. Similarly, from a depth 3/4H, the maximum design pressure can be decreased to zero pressure at the base of the excavation.

The ground water pressure distribution along the shoring wall in conjunction with the above soil pressures is only applicable where an impermeable boundary condition is created along the perimeter of the excavation, as is the case with an interlocking caisson wall. Conventional soldier pile and lagging do not experience ground water pressures, as water is allowed to drain freely through the wall.

6.2.2 Soldier Pile Toe Design

Soldier pile toes will be made in the very stiff to hard clayey silt till. The horizontal resistance of the soldier pile toes will be developed by embedment below the base of excavation, where resistance is developed from passive earth pressure.

For the design of soldier pile toes in the hard cohesive clayey silt till beneath the excavation base, the commentary on the Ontario Bridge Design Code 3rd edition suggests that passive earth pressure be taken as twice the undrained shear strength at surface increasing to 9 times the undrained shear strength at 3 effective pile diameters depth. This capacity is distributed over the effective pile width. The undrained shear strength of the clayey silt till is estimated to be a minimum of 150 kPa.

If the soldier piles are subject to vertical loading, then the toes will support the load by bearing on the base of the concrete toe fill and friction on the embedded portion of the soldier pile toe concrete. The unfactored ultimate end bearing capacity in the undisturbed silty clay to clayey silt till is estimated to be about 300 kPa. The developable ultimate adhesion in the undisturbed silty clay to clayey silt till is estimated to be not less than 60 kPa.

6.2.3 Shoring Support

If anchor support is necessary and determined to be feasible, the shoring system should be supported by pre-stressed soil anchors extending beneath the adjacent lands. Pre-stressed anchors are installed and stressed in advance of excavation and this limits movement of the shoring system as much as is practically possible. The use of anchors on adjacent properties requires the consent of the adjacent land owners, expressed in encroachment agreements.

Raker footings established in the undisturbed clayey silt till at an inclination of 45 degrees can be designed for a maximum factored geotechnical resistance at ULS of 200 kPa.

The design adhesion for earth anchors is controlled as much by the installation technique as the soil and therefore a proto-type anchor must be made in each anchor level executed to demonstrate the anchor capacity and validate the design assumptions. It is expected that post-grouted anchors can be made such that an anchor will safely carry about 60 kN/m of adhered anchor length (at a nominal diameter of 150 mm) within the clayey silt till stratum. Higher bond stresses are possible but proof testing of anchorages on a site by site basis is required.

6.3 Depth of Frost Penetration

The design earth cover for frost protection of foundations exposed to ambient environmental temperatures is 1.2 metres in the Hamilton/Niagara area. Experience suggests that the temperature in “unheated” underground parking levels two or more levels below grade with normal ventilation provisions is not as severe as the ambient open air condition. The earth cover required to prevent frost effects on foundations in the lower parking levels need not be any greater than 1.2 metres, and experience in a number of structures has shown that perimeter foundations provided with 600 mm of cover perform adequately as do interior isolated foundations with 900 mm of cover. At locations adjacent to ventilation shafts, it is normal practice to provide insulation to ensure that foundations are not affected by the cold air flow.

For buried utility lines, variations from the above noted depth of frost penetration might be considered, depending on various factors such as the type of backfilling materials or the temperature and moisture exposure of the area (prevailing winds, drifting snow, etc.). However, these variations do not generally represent a concern unless special equipment and/or buried utilities have specific requirements regarding the subsurface temperature and moisture regime (i.e., water lines or sensitive electrical utilities etc.). In such special situations further tests and analysis should be conducted on a case-by-case basis.

The depth of frost penetration is also defined as the zone of active weathering where sizeable variations in the moisture content accompany the yearly temperature fluctuations. Therefore, the foundation grades should be established at or below this depth. For the light poles and other light structures that are to be installed on a single footing, if some frost heave (25 mm to 50 mm) cannot be tolerated, the foundation elements should also be provided with the above noted minimum depth of soil cover or equivalent exterior-grade insulation.

The soil at this site is susceptible to frost effects which would have the potential to deform hard landscaping adjacent to the building. At locations where buildings are expected to have flush entrances, care must be taken in detailing the exterior slabs / sidewalks, providing insulation / drainage / non-frost susceptible backfill to maintain the flush threshold during freezing weather conditions.

6.4 Site Work

The soil at this site is medium to fine grained and may become weakened or loosened when subjected to construction traffic. If site work is carried out during periods of wet weather, then it can be expected that the subgrade will be disturbed unless an adequate granular working surface is provided to protect the integrity of the subgrade soils from construction traffic. The disturbance caused by the traffic can result in the removal of disturbed soil and use of fill material for site restoration or underfloor fills that is not intrinsic to project requirements.

The timing of the major grading works on the site is critical to the performance of the work. It may not be feasible to carry out fill operations during wet or freezing conditions. The schedule must provide adequate time to complete the work, allowing for delays due to adverse weather.

The subgrade at this site is considered to be frost susceptible. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the exposed soil will be required. Consideration must be given to frost effects, such as heave or softening, on exposed soil surfaces in the context of this particular project development

6.5 Quality Control

6.5.1 Shoring

The Town of Grimsby will require that the shoring installations be monitored during the period of construction to demonstrate that the shoring is performing adequately. Terraprobe has considerable experience in the provision of shoring instrumentation and monitoring services for a number of similar sites.

The provisions of the Ontario Building Code require that the construction of the earth retaining structures be monitored on a continuous basis. The shoring system constitutes an earth retaining structure as provided in Section 4.2.2.3 of the Ontario Building Code 2012. Terraprobe should be retained to provide this review as the shoring installations are made. It is an integral part of the geotechnical design function as it relates to shoring design considerations.

Assuming soil anchors will be used to support the shoring system on this site, a minimum of one anchor as each target anchorage level must be performance tested to verify the design adhesion used for the anchorages. This performance test anchor shall be consistent dimension in anchor and free stressing zones with the proposed production anchors and be provided with adequate tendon steel capacity to test the anchor to twice the design working load. The performance tests shall be monitored and evaluated by the geotechnical engineer. Production anchorages should not be installed until the performance test at each level has adequately demonstrated the design adhesion value. All production anchorages shall be monitored during stressing and evaluated by a geotechnical engineer.

6.5.2 Foundations

The proposed structures will be founded on conventional spread footings. All foundation installations must be reviewed in the field by Terraprobe, the geotechnical engineer, as they are constructed. The on-site review of the condition of the foundation soil as the foundations are constructed is an integral part of the geotechnical engineering design function and is required by Section 4.2.2.2 of the Ontario Building Code 2012. If Terraprobe is not retained to carry out foundation engineering field review during construction, then Terraprobe accepts no responsibility for the performance or non-performance of the foundations, even if they are ostensibly constructed in accordance with the conceptual design advice contained in this report.

6.5.3 Slabs on Grade

The long term performance of the slab on grade is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as practically possible. The design advice in this report is based on an assessment of the subgrade support capabilities as indicated by the boreholes. These conditions may vary across the site depending on the final design grades and therefore, the preparation of the subgrade and the compaction of all fill should be monitored by Terraprobe at the time of construction to confirm material quality, thickness, and to ensure adequate compaction.

6.5.4 General

The requirements for fill placement on this project have been stipulated relative to Standard Proctor Maximum Dry Density (SPMDD). In situ determinations of density during fill and asphaltic pavement placement on site are required to demonstrate that the specified placement density is achieved. Terraprobe is a CNSC certified operator of appropriate nuclear density gauges for this work and can provide sampling and testing services for the project as necessary, with our qualified technical staff.

Concrete will be specified in accordance with the requirements of CAN3 - CSA A23.1/2. Terraprobe maintains a CSA certified concrete laboratory and can provide concrete sampling and testing services for the project as necessary.

Terraprobe staff can also provide quality control services for Building Envelope, Roofing and Structural Steel, as necessary, for the Structural and Architectural quality control requirements of the project. Terraprobe is certified by the Canadian Welding Bureau under W178.1.

7.0 LIMITATIONS AND USE OF REPORT

7.1 Procedures

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained from this investigation.

The drilling work was carried out by a drilling contractor and was observed and recorded by Terraprobe on a full time basis. The boreholes were made by a continuous flight power auger machine using solid stem augers. The Terraprobe technician logged the boreholes and examined the samples as they were obtained. The samples obtained were sealed in clean, air-tight containers and transferred to the Terraprobe laboratory, where they were reviewed for consistency of description by a geotechnical engineer. Ground water monitoring wells were installed in two boreholes to measure long-term ground water levels.

The samples of the strata penetrated were obtained using the Split-Barrel Method technique (ASTM D1586). The samples were taken at intervals. The conventional interval sampling procedure used for this investigation does not recover continuous samples of soil at any borehole location. There is consequently some interpolation of the borehole layering between samples and indications of changes in stratigraphy as shown on the borehole logs are approximate.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. A comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations.

It may not be possible to drill a sufficient number of boreholes, or sample and report them in a way that would provide all the subsurface information and geotechnical advice to completely identify all aspects of the site and works that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project must be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, and their approach to the construction works, cognizant of the risks implicit in the subsurface investigation activities.

7.2 Changes in Site and Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. In particular, caution should be exercised in the consideration of contractual responsibilities as they relate to control of seepage, disturbance of soils, and frost protection.

The design parameters provided and the engineering advice offered in this report are based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained design consultants in the design phase of the project. If there are changes to the project scope and development features, the interpretations made of the subsurface information, the geotechnical design parameters, advice and comments relating to constructability issues and quality control may not be relevant or complete for the project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

7.3 Use of Report

This report is prepared for the express use of Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc., and their retained design consultants. It is not for use by others. This report is copyright of Terraprobe Inc., and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe. The client and their retained design consultants are authorized users.

It is recognized that The Town of Grimsby, in their capacity as the planning and building authority under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both as are expressed and implied.

Terraprobe Inc.

LICENSED PROFESSIONAL ENGINEER
P. T. CANNON
May 26/21
PROVINCE OF ONTARIO

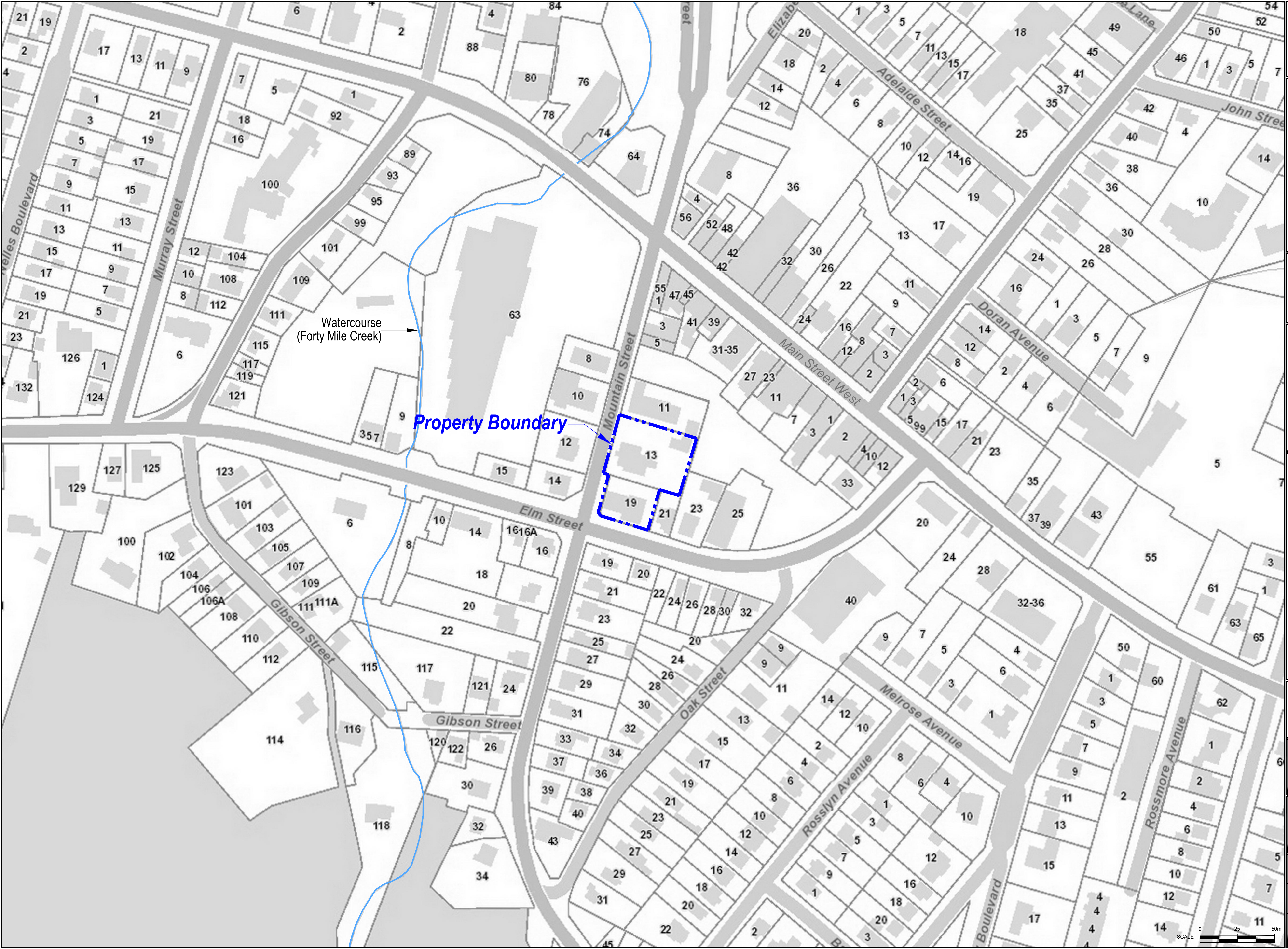
K Greenman

Patrick Cannon, P. Eng.
Principal

Katie Greenman, B.Sc., C.Tech.
Project Manager

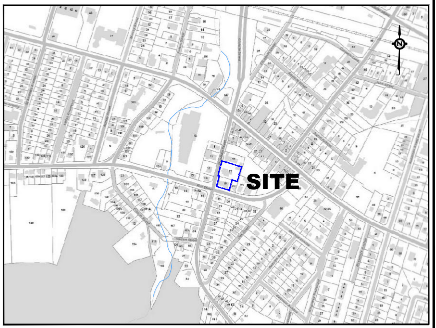
FIGURES

TERRAPROBE INC.



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials, Inspection & Testing

KEY MAP



REFERENCE:
Ministry of Natural Resources

NOTES:
Client: Valentine Coleman 1 Inc. and
Valentine Coleman 2 Inc.

LEGEND:

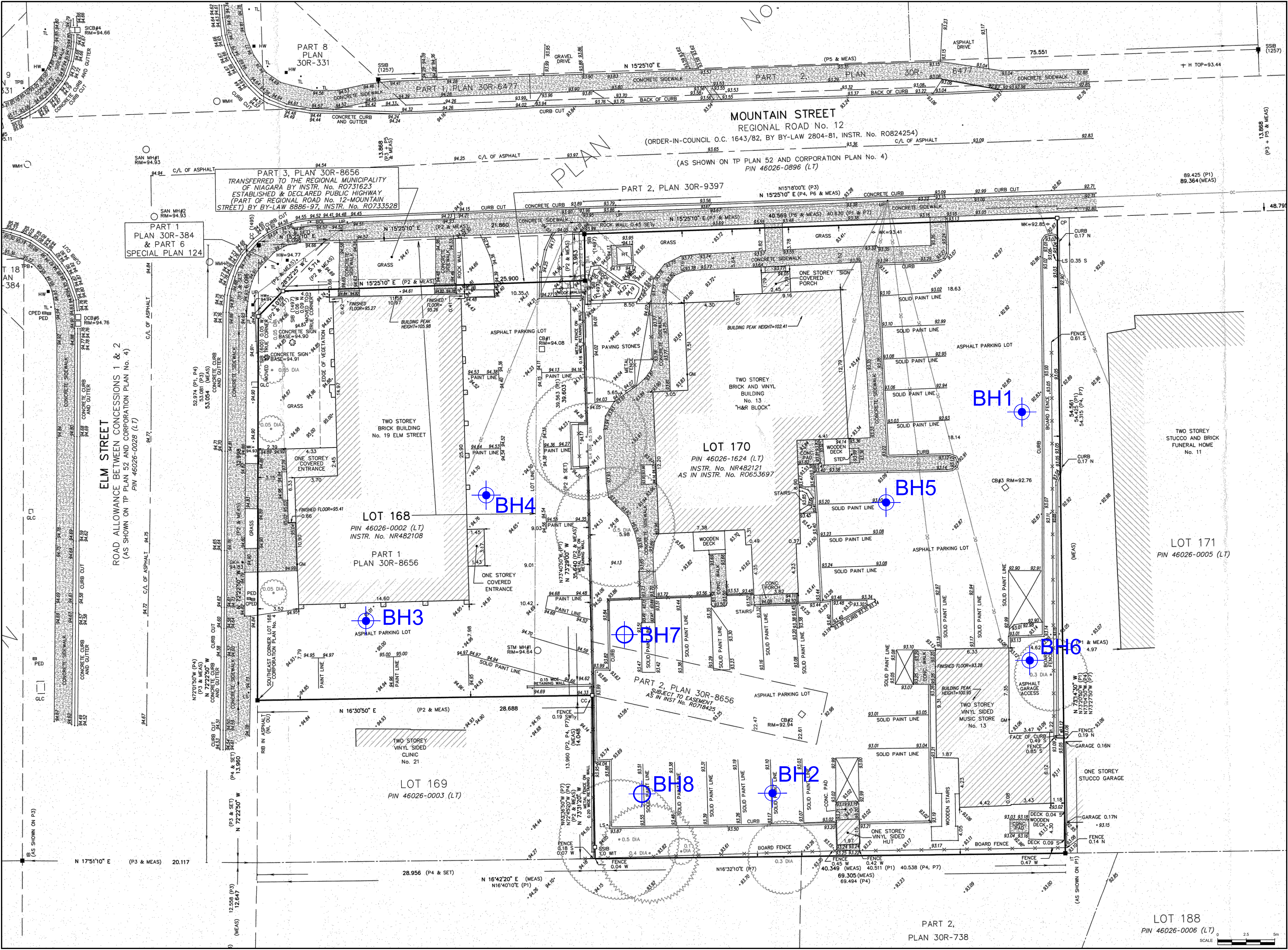
-·-·-	Property Boundary

PROJECT TITLE:
Geotechnical Investigation

SITE LOCATION:
19 Elm Street and 13 Mountain Street,
Grimsby, Ontario

FIGURE TITLE:
SITE LOCATION PLAN

REV NO.: 0
FILE NO.: 7-18-0051-01
SCALE: AS SHOWN
FIGURE NO.: 1
DATE: May, 2021



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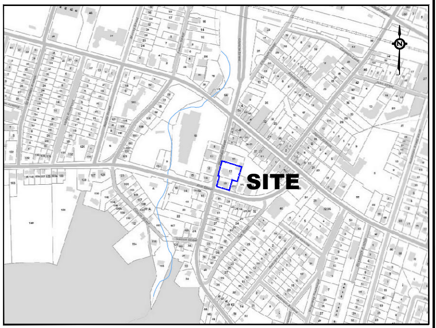
KEY MAP



REFERENCE:

Ministry of Natural Resources

NOTES:

Client: Valentine Coleman 1 Inc. and
Valentine Coleman 2 Inc.

Reference: J.D. Barnes Limited No. 20-16-364-00
Dated: April 9,2021

LEGEND:

— · —	Property Boundary
BH1	Monitoring Well Location
BH7	Borehole Location

PROJECT TITLE:

Geotechnical Investigation

SITE LOCATION:

19 Elm Street and 13 Mountain Street,
Grimsby, Ontario

FIGURE TITLE:

BOREHOLE AND MONITORING WELL LOCATION PLAN
(Existing Conditions)

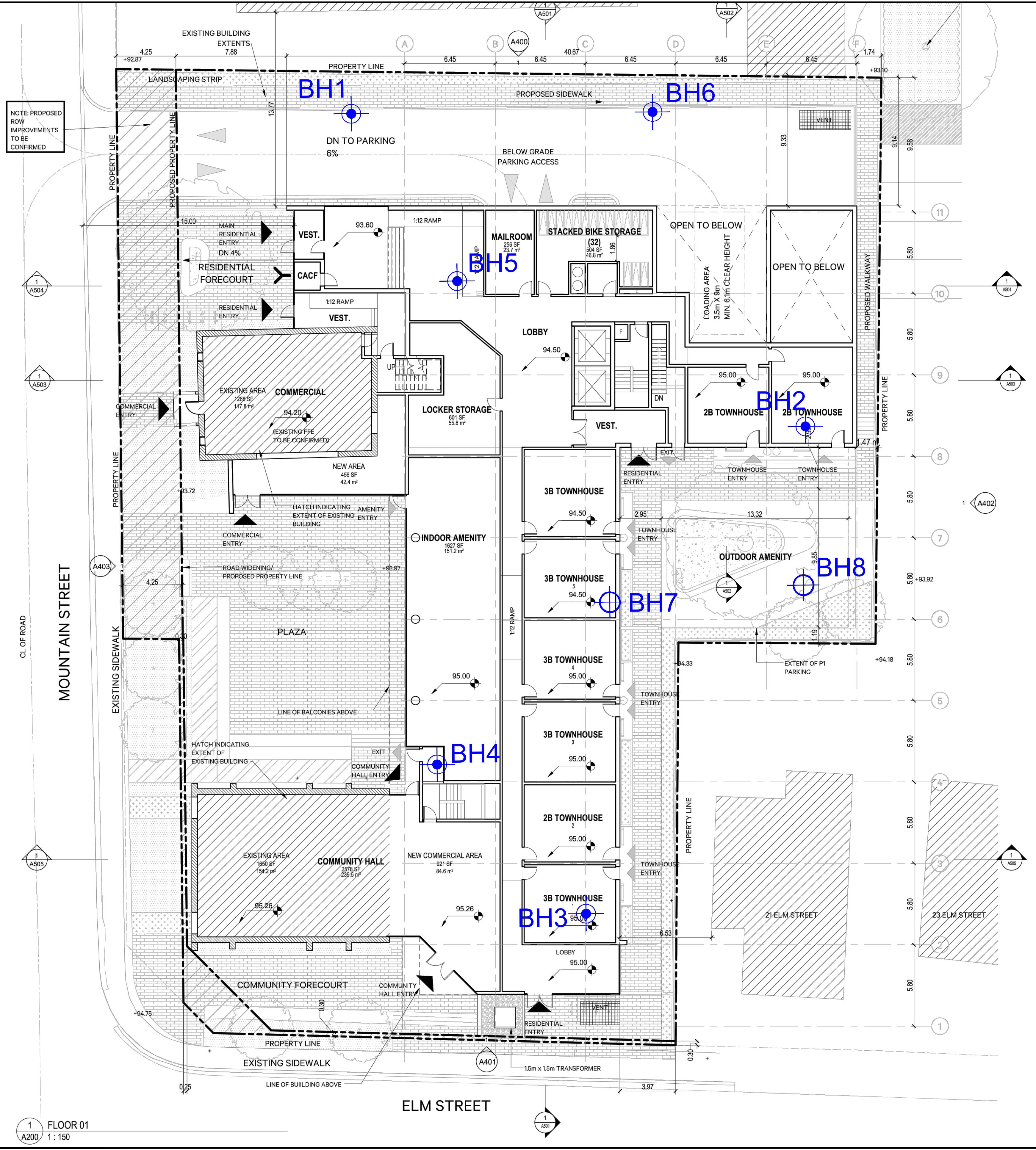
REV NO.: 0

FILE NO.: 7-18-0051-01

SCALE: AS SHOWN

FIGURE NO.: 2

DATE: May, 2021



TOWNHOUSE UNIT AREAS

UNIT TYPE	FLOOR	AREA METRIC	AREA IMPERIAL
1			
3B TOWNHOUSE	FLOOR 01	40 m²	427 SF
3B TOWNHOUSE	FLOOR 02	80 m²	856 SF
		119 m²	1283 SF
2			
2B TOWNHOUSE	FLOOR 01	39 m²	425 SF
2B TOWNHOUSE	FLOOR 02	49 m²	531 SF
		89 m²	956 SF
3			
3B TOWNHOUSE	FLOOR 01	41 m²	440 SF
3B TOWNHOUSE	FLOOR 02	77 m²	830 SF
		118 m²	1270 SF
4			
3B TOWNHOUSE	FLOOR 01	40 m²	432 SF
3B TOWNHOUSE	FLOOR 02	77 m²	830 SF
		117 m²	1263 SF
5			
3B TOWNHOUSE	FLOOR 01	40 m²	432 SF
3B TOWNHOUSE	FLOOR 02	77 m²	830 SF
		117 m²	1263 SF
6			
3B TOWNHOUSE	FLOOR 01	45 m²	480 SF
3B TOWNHOUSE	FLOOR 02	77 m²	830 SF
		122 m²	1311 SF
7			
2B TOWNHOUSE	FLOOR 01	35 m²	380 SF
2B TOWNHOUSE	FLOOR 02	54 m²	584 SF
		90 m²	964 SF
8			
2B TOWNHOUSE	FLOOR 01	46 m²	494 SF
2B TOWNHOUSE	FLOOR 02	40 m²	425 SF
		85 m²	920 SF

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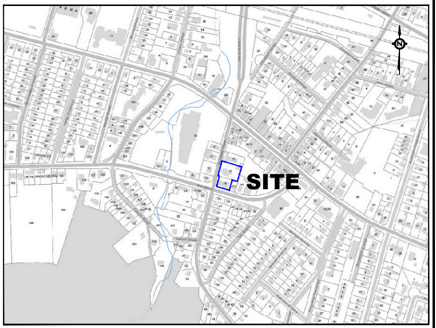
Construction Materials, Inspection & Testing

KEY MAP



REFERENCE:
Ministry of Natural Resources

NOTES:

Client: Valentine Coleman 1 Inc. and Valentine Coleman 2 Inc.

Reference: SvN, A100; Dated:March 19, 2021

LEGEND:

━ · ━	Property Boundary
BH1 ⊕	Monitoring Well Location
BH7 ⊕	Borehole Location

PROJECT TITLE:
Geotechnical Investigation

SITE LOCATION:
19 Elm Street and 13 Mountain Street,
Grimsby, Ontario

FIGURE TITLE:
BOREHOLE AND MONITORING WELL LOCATION PLAN
(Proposed Site Plan Level 1)

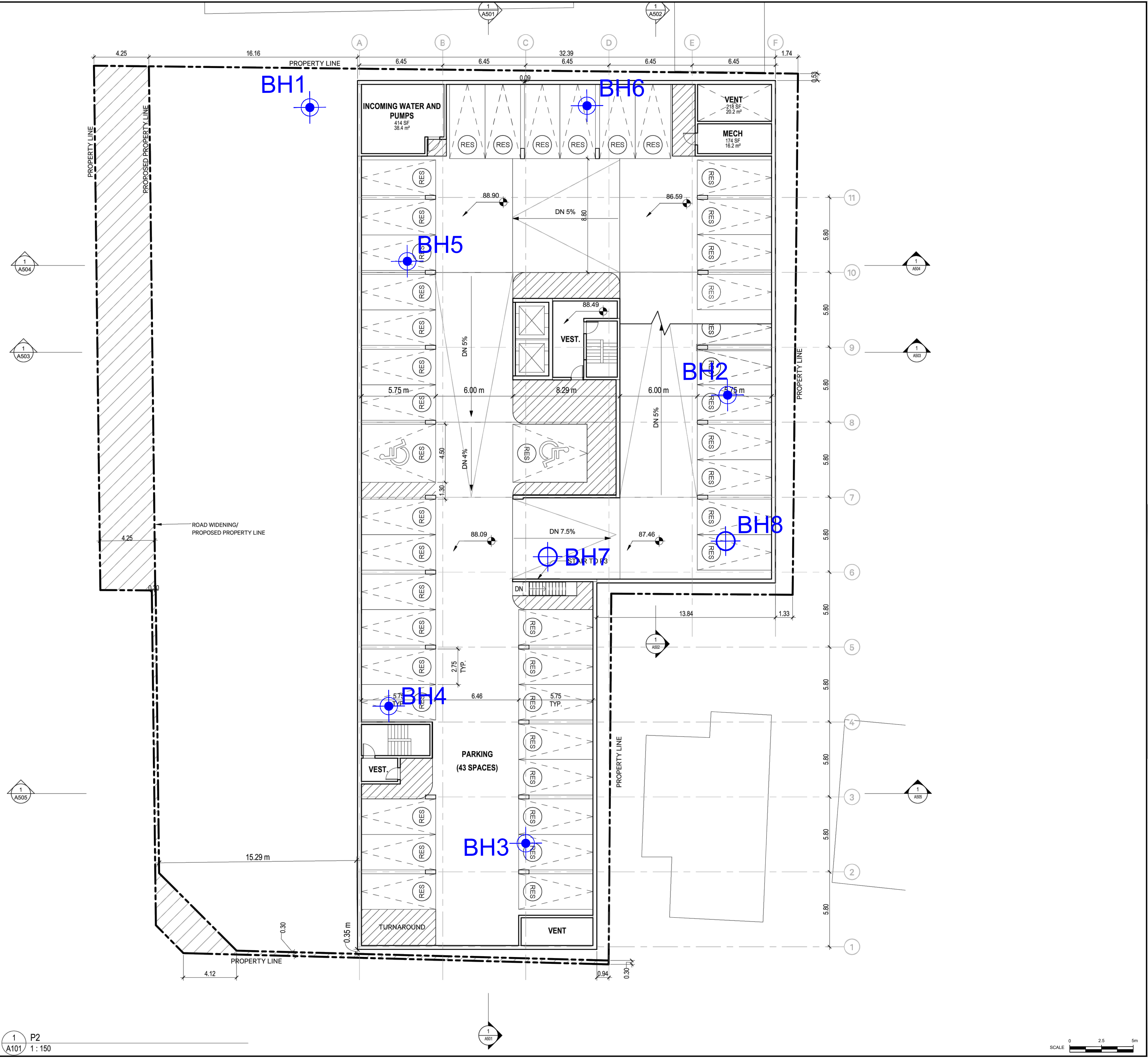
REV NO.: 0

FILE NO.: 7-18-0051-01

SCALE: AS SHOWN

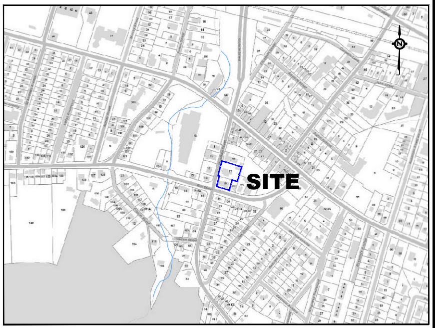
FIGURE NO.: 3a

DATE: May, 2021



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials, Inspection & Testing

KEY MAP:



REFERENCE:
Ministry of Natural Resources

NOTES:

Client: Valentine Coleman 1 Inc. and
Valentine Coleman 2 Inc.

Reference: SvN, A100; Dated:March 19, 2021

LEGEND:

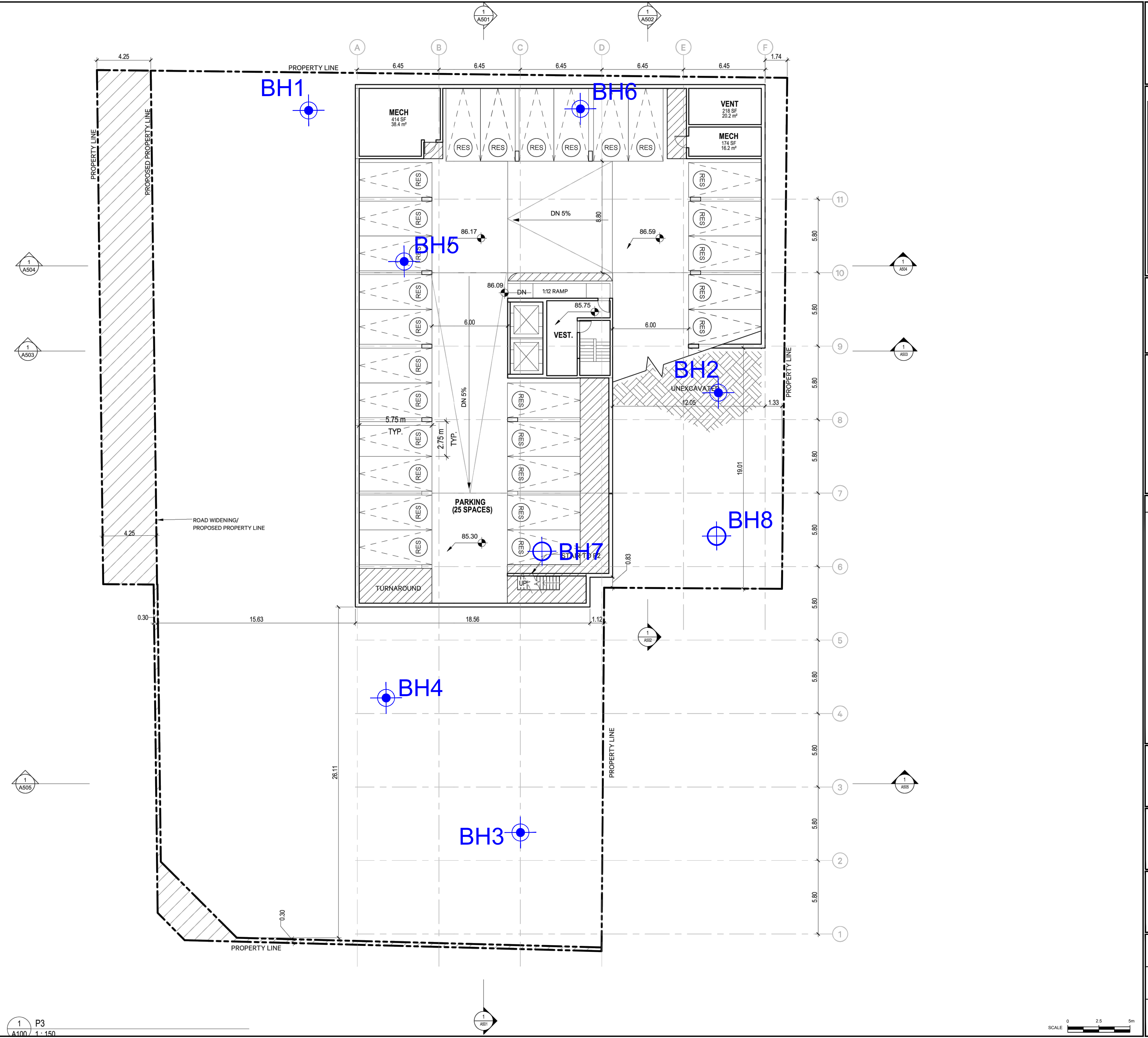
-·-·-	Property Boundary
BH1	Monitoring Well Location
BH7	Borehole Location

PROJECT TITLE:
Geotechnical Investigation

SITE LOCATION:
19 Elm Street and 13 Mountain Street,
Grimsby, Ontario

FIGURE TITLE:
BOREHOLE AND MONITORING WELL LOCATION PLAN
(Proposed Site Plan P2 Level)

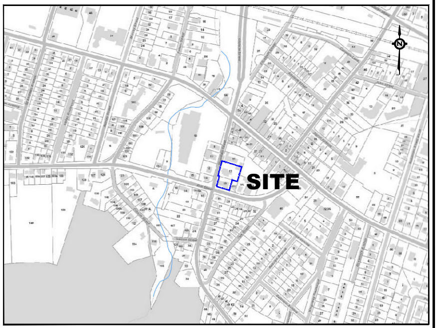
REV NO.: 0
FILE NO.: 7-18-0051-01
SCALE: AS SHOWN
FIGURE NO.: 3b
DATE: May, 2021



Terraprobe Inc.

Consulting Geotechnical & Environmental Engineering
Construction Materials, Inspection & Testing

KEY MAP



REFERENCE:

Ministry of Natural Resources

NOTES:

Client: Valentine Coleman 1 Inc. and
Valentine Coleman 2 Inc.

Reference: SvN, A100; Dated:March 19, 2021

LEGEND:

▬ · ▬	Property Boundary
BH1	Monitoring Well Location
BH7	Borehole Location

PROJECT TITLE:

Geotechnical Investigation

SITE LOCATION:

19 Elm Street and 13 Mountain Street,
Grimsby, Ontario

FIGURE TITLE:

BOREHOLE AND MONITORING WELL LOCATION PLAN
(Proposed Site Plan P3 Level)

REV NO.: 0

FILE NO.: 7-18-0051-01

SCALE: AS SHOWN

DATE: May, 2021

FIGURE NO.: 3c

APPENDIX A

TERRAPROBE INC.

Terraprobe

ABBREVIATIONS AND TERMINOLOGY

SAMPLING METHODS

AS	auger sample
CORE	cored sample
DP	direct push
FV	field vane
GS	grab sample
SS	split spoon
ST	shelby tube
WS	wash sample

PENETRATION RESISTANCE

Standard Penetration Test (SPT) resistance ('N' values) is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a standard 50 mm (2 in.) diameter split spoon sampler for a distance of 0.3 m (12 in.).

Dynamic Cone Test (DCT) resistance is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a conical steel point of 50 mm (2 in.) diameter and with 60° sides on 'A' size drill rods for a distance of 0.3 m (12 in.)."

COHESIONLESS SOILS

Compactness	'N' value
very loose	< 4
loose	4 – 10
compact	10 – 30
dense	30 – 50
very dense	> 50

COHESIVE SOILS

Consistency	'N' value	Undrained Shear Strength (kPa)
very soft	< 2	< 12
soft	2 – 4	12 – 25
firm	4 – 8	25 – 50
stiff	8 – 15	50 – 100
very stiff	15 – 30	100 – 200
hard	> 30	> 200

COMPOSITION

Term (e.g)	% by weight
trace silt	< 10
some silt	10 – 20
silt*y*	20 – 35
sand *and* silt	> 35

TESTS AND SYMBOLS

MH	mechanical sieve and hydrometer analysis
w, w_c	water content
w_L, LL	liquid limit
w_P, PL	plastic limit
I_P, PI	plasticity index
k	coefficient of permeability
γ	soil unit weight, bulk
φ'	internal friction angle
c'	effective cohesion
c_u	undrained shear strength

▽	Unstabilized water level
▼	1st water level measurement
▼	2nd water level measurement
▼	Most recent water level measurement
3.0 +	Undrained shear strength from field vane (with sensitivity)
C_c	compression index
c_v	coefficient of consolidation
m_v	coefficient of compressibility
e	void ratio

FIELD MOISTURE DESCRIPTIONS

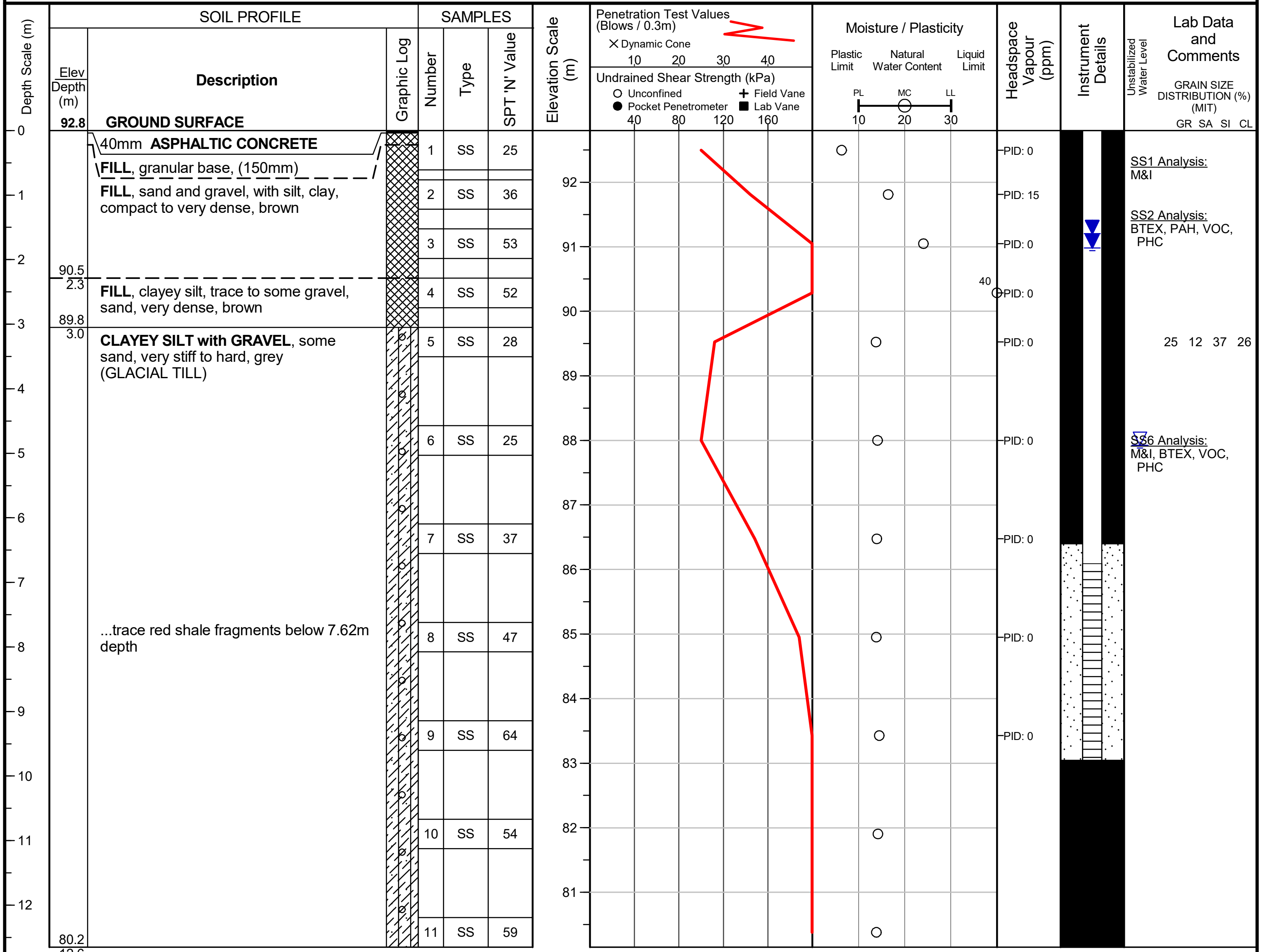
Damp	refers to a soil sample that does not exhibit any observable pore water from field/hand inspection.
Moist	refers to a soil sample that exhibits evidence of existing pore water (e.g. sample feels cool, cohesive soil is at plastic limit) but does not have visible pore water
Wet	refers to a soil sample that has visible pore water

Terraprobe

LOG OF BOREHOLE 1

Project No. : 7-18-0051-42
Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Originated by : JM
Date started : March 25, 2021
Project : 13 Mountain Street and 19 Elm Street
Compiled by : TW
Sheet No. : 1 of 1
Location : Grimsby, Ontario
Checked by : TW

Position : E: 616797, N: 4783259 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Mini Mole, track-mounted
Drilling Method : Solid stem augers



Elev Depth (m)	Description
92.8	**GROUND SURFACE**
	40mm **ASPHALTIC CONCRETE**
	FILL, granular base, (150mm)
	FILL, sand and gravel, with silt, clay, compact to very dense, brown
90.5 2.3	**FILL**, clayey silt, trace to some gravel, sand, very dense, brown
89.8 3.0	**CLAYEY SILT with GRAVEL**, some sand, very stiff to hard, grey (GLACIAL TILL) ...trace red shale fragments below 7.62m depth
80.2 12.6	**END OF BOREHOLE**

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments
1	SS	25	PID: 0	SS1 Analysis: M&I
2	SS	36	PID: 15	SS2 Analysis: BTEX, PAH, VOC, PHC
3	SS	53	PID: 0	
4	SS	52	PID: 0	
5	SS	28	PID: 0	25 12 37 26
6	SS	25	PID: 0	SS6 Analysis: M&I, BTEX, VOC, PHC
7	SS	37	PID: 0	
8	SS	47	PID: 0	
9	SS	64	PID: 0	
10	SS	54		
11	SS	59		

Unstabilized water level measured at 4.9 m below ground surface; borehole was open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	1.6	91.2
Apr 19, 2021	1.6	91.2
Apr 27, 2021	1.6	91.2
May 3, 2021	1.6	91.2
May 6, 2021	1.6	91.2
May 19, 2021	1.8	91.0

LOG OF BOREHOLE 2

Project No. : 7-18-0051-42
Date started : March 23, 2021
Sheet No. : 1 of 1

Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Project : 13 Mountain Street and 19 Elm Street
Location : Grimsby, Ontario

Originated by : JM
Compiled by : TW
Checked by : TW

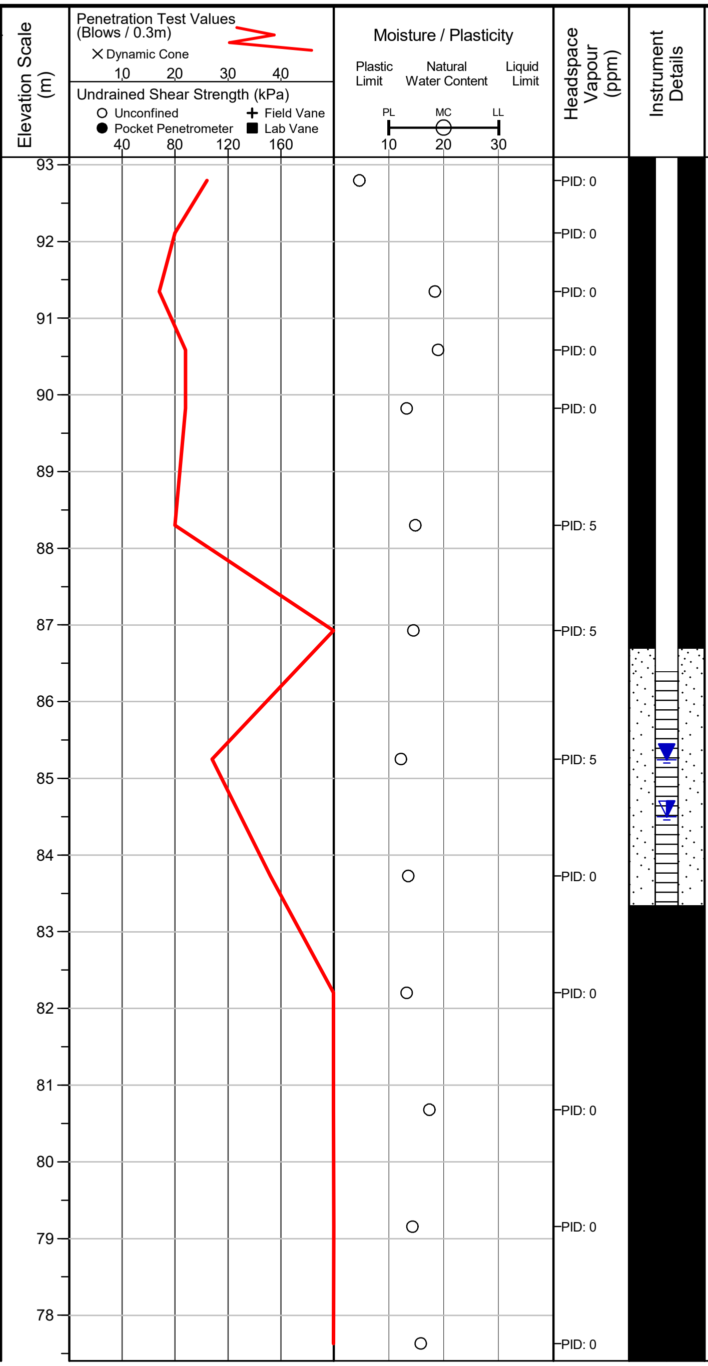
Position : E: 616821, N: 4783229 (UTM 17T)
Rig type : Mini Mole, track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
93.1	**GROUND SURFACE**
	55mm **ASPHALTIC CONCRETE**
	FILL, sand and gravel, some silt, clay, compact, brown
90.8 2.3	**CLAYEY SILT with GRAVEL**, some sand, very stiff to hard, brown to grey (GLACIAL TILL) ...becoming grey at 2.74m depth
77.4 15.7	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	26
2	SS	20
3	SS	17
4	SS	22
5	SS	22
6	SS	20
7	SS	50 / 150mm
8	SS	27
9	SS	38
10	SS	57
11	SS	59
12	SS	50
13	SS	57



Depth Scale (m): 0 – 15

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR	SA	SI	CL
23	14	39	24

SS2 Analysis:
M&I, PAH

SS3 Analysis:
BTEX, VOC, PHC

SS6 Analysis:
BTEX, VOC, PHC

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

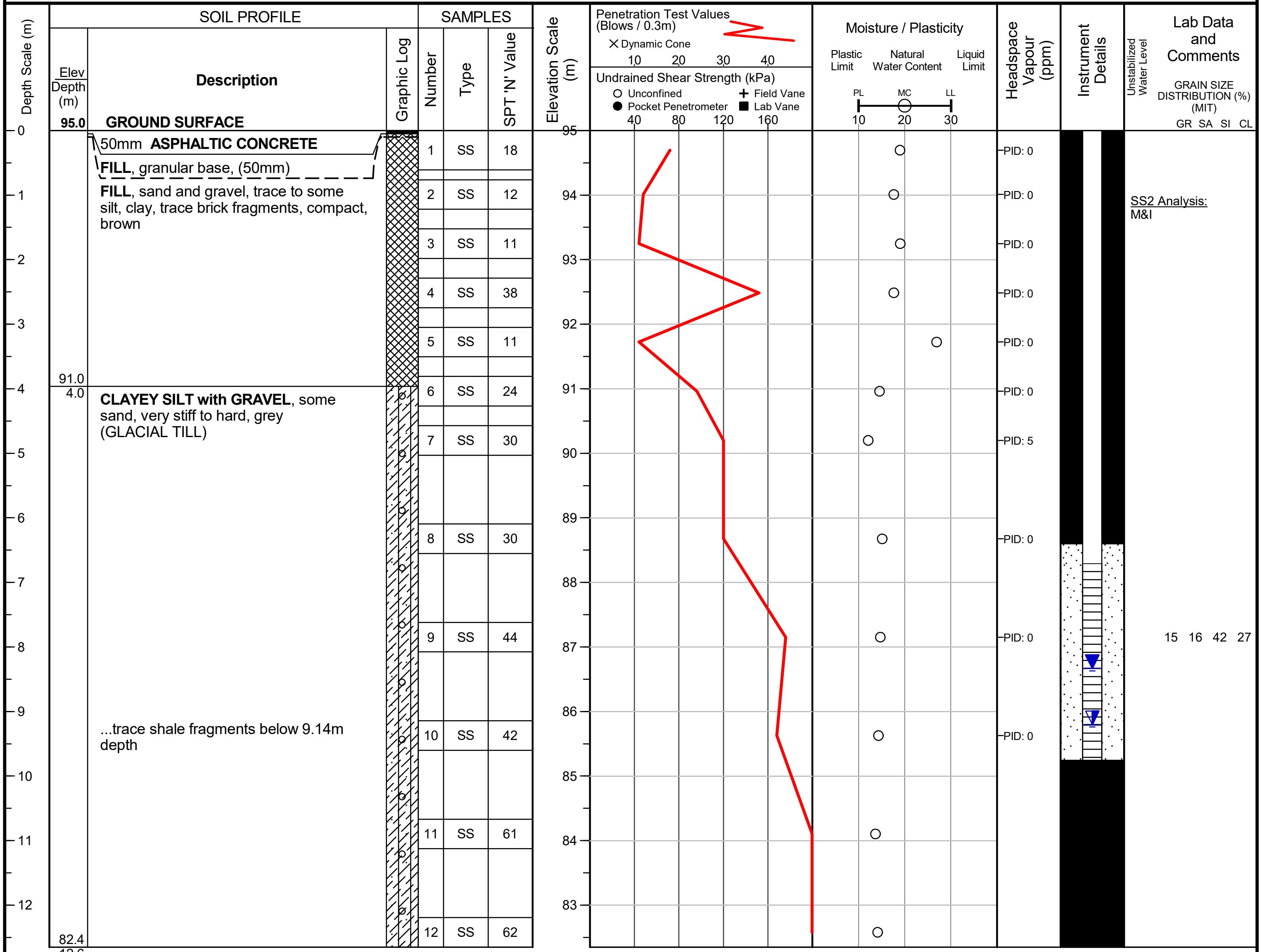
Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	dry	n/a
Apr 19, 2021	8.6	84.5
Apr 27, 2021	8.0	85.1
May 3, 2021	7.3	85.8
May 6, 2021	8.7	84.4
May 19, 2021	7.9	85.2

Terraprobe

LOG OF BOREHOLE 3

Project No. : 7-18-0051-42
Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Originated by : JM
Date started : March 26, 2021
Project : 13 Mountain Street and 19 Elm Street
Compiled by : TW
Sheet No. : 1 of 1
Location : Grimsby, Ontario
Checked by : TW

Position : E: 616798, N: 4783200 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Mini Mole, track-mounted
Drilling Method : Solid stem augers



Elev / Depth (m)	Description
95.0	**GROUND SURFACE**
	50mm **ASPHALTIC CONCRETE**
	FILL, granular base, (50mm)
	FILL, sand and gravel, trace to some silt, clay, trace brick fragments, compact, brown
91.0 4.0	**CLAYEY SILT with GRAVEL**, some sand, very stiff to hard, grey (GLACIAL TILL)
	...trace shale fragments below 9.14m depth
82.4 12.6	

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments
1	SS	18	PID: 0	
2	SS	12	PID: 0	SS2 Analysis: M&I
3	SS	11	PID: 0	
4	SS	38	PID: 0	
5	SS	11	PID: 0	
6	SS	24	PID: 0	
7	SS	30	PID: 5	
8	SS	30	PID: 0	
9	SS	44	PID: 0	15 16 42 27
10	SS	42	PID: 0	
11	SS	61		
12	SS	62		

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	dry	n/a
Apr 19, 2021	9.2	85.8
Apr 27, 2021	8.6	86.4
May 3, 2021	8.3	86.7
May 6, 2021	9.2	85.8
May 19, 2021	8.3	86.7

LOG OF BOREHOLE 4

Terraprobe

Project No. : 7-18-0051-42
Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Originated by : JM

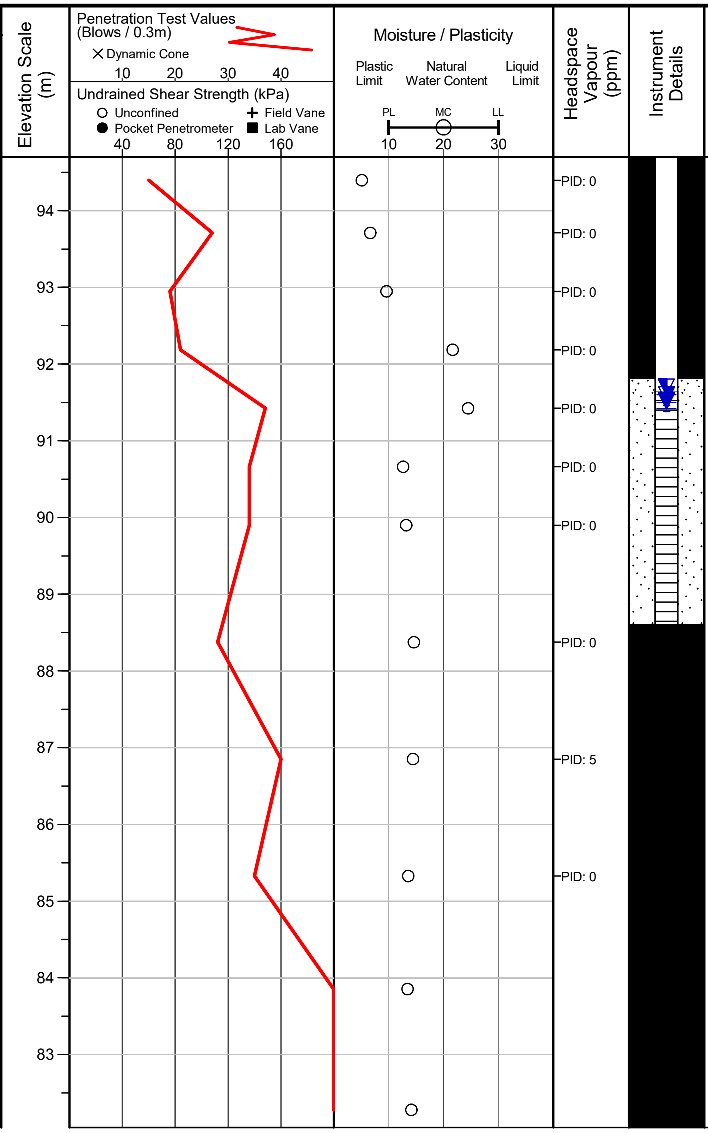
Date started : March 26, 2021
Project : 13 Mountain Street and 19 Elm Street
Compiled by : TW

Sheet No. : 1 of 1
Location : Grimsby, Ontario
Checked by : TW

Position : E: 616792, N: 4783210 (UTM 17T)
Elevation Datum : Geodetic

Rig type : Mini Mole, track-mounted
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments
94.7	**GROUND SURFACE**					
94.3 0.4	40mm **ASPHALTIC CONCRETE** **FILL**, granular base, (360mm)	1	SS	15	PID: 0	
	FILL, sand and gravel, trace to some silt, clay, trace brick fragments, compact to dense, brown	2	SS	27	PID: 0	SS2 Analysis: PAH
		3	SS	19	PID: 0	SS3 Analysis: M&I
		4	SS	21	PID: 0	
		5	SS	37	PID: 0	
90.9 3.8	**CLAYEY SILT with GRAVEL**, some sand, very stiff to hard, grey (GLACIAL TILL)	6	SS	34	PID: 0	
		7	SS	34	PID: 0	GR 16, SA 14, SI 43, CL 27
		8	SS	28	PID: 0	
		9	SS	40	PID: 5	
		10	SS	35	PID: 0	
		11	SS	72 / 200mm		
82.1 12.6		12	SS	55		



Lab Data and Comments — GRAIN SIZE DISTRIBUTION (%) (MIT): GR SA SI CL

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	3.1	91.6
Apr 19, 2021	3.2	91.5
Apr 27, 2021	3.2	91.5
May 3, 2021	3.2	91.5
May 6, 2021	3.2	91.5
May 19, 2021	3.3	91.4

Terraprobe

LOG OF BOREHOLE 5

Project No. : 7-18-0051-42
Date started : March 24, 2021
Sheet No. : 1 of 1

Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Project : 13 Mountain Street and 19 Elm Street
Location : Grimsby, Ontario

Originated by : JM
Compiled by : TW
Checked by : TW

Position : E: 616804, N: 4783243 (UTM 17T)
Rig type : Mini Mole, track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
93.1	**GROUND SURFACE**
	25mm **ASPHALTIC CONCRETE**
	FILL, granular base, (225mm)
	FILL, clayey silt, some sand, gravel, compact to very dense, brown
90.8 2.3	**CLAYEY SILT with GRAVEL**, some sand, hard, brown (GLACIAL TILL) ...becoming grey below 2.44m depth ...red shale fragments below 9.14m depth ...straight-drilled beyond 12.19m depth
74.8	
74.7 18.4	**WEATHERED SHALE**, hard, reddish brown (QUEENSTON FORMATION)

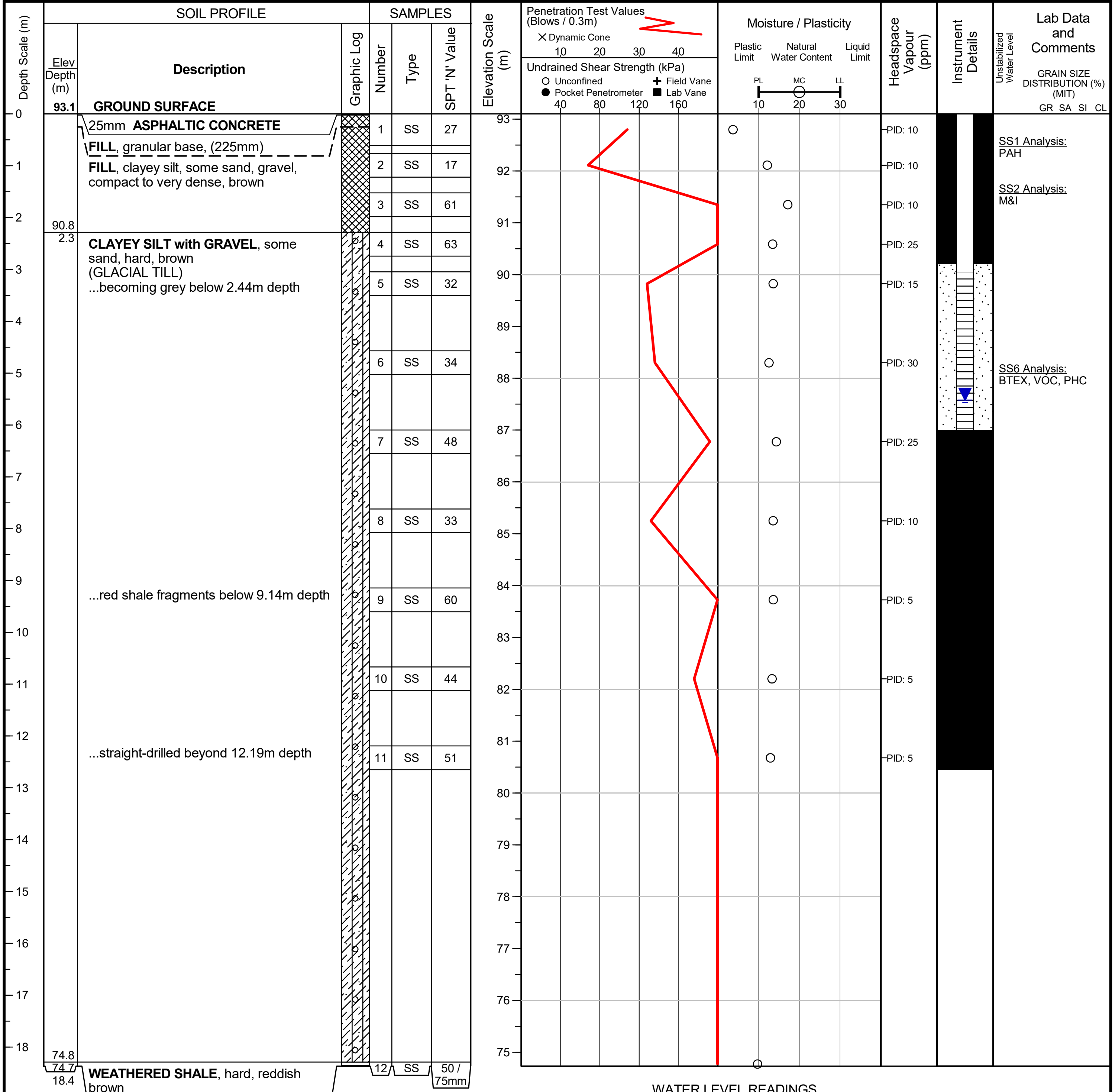
END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

SAMPLES

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments
1	SS	27	PID: 10	SS1 Analysis: PAH
2	SS	17	PID: 10	SS2 Analysis: M&I
3	SS	61	PID: 10	
4	SS	63	PID: 25	
5	SS	32	PID: 15	
6	SS	34	PID: 30	SS6 Analysis: BTEX, VOC, PHC
7	SS	48	PID: 25	
8	SS	33	PID: 10	
9	SS	60	PID: 5	
10	SS	44	PID: 5	
11	SS	51	PID: 5	
12	SS	50 / 75mm		



WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	dry	n/a
Apr 19, 2021	dry	n/a
Apr 27, 2021	6.2	86.9
May 3, 2021	6.0	87.1
May 6, 2021	5.9	87.2
May 19, 2021	5.5	87.6

file: 7-18-0051-42 - elm st.gpj

LOG OF BOREHOLE 6

Project No. : 7-18-0051-42
Date started : March 25, 2021
Sheet No. : 1 of 1

Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Project : 13 Mountain Street and 19 Elm Street
Location : Grimsby, Ontario

Originated by : JM
Compiled by : TW
Checked by : TW

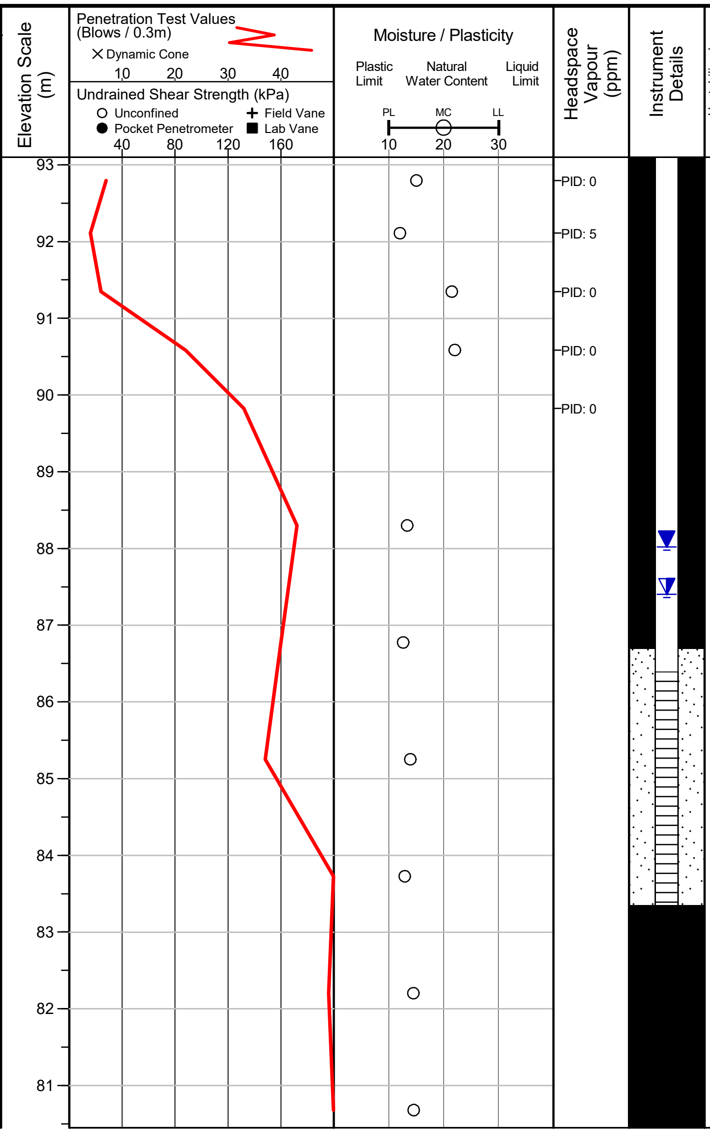
Position : E: 616819, N: 4783255 (UTM 17T)
Rig type : Mini Mole, track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
93.1	**GROUND SURFACE**
	FILL, gravel, (100mm pea gravel)
92.5 0.6	**FILL**, silty sand and granular
	FILL, sandy silt to clayey silt, trace gravel, loose to compact, brown
90.8 2.3	**CLAYEY SILT and GRAVEL**, some sand, hard, brown (GLACIAL TILL) ...becoming grey below 3.05m depth
80.5 12.6	

SAMPLES

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments
1	SS	7	PID: 0	
2	SS	4	PID: 5	SS2 Analysis: M&I, BTEX, PAH, VOC, PHC
3	SS	6	PID: 0	
4	SS	22	PID: 0	
5	SS	33	PID: 0	SS5 Analysis: M&I, PAH
6	SS	43		SS6 Analysis: VOC, PHC
7	SS	40		
8	SS	37		
9	SS	54		
10	SS	49		
11	SS	54		



GRAIN SIZE DISTRIBUTION (%) (MIT)
GR SA SI CL

END OF BOREHOLE

Unstabilized water level measured at 9.1 m below ground surface; borehole was open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 31, 2021	dry	n/a
Apr 19, 2021	5.7	87.4
Apr 27, 2021	5.4	87.7
May 3, 2021	5.2	87.9
May 6, 2021	5.1	88.0
May 19, 2021	5.1	88.0

file: 7-18-0051-42 - elm st.gpj

LOG OF BOREHOLE 7

Project No. : 7-18-0051-42
Client : Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.
Originated by : JM
Date started : March 31, 2021
Project : 13 Mountain Street and 19 Elm Street
Compiled by : TW
Sheet No. : 1 of 1
Location : Grimsby, Ontario
Checked by : TW

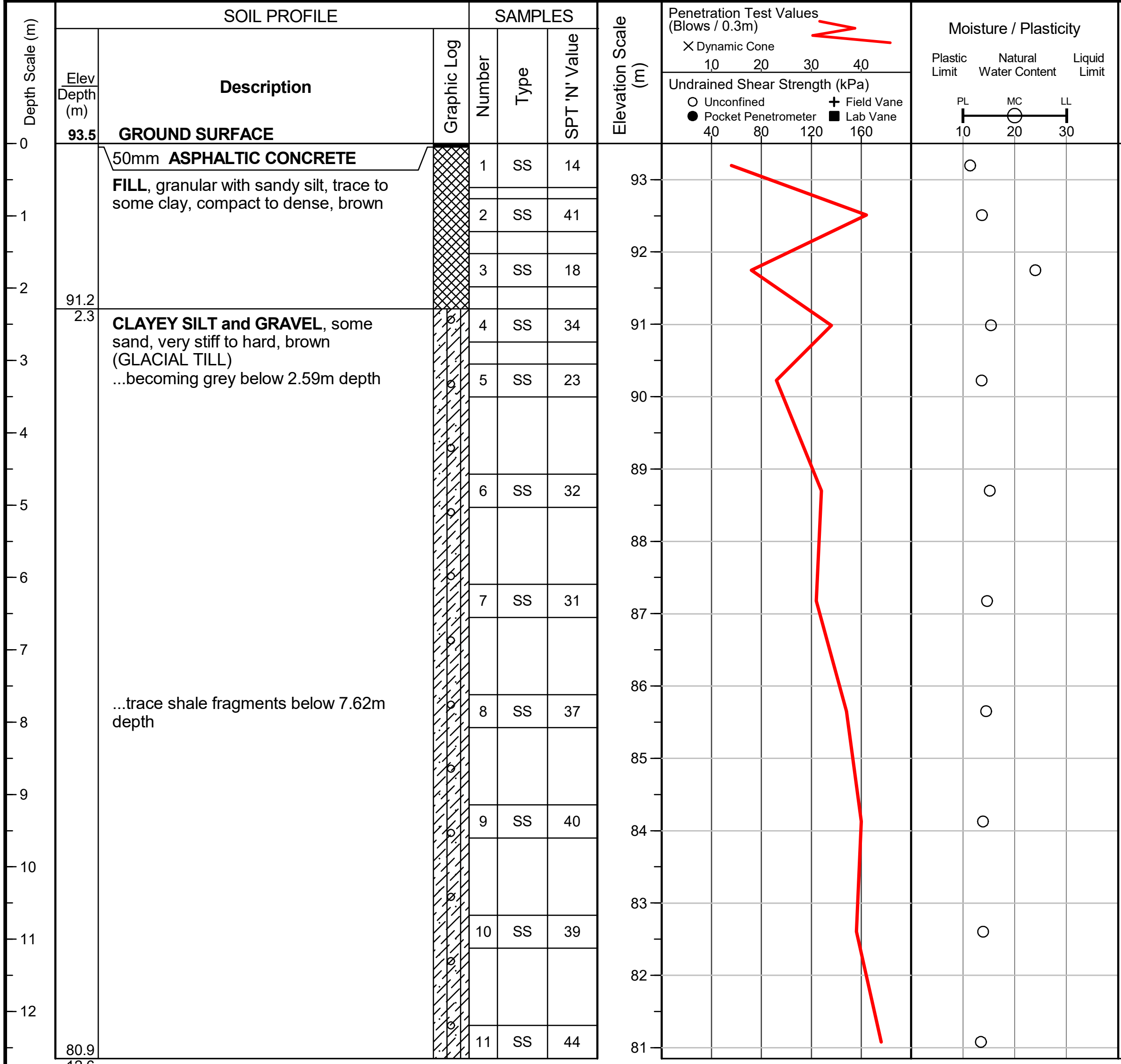
Position : E: 616806, N: 4783217 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Mini Mole, track-mounted
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
93.5	**GROUND SURFACE**
	50mm **ASPHALTIC CONCRETE**
	FILL, granular with sandy silt, trace to some clay, compact to dense, brown
91.2 2.3	**CLAYEY SILT and GRAVEL**, some sand, very stiff to hard, brown (GLACIAL TILL) ...becoming grey below 2.59m depth ...trace shale fragments below 7.62m depth
80.9 12.6	

SAMPLES

Number	Type	SPT 'N' Value
1	SS	14
2	SS	41
3	SS	18
4	SS	34
5	SS	23
6	SS	32
7	SS	31
8	SS	37
9	SS	40
10	SS	39
11	SS	44



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)
GR SA SI CL

SS1 Analysis:
M&I

SS3 Analysis:
M&I, PAH

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

Terraprobe

LOG OF BOREHOLE 8

Project No.	: 7-18-0051-42	Client	: Valentine Coleman 1 Inc. & Valentine Coleman 2 Inc.	Originated by	: JM
Date started	: March 31, 2021	Project	: 13 Mountain Street and 19 Elm Street	Compiled by	: TW
Sheet No.	: 1 of 1	Location	: Grimsby, Ontario	Checked by	: TW

Position : E: 616817, N: 4783215 (UTM 17T)

Rig type : Mini Mole, track-mounted

Elevation Datum : Geodetic

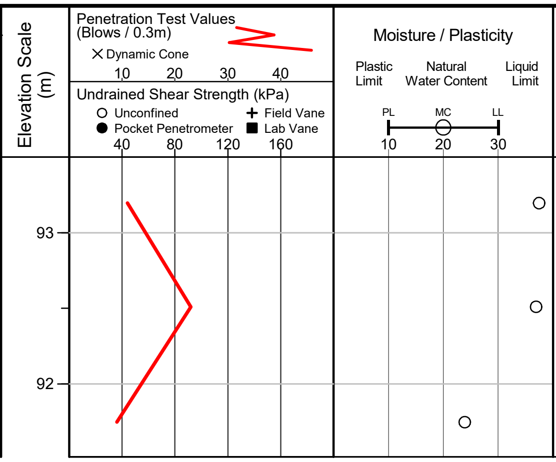
Drilling Method : Solid stem augers

SOIL PROFILE

Depth Scale (m)	Elev Depth (m)	Description
0	93.5	**GROUND SURFACE**
		50mm **ASPHALTIC CONCRETE**
		FILL, granular base, (150mm)
		FILL, clayey silt, some gravel, trace sand, loose to compact, brown to dark brown
1		
	91.5 2.0	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value	Lab Data and Comments
1	SS	11	SS1 Analysis: M&I, PAH
2	SS	23	
3	SS	9	SS3 Analysis: M&I, BTEX, VOC, PHC



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

GRAIN SIZE DISTRIBUTION (%) (MIT)

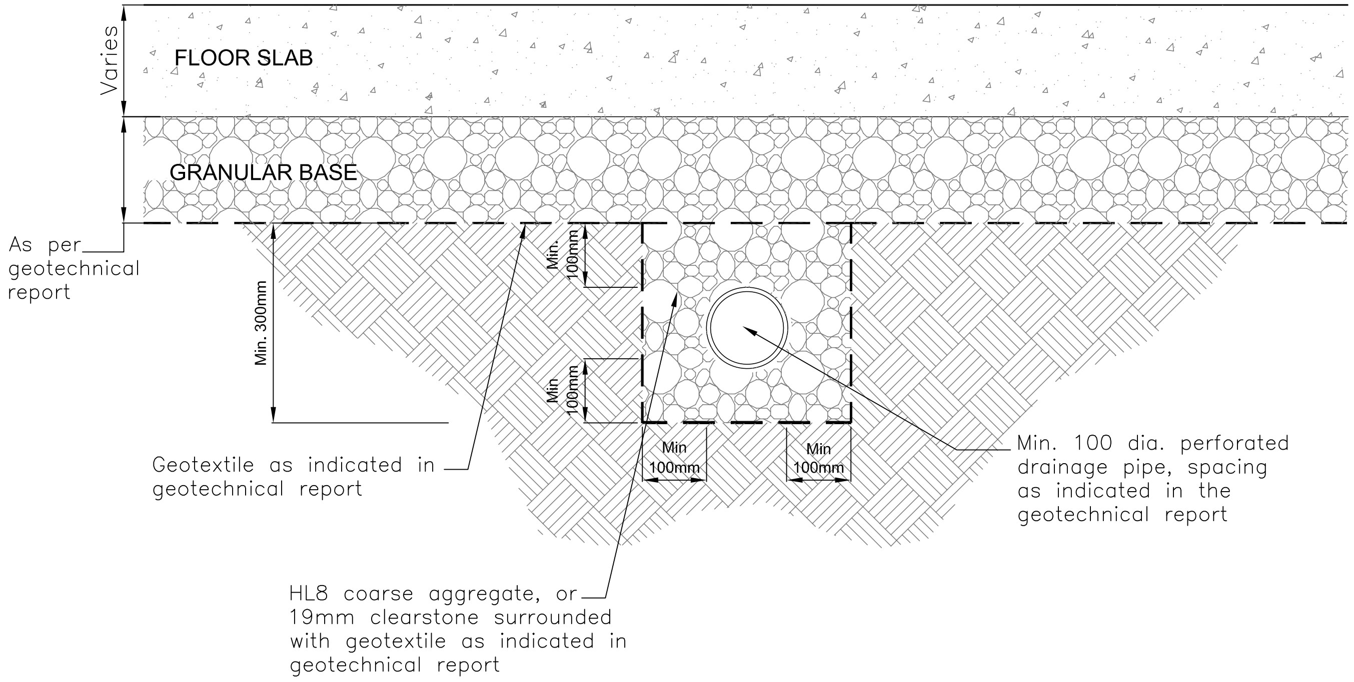
GR SA SI CL

Borehole was dry and open upon completion of drilling.

BASEMENT DRAINAGE DETAILS

APPENDIX B

Terraprobe Inc.

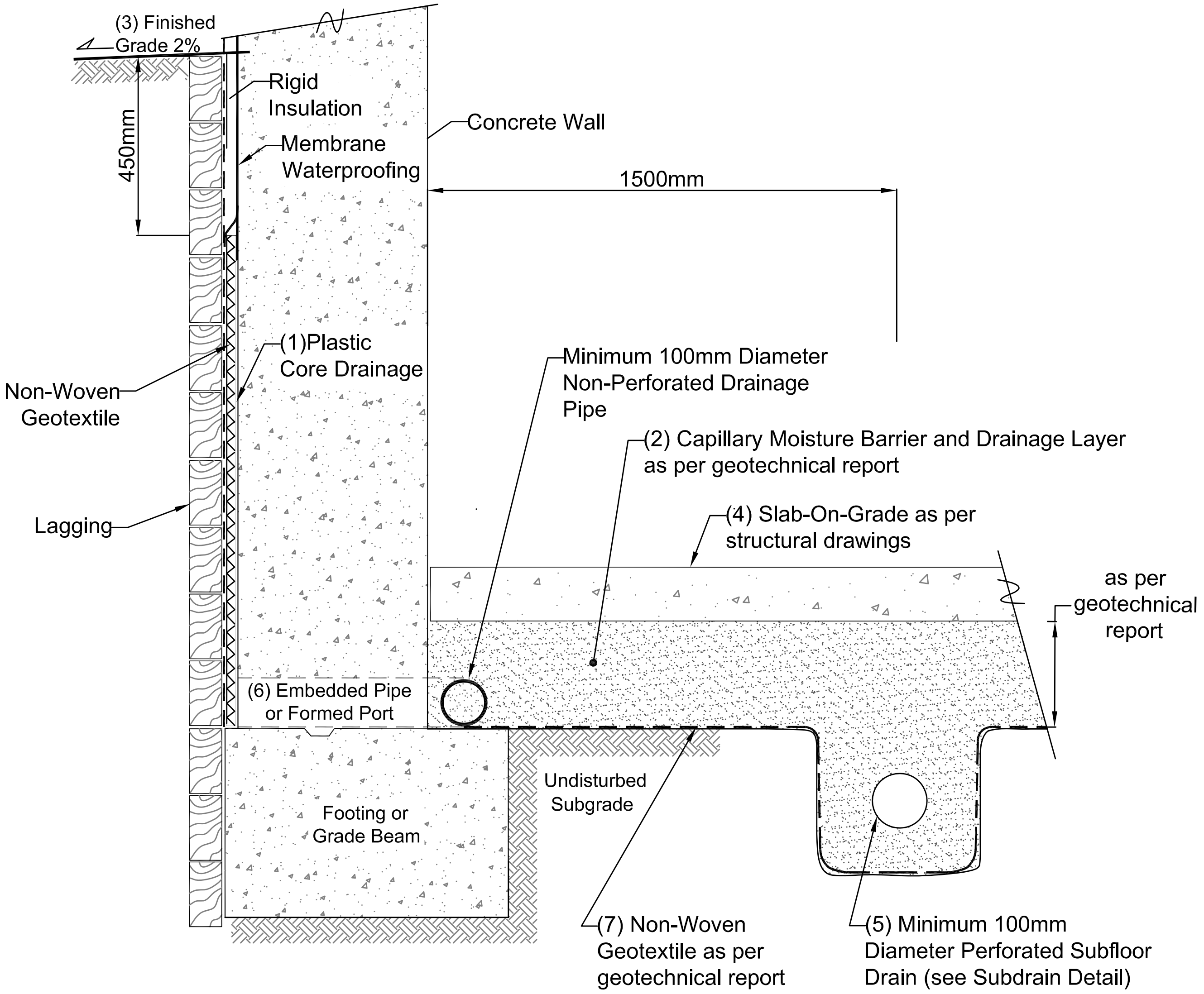


Schematic Only
Not to Scale

Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

BASEMENT SUBDRAIN DETAIL



NOTES

1) Prefabricated drainage panels to consist of Terrafix - TERRADRAIN 200, Mirafi - Miradrain 6000, or approved equivalent. Panels should provide continuous cover with a minimum overlap of 300mm.

2) Capillary moisture barrier/drainage layer to consist of a minimum 200mm layer of 19mm clear stone (OPSS 1004), or as indicated in geotechnical report, compacted to a dense state. Upper 50mm can be replaced with Granular “A” (OPSS 1010) compacted to 98% SPMDD where vehicular traffic is required.

3) Exterior finished grade away from wall at a minimum grade of 2% for min. 1.2m.

4) Building floor slab-on-grade shall not be structurally connected to foundation wall or footing.

5) Subfloor drain invert to be a minimum of 300mm below underside of floor slab, to be set in parallel rows, one way, and at the spacing specified in the geotechnical report.

6) Embedded pipes/formed ports to be set a distance of maximum 3m on-centre. Each port to have a minimum cross-sectional area of 1500mm². Perimeter drainage must be collected and conveyed directly to the building sumps in non-perforated pipe.

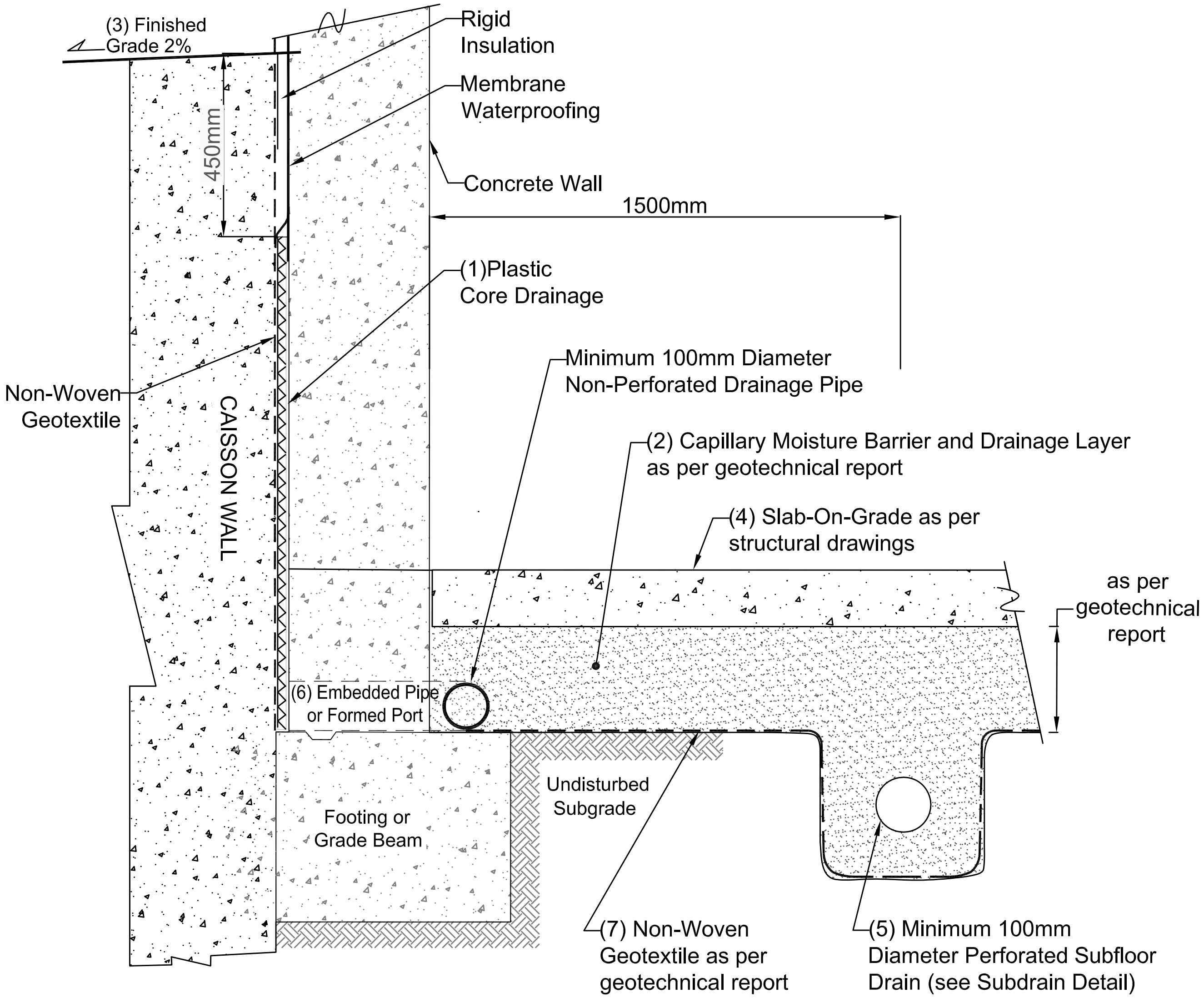
7) When the subgrade consists of a cohesionless soil, the subgrade must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).

N.T.S.

Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

SCHEMATIC DRAINAGE DETAIL
SOLDIER PILE & LAGGING SHORING SYSTEM



NOTES

1) Prefabricated drainage panels to consist of Terrafix - TERRADRAIN 200, Mirafi - Miradrain 6000, or approved equivalent. Panels should provide continuous cover with a minimum overlap of 300mm.
2) Capillary moisture barrier/drainage layer to consist of a minimum 200mm layer of 19mm clear stone (OPSS 1004), or as indicated in geotechnical report, compacted to a dense state. Upper 50mm can be replaced with Granular “A” (OPSS 1010) compacted to 98% SPMDD where vehicular traffic is required.
3) Exterior finished grade away from wall at a minimum grade of 2% for min. 1.2m.
4) Building floor slab-on-grade shall not be structurally connected to foundation wall or footing.
5) Subfloor drain invert to be a minimum of 300mm below underside of floor slab, to be set in parallel rows, one way, and at the spacing specified in the geotechnical report.
6) Embedded pipes/formed ports to be set a distance of maximum 3m on-centre. Each port to have a minimum cross-sectional area of 1500mm². Perimeter drainage must be collected and conveyed directly to the building sumps in non-perforated pipe.
7) When the subgrade consists of a cohesionless soil, the subgrade must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).

N.T.S.

Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

SCHEMATIC DRAINAGE DETAIL
CAISSON WALL SHORING SYSTEM