Triple Crown Line Development Inc.

Revised Slope Stability Analysis
Triple Crown Line Residential Development
Airport Road and Cranston Drive
City of Caledon East, Ontario

Project Number
BRM-00235186-G0

Prepared By:

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Appendices

1 Introduction

The report presents the results of a slope stability evaluation to verify the potential impact on the existing slopes along the south and east property boundaries due to construction of the Proposed Residential Subdivision at Airport Road and Cranston Drive, Caledon East, Ontario. This report also provides the stability analyses for the post construction conditions.

A previous report (Reference BRM-00235186-D0) dated July 25, 2017 was prepared by EXP Services Inc. (EXP). This updated report was prepared to address comments received from Toronto and Region Conservation Authority (TRCA) and the Town of Caledon, on the previous report.

The slope stability analyses were carried out using the borehole information from a geotechnical report titled “Geotechnical Investigation, Proposed Residential Development, Airport Road and Cranston Drive, Caledon East, Ontario” (Reference BRM-00235186-D0) dated June 8, 2017 (Revised September 11, 2018) prepared by EXP.

For this study, EXP was provided with Grading Plan Contour Drawing Nos. GR-1 and Cross-Section Drawing Nos. SEC-1 to SEC-6, SWM-1, & SWM-2 prepared by Schaeffers Consulting Engineers, dated August 2018. The plans and cross sections show proposed finished grades along the slopes at the property boundaries. The updated Grading Plan includes information allowing for assessment of the site as it currently exists, as well as post construction conditions following proposed regrading and installation of retaining walls etc. along the slopes at the property boundaries.

2 Site Visit

The study included a site visit to visually inspect the conditions of the slopes and to record the current general slope condition, including signs of instability, if any, vegetative cover, and any internal or surface erosion.

3 Slope Conditions

The subject slopes are located on the south-east corner of Airport Road and Valewood Drive, in City of Caledon, Ontario.

The slopes are approximately 4 to 10 m high. The overall slope gradient varies from approximately 3H:1V to 17H:1V. The slopes are covered with grasses and there are also some mature trees growing on the slopes.

During the site visits on June 25, 2017 and January 19, 2018, no visible signs of instability (e.g., surface failure, leaning trees, tension cracks, etc.) were noted. No stream flow was observed during our site visit.

For this study, the site conditions, contour drawing and available cross section plans showing proposed finished grades, and the updated Grading Plan showing pre-development site conditions were reviewed. Based on the information, Sections 2 and 5 as shown on the attached Drawing No. 1 (reproduced from Drawing Nos. GR-2 to GR-5), were selected as critical sections for slope stability analysis under pre-development conditions. Sections 1, 2, 3, 5 (transcribed on to Drawing No. 1 from Drawing Nos. GR-2 to GR-5), and 1A shown on Drawing No. 1, were selected as critical sections under post-development conditions. Elsewhere, slopes are indicated as 3H:1V or flatter, thereby requiring no analysis to confirm that the stable top of bank would coincide with top of bank staked out by Toronto and Region Conservation Authority (TRCA) representatives in the field as indicated on the updated Grading Plan.

Photographs 1 through 4 attached in Appendix C show the general conditions of the slopes at the time of this study.

4 Subsurface Conditions

The detailed soil profiles encountered in each borehole and the results of laboratory moisture content determinations are indicated on the attached borehole logs. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to 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 Descriptions" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

4.1 Subsoil

4.1.1 Section 2 (Borehole 14)

Borehole 14 was drilled along the top of the slope.

4.1.1.1 Topsoil

Present at the ground surface of the slope is a layer of topsoil. The thickness of the topsoil was determined at the borehole location. The measured topsoil thickness is 450 mm.

4.1.1.2 Sand

A deposit of sand was encountered below the topsoil in Borehole 14 to a depth of 2.2 m below the existing ground surface. The sand is brown in colour and has a natural moisture content of 16 to 23 percent. The SPT 'N' values of the sand were 3 to 10 blows per 300 mm, which indicates a loose to compact condition.

4.1.1.3 Clayey Silt Till

A deposit of clayey silt till was encountered below the sand in Borehole 14 to a depth of 5.6 m below the existing ground surface. The clayey silt till is brown in colour and has a natural moisture content of 17 to 19 percent. The SPT 'N' values of the clayey silt till were 14 to 29 blows per 300 mm, which indicates a stiff to very stiff consistency.

4.1.1.4 Sandy Silt Till

A deposit of sandy silt till was found below the clayey silt till in Borehole 14 and extends to the borehole termination depth of about 6.6 m. The sandy silt till is generally brown in colour and wet. This deposit has a natural moisture content of 11 percent. The SPT ‘N’ value of the sandy silt till was 31 blows per 300 mm, which indicates dense conditions.

4.1.1.5 Groundwater

The groundwater condition at the site was assessed by observing the water level in the open hole during the field work. However, wet sand was encountered in the borehole above the clayey silt till layer. No groundwater was observed upon completion of drilling of the borehole. Seasonal fluctuations of the groundwater level at the site should be anticipated.

4.1.2 Section 9 (Borehole 61)

Borehole 61 was drilled along the top of the slope.

4.1.2.1 Topsoil

Present at the ground surface of the slope is a layer of topsoil. The thickness of the topsoil was determined at the borehole location. The measured topsoil thickness is 75 mm.

4.1.2.2 Fill

An existing fill layer was encountered below the topsoil in Borehole 61 to a depth of 1.9 m below the existing ground surface. The existing fill is a dark brown sandy silt with trace clay and has a natural moisture content of 19 to 21 percent. The SPT ‘N’ values of the fill were 0 to 5 blows per 300 mm which indicates a very loose to loose condition.

4.1.2.3 Sandy Silt Till

A deposit of sandy silt till was found below the existing fill in Borehole 61 and extends to a depth of 2.9 m below the existing ground surface. The sandy silt till is generally brown in colour and moist. This deposit has a natural moisture content of 12 percent. The SPT ‘N’ value of the sandy silt till was 21 blows per 300 mm, which indicates compact conditions.

4.1.2.4 Silty Sand

A silty sand layer was encountered below the sandy silt till in Borehole 61 to the borehole termination depth of about 6.6 m below the existing ground surface. The silty sand is brown in colour and has a natural moisture content of 8 to 10 percent. The SPT ‘N’ values of the silty sand were 46 to 71 blows per 300 mm, which indicates dense to very dense conditions.

4.1.2.5 Groundwater

The groundwater condition at the site was assessed by observing the water levels in the open hole during the field work. No groundwater was observed upon completion of drilling of the borehole. No groundwater was observed in the monitoring well after elapsed times of 1 and 3 days, respectively. Seasonal fluctuations of the groundwater level at the site should be anticipated.

4.1.3 Section 10 (Borehole 62)

Borehole 62 was drilled along the top of the slope.

4.1.3.1 Topsoil

Present at the ground surface of the slope is a layer of topsoil. The thickness of the topsoil was determined at the borehole location. The measured topsoil thickness is 200 mm.

4.1.3.2 Silty Sand

A deposit of silty sand was found below the topsoil in Borehole 62 and extends to a depth of 4.0 m below the existing ground surface. The silty sand is generally brown in colour and contains silt layers. This deposit has a natural moisture content of 15 to 21 percent. The SPT ‘N’ value of the silty sand was 3 to 14 blows per 300 mm, which indicates loose to compact conditions.

4.1.3.3 Sandy Silt Till

A deposit of sandy silt till was encountered below the silty sand in Borehole 62 and extends to a depth of 7.0 m below the existing ground surface. The sandy silt till is brown in colour and has a natural moisture content of 11 to 14 percent. The SPT ‘N’ values of the sandy silt till were 31 to 78 blows per 300 mm, which indicates dense to very dense conditions.

4.1.3.4 Lower Silty Sand

A deposit of lower silty sand was encountered below the sandy silt till in Borehole 62 and extends to the borehole termination depth of 9.5 m below the existing ground surface. The lower silty sand is brown in colour and has a natural moisture content of 4 to 10 percent. The

SPT ‘N’ value of the silty sand was >50 blows per 300 mm, which indicates very dense conditions.

4.1.3.5 Groundwater

The groundwater condition at the test location was assessed by observing the water levels in the open hole during the field work. Wet cave was observed at 3.05 m in the borehole indicating that water is present at this level. Seasonal fluctuations of the groundwater level at the site should be anticipated.

4.1.4 Section 12 (Boreholes 64 and 65)

Boreholes 64 and 65 were drilled at the top of the slope.

4.1.4.1 Topsoil

Present at the ground surface of the slope is a layer of topsoil. The thickness of the topsoil was determined at the borehole location. The measured topsoil thickness is 165 mm to 300 mm.

4.1.4.2 Fill

An existing fill layer was encountered below the topsoil in Borehole 65 extending to a depth of about 1.9 m below existing grade. The fill consists of brown clayey silt and has a natural moisture content of 14 to 20 percent. The SPT ‘N’ values of the fill were 5 blows per 300 mm (in 2 samples), which indicates a loose condition.

4.1.4.3 Sandy Silt Till

A deposit of sandy silt till was found below the topsoil in Borehole 64 and below the fill in Borehole 65, and extends to depths of about 7.0 m and 4.0 m, respectively. The sandy silt till is generally brown in colour and moist. This deposit has a natural moisture content of 5 to 19 percent. The SPT ‘N’ values of the sandy silt till were 14 to 54 blows per 300 mm, which indicates compact to dense conditions.

4.1.4.4 Silty Sand

A deposit of silty sand was encountered below the sandy silt till in Boreholes 64 and 65 to depths of 8.5 m and 5.5 m below the existing ground surface, respectively. The silty sand is brown in colour and has a natural moisture content of 18 to 20 percent. The SPT ‘N’ values of the silty sand were 21 to 37 blows per 300 mm, which indicates compact to dense conditions.

4.1.4.5 Clayey Silt Till

A deposit of clayey silt till was encountered below the silty sand in Borehole 65 to the borehole termination depth of 8.0 m below the existing ground surface. The clayey silt till is brown in colour and has a natural moisture content of 13 to 15 percent. The SPT ‘N’ values of the clayey silt till were 21 to 39 blows per 300 mm, which indicates a hard consistency.

4.1.4.6 Lower Sandy Silt Till

A deposit of lower sandy silt till was found below the silty sand in Borehole 64 and extends to the borehole termination depth of about 12.3 m. The lower sandy silt till is generally brown in colour and moist. This deposit has a natural moisture content of 16 to 14 percent. The SPT ‘N’ values of the lower sandy silt till were 16 to >50 blows per 300 mm, which indicates compact to very dense conditions.

4.1.4.7 Groundwater

The groundwater condition at the test location was assessed by observing the water levels in the open hole during the field work and in a monitoring well installed in the borehole. No groundwater was observed at the end of borehole drilling. The groundwater level was recorded in the monitoring well at 12.05 m below the existing ground surface 2 days after completion of drilling. This corresponds to approximate Elevation 300.2 m.

Seasonal fluctuations of the groundwater level at the site should be anticipated.

5 General Slope Stability Analyses

5.1 Methodology

Stability analysis was performed at two critical pre-development slope sections (Section 2 and Section 5) and at five critical post-development slope sections (Sections 1, 1A, 2, 3, 5 and 11) shown on Drawing No. 1. Where Sections involved more than one (1) slope, all slopes were analyzed for evaluation of the minimum Factor of Safety. Embankment geometry as provided in the earlier referenced Drawing Nos. SEC-1 to SEC-3 (Schaeffers) was utilized for analyses at Sections 1, 2, 3 and 5. Embankment geometry for Section 1A was generated by EXP from the updated Grading Plan (Design Plan Services Inc.).

All stability analyses were carried out using the Slope/W software (GeoStudio 2012), and subsurface conditions revealed by the boreholes referenced for the respective slope sections. The factor of safety (F.S.) against slope failure was evaluated based on the limit equilibrium analysis method proposed by Morgenstern and Price for circular sliding surfaces.

The soil parameters adopted in the analyses are summarized in Table 1. These parameters are estimated from the index properties of the soil units, and are considered to be realistic and slightly conservative.

Table 1: Soil Properties used in Analysis

Material	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Angle of Shearing Resistance
Engineered Fill	20	0	30°
Clayey Silt Till	22	5	34°
Sandy Silt Till	22	0	38°
Sand/Silty Sand	20	0	36°
Armour Stone	24	0	40°

Each section was analyzed under static and seismic conditions. Design ground acceleration for the project site was determined from the Earthquake Hazards Program Website by interpolating 2015 National Building Code of Canada Seismic Hazard values. The map indicates a peak horizontal ground acceleration (PHGA) value of approximately 0.08 g at the project site[1]. The value is associated with an earthquake having 2 percent probability of exceedance in a 50-year period, (0.000404 per annum probability).

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[1] g = the acceleration of gravity = ~9.81 m/sec^2

Based on the topo drawings provided to EXP, existing slopes at Sections 2, 9, 10 and 12 are flatter than 3H:1V. As such no slope stability assessment is required. Further, the proposed slopes at Section 3, 4, 5, 6, 7, 8 are also flatter than 3H:1V or installation of retaining wall is less than 1.0 m high. As such analysis is not required.

The results of the analyses are shown in Figures 1 to 8 in Appendix 'B', and are summarized in the following Table 2.

Table 2: Stability Analyses Results

Sections	**Minimum Safety Factors**			
	Static	**Figure**	**Seismic**	**Figure**
1	N.A.	-	N.A.	-
2 (After Construction)	1.51	1	1.17	2
2 (Existing Conditions)	N.A.	-	N.A.	-
3	N.A.	-	N.A.	-
4	N.A.	-	N.A.	-
5	N.A.	-	N.A.	-
6	N.A.	-	N.A.	-
7	N.A.	-	N.A.	-
8	N.A.	-	N.A.	-
9 (After Construction)	2.36	3	1.93	4
9 (Existing Conditions)	N.A.	-	N.A.	-
10 (After Construction)	3.26	5	2.46	6
10 (Existing Conditions)	N.A.	-	N.A.	-
11	N.A.	-	N.A.	-
12 (After Construction)	2.83	7	2.23	8
12 (Existing Conditions)	N.A.	-	N.A.	-

In general, according to guidelines of the Toronto Region Conservation Authority (TRCA), acceptable minimum Factors of Safety under static and seismic conditions are 1.5 and 1.1, respectively.

5.2 Results of Stability Analyses

5.2.1 Section 2 (Figures 1 and 2)

The existing slope at this section is about 4.5 m high, and the slope gradient is very gentle at about 8H:1V at the toe and 22H:1V in the upper slope. The proposed slope is 5.0 m high, with a maximum retaining wall height of 2.5 m, gradient of 3H:1V at the toe of the slope and 20H:1V at the upper slope. The minimum calculated values of F.S. for this proposed section are 1.51 and 1.17 under static and seismic conditions, respectively. The results indicate that the physical top of slope will be the long term stable top of slope.

5.2.2 Section 9 (Figures 3 and 4)

The existing slope at this section is about 4.5 m high, and the slope gradient is very gentle at about 25H:1V with 3H:1V at the toe. The proposed slope at this section is the same as the existing, except for some trimming at the top of the slope and proposed retaining wall with a maximum height of 2.4 m. The minimum calculated values of F.S. for this proposed section are 2.36 and 1.93 under static and seismic conditions, respectively. The results indicate that the physical top of slope will be the long term stable top of slope.

5.2.3 Section 10 (Figures 5 and 6)

The existing slope is about 5.0 m high, with gradients at approximately 10H:1V in the upper slope and about 5H:1V at the toe.

The proposed slope at this section is about 6.0 m high with about 1.1 m height wall, and the slope gradient is very gentle at about 5H:1V at the toe and 15H:1V in the upper slope. The minimum calculated values of F.S. for this section are 3.26 and 2.46 under static and seismic conditions, respectively. The results indicate that the physical top of slope will be the long term stable top of slope.

5.2.4 Section 12 (Figures 7 and 8)

The existing slope at this section is about 7.0 m high, and the slope gradient is very gentle at about 16H:1V to 13H:1V. The proposed slope at this section is about 5.0 m high with a 2.5 m high retaining wall, and the slope gradient is very gentle at about 14H:1V in the middle and 3H:1V at the top and toe. The minimum calculated values of F.S. for this section are 2.83 and 2.23 under static and seismic conditions, respectively. The results indicate that the physical top of slope will be the long term stable top of slope.

5.3 Toe Erosion Allowance

Toe erosion allowance due to creek flow need not be considered since the creek is more than 15 m from the toe.

6 Stormwater Management Pond

The proposed storm water management Pond (SWMP) will be constructed at southwest corner of the Proposed Residential Development, 15717 Airport Road, Brampton, Ontario.

The proposed SWMP is designed with a wet cell and forebay floor elevation of 292.2 m. The proposed interior slope above the 100-year water level will be 3:1 to 5:1 (horizontal:vertical) and 5:1 (horizontal:vertical) below the 100-year water level. The pond will be constructed by excavation.

6.1 Subsurface Soil and Groundwater Conditions

Boreholes put down at the proposed SWMP area [from the Geotechnical Investigation, Proposed Residential Subdivision, Airport Road and Cranston Drive, Caledon East, Ontario prepared by EXP, dated June 8, 2017 (Revised September 11, 2018) report] are Boreholes 1 to 4. These boreholes are included for reference in Appendix A.

In general, the boreholes encountered sandy silt till deposits, below the topsoil and existing fill at Elevations 289.9 to 310.7 m. Underlying the sandy silt till, silty sand was encountered to the full depth explored. The piezometer installed in Borehole 2 indicated the groundwater level lies at Elevation 293.3 m.

6.2 Uplift Safety Factor

The groundwater table within the SWM Pond area was recorded at approximate Elevation of 293.3 m which is about 1.1 m higher than the proposed pond bottom Elevation 292.2 m.

Given the silty sand subgrade material, installation of a liner is required at the SWMP. With the liner installed, potential base heave may occur due to hydrostatic uplift pressure when the pond is emptied for cleaning and maintenance activities.

6.3 Seepage Analysis

A seepage analysis has not been carried out since the pond design does not incorporate an embankment berm; therefore, there is no need to assess the existing gradient to determine the potential for piping failure.

6.4 Embankment Slope Stability Analysis

The stability of the SWM Pond slope (Section 2-2, on Schaeffers Drawing No. SWM-s) has been analyzed by using the computer software (Slope/W 2012), and the results are shown in

Figures D-1 to D-3 in Appendix D. The soil parameters adopted in the stability analyses are also shown on the Figures. The results indicate that both the embankments have adequate factors of safety under static, seismic and rapid drawdown conditions.

The earthquake ground motion parameters for the SWM Pond are estimated using the 2015 National Building Code of Canada Seismic Hazard values. The hazard level for site class C corresponding to an earthquake having 2 percent probability of exceedance in a 50 year period (return period of 2475 years) are given by damped reference spectral response acceleration values of Sa(0.2)=0.132g, Sa(0.5)=0.083g, Sa(1.0)=0.048g, Sa(2.0)=0.025g and the reference peak ground acceleration (PGA) of 0.081g (g=acceleration due to gravity).

The results of the analyses are summarized in Table 3 below. The factors of safety shown in the table are calculated with Morgenstern and Price Method for circular sliding surfaces.

Table 3: Slope Stability Analyses Results

Location	Calculated Factor of Safety		
	Static (Min required = 1.5)	Seismic (Min required = 1.1)	Rapid Drawdown (Min required = 1.2)
SWMP (Section 2-2)	1.87 (Figure B-1)	1.77 (Figure B-2)	1.95 (Figure B-3)

6.5 Pond Construction

6.5.1 Forebay and Wet Cell

Subjected to effective groundwater control measures during construction, general bulk excavation to the pond bottom should be relatively straightforward using hydraulic equipment and must be carried out in accordance with the Occupational Health and Safety Act and local regulations.

Excavation for the pond bottom is expected to extend 1.1 m below the groundwater table. As such, proper dewatering measures, such as a well point system, will likely be required to depress groundwater to facilitate the excavation. The groundwater should be depressed to and maintained at least 1 m below the proposed lowest excavation level during construction. The actual type and details of the dewatering system should be determined by a specialist dewatering contractor cognizant of their own equipment and experience. The dewatering system should be maintained until pond construction is complete.

6.5.2 Pond Liner

Based on the prevailing groundwater levels, the anticipated issues are as follows:

- Groundwater would seep into the SWM Pond.
- The surface runoff collected in the SWM Pond would be in direct contact with groundwater.
- The development of surface seepage pressures would impact the stability of the side slopes.

The base and side slopes of the SWM pond should be lined with a synthetic liner (Bentofix NWL or equivalent) or clay liner to a minimum 0.3 m above maximum storage levels.

A compacted clay liner should have a minimum thickness of 600 mm. The liner can be constructed using native soils amended with bentonite. Bentonite should be mixed with the soils at a minimum application rate of 0.05 kilonewtons of bentonite per square meter of surface area per 25 mm of compacted liner. The bentonite must be blended uniformly with the soil, moisture conditioned, and then compacted. The soil liner should be compacted to a minimum of 95 percent of the mixture’s maximum dry density as determined by ASTM Test Designation D-698 (Standard Proctor).

A synthetic liner (Bentofix NWL or equivalent) or a composite liner can be considered. The liner should be installed on a properly prepared subgrade in accordance with the liner manufacturer’s specifications. If the pond slopes are to be vegetated, it will be necessary to specify a liner that will exhibit sufficient friction to insure topsoil will not slide off the liner when the pond is in service. Alternatively, a geo-cell confinement system could be installed over the liner and infilled with topsoil above the permanent water elevation. As penetrations through the liner would not be allowed, the geo-cell system would need to be anchored at the top of the pond in a keyway and supported by tendons that extend through the geo-cell webbing. Geo-Web cellular confinement or similar system could be considered for this purpose.

With the installation of clay or synthetic liner, potential base heave may occur due to hydrostatic uplift pressure when the pond is emptied for cleaning and maintenance activities. The various scenarios for mitigation of heaving issues due to hydrostatic uplift pressure in the SWM Pond No. 2 are summarized in Table 4 below.

Table 4: Pond Liner Options

Condition	Liner Type	Drainage	Ballast/Marker Stone Requirements
1	Clay – 600mm thick	Subdrain	Maximum 150 mm Stone – 200 mm thick
2	Synthetic	Subdrain	Maximum 150 mm Stone – 200 mm thick

The recommended subdrain system should consist of three evenly spaced 150 mm diameter perforated HDPE drainage pipes. These should be surrounded by pea gravel, which should be wrapped continuously with a non-woven geotextile filter fabric. The drains should be placed 100 mm from the bottom of 600 mm wide and 450 mm deep trenches. The location and extent of the subdrain system should be field verified by the geotechnical engineer at the time of construction.

6.6 Erosion

The native sandy silt till to silty sand at the SWM Pond area is highly erodible material. Without adequate erosion protection, it is expected that stream flow, internal seepage, and scouring will cause slope erosion, eventually leading to slope instability and failure.

A geo-cell confinement system installed with topsoil or granular should be installed to protect the pond slope from erosion and for detection of pond bottom during maintenance, such as removal of sediment.

7 Conclusions and Recommendations

It is the conclusion of this study that the proposed construction of Proposed Residential Subdivision construction is feasible, and the proposed development would not impact the current stability of the slopes at the site.

The following are our recommendations:

1. The engineered fill should be constructed under the full-time supervision of a qualified geotechnical engineer.
2. No storm water should be allowed to be discharged onto the slope in an uncontrolled manner.
3. During construction, no stockpiles of construction material should be placed within about 10 m of the crest of the slope or on the existing slope surface.
4. All retaining walls should be designed to achieve acceptable internal and external stability safety factors.

8 General Comments

When design and specifications based on the results reported herein are required, **exp** should be retained for a general review to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, **exp** will assume no responsibility for interpretation of the recommendations in the report.

This report has been prepared for and is intended for the exclusive use of Triple Crown Line Development, TRCA, and Regional Municipality of Caledon, and its clients and engineers. Any use which a third party makes of this report, or any part thereof, of any reliance on or decision to be made based on it, are the responsibility of such third parties. **Exp** accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or actions based on this report. The contents of this report should not be relied upon by any other party without the express written consent of **exp**. The findings are relevant for the dates of our site visits and should not be relied upon to represent conditions at later dates.

We trust that this report is sufficient for your purposes. Should you have any questions regarding this report, please do not hesitate to contact the undersigned.

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Appendix A:

Borehole Location Plan
Borehole Logs

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LEGEND:

BH 58 ◐ Borehole

BH 56 ◐ Monitoring Well

BH 47 ◐ Nested Monitoring Wells

Note:

1. The boundaries and soil types have been established only at the borehole locations. Between boreholes the boundaries are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for 3 months and then destroyed unless the client advises otherwise.
3. Topsoil quantities and/or volumes of unsuitable fill should not be established from the information provided at the borehole locations.
4. Borehole elevations should not be used to design building(s), or floor slab(s), or parking lot(s) grades.
5. This drawing to be read with subject report, project number as shown below.
6. See report text for site datum.
7. Test hole locations are approximate.
8. Dimensions shown on this drawing are in metric units, unless otherwise noted.

exp.

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DRAWN: HAL
CHECKED: TA
P.M.: JKF

SCALE
0 20 40 60 80 100

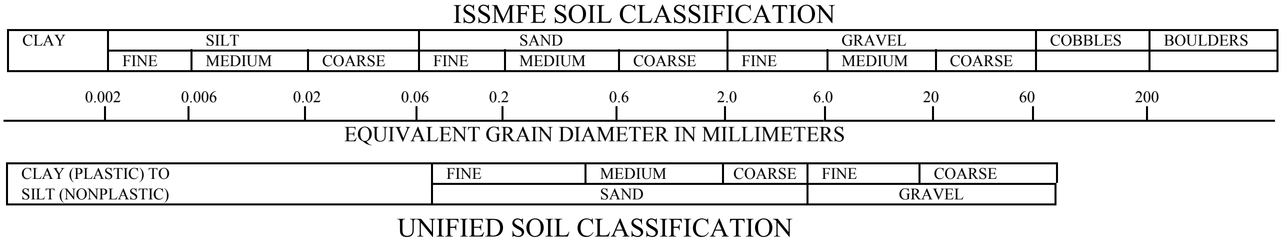
Borehole Location Plan
Proposed Residential Subdivision
Airport Road and Cranston Drive
Caledon East, Ontario

Reference: BRM-00235186-D0

Drawing: 1

Notes on Sample Descriptions and Soil Types Drawing 1A

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



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 (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of

till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

4. Excerpt from “OHSA Regulations for Construction Projects,” Part III, Section 226:

- **Soil Types**

Type 1 Soil

a) is hard, very dense and only able to be penetrated with difficulty by a small sharp object;
b) has a low natural moisture content and a high degree of internal strength;
c) has no signs of water seepage; and
d) can be excavated only by mechanical equipment.

Type 2 Soil

a) is very stiff, dense and can be penetrated with moderate difficulty by a small sharp object;
b) has a low to medium natural moisture content and a medium degree of internal strength; and
c) has a damp appearance after it is excavated.

Type 3 Soil

a) is stiff to firm and compact to loose in consistency or is previously excavated soil;
b) exhibits signs of surface cracking;
c) exhibits signs of water seepage;
d) if it is dry, may run easily into a well-defined conical pile; and
e) has a low degree of internal strength.

Type 4 Soil

a) is soft to very soft and very loose in consistency, very sensitive and upon disturbance is significantly reduced in natural strength;
b) runs easily or flows, unless it is completely supported before excavating procedures;
c) has almost no internal strength;
d) is wet or muddy; and
e) exerts substantial fluid pressure on its supporting system. O. Reg. 213/91, s. 226.

Log of Borehole 1

Project No. BRM-00235186-D0

Drawing No. 2

Project: Geotechnical Investigation

Sheet No. 1 of 1

Location: Airport Road and Cranston Drive

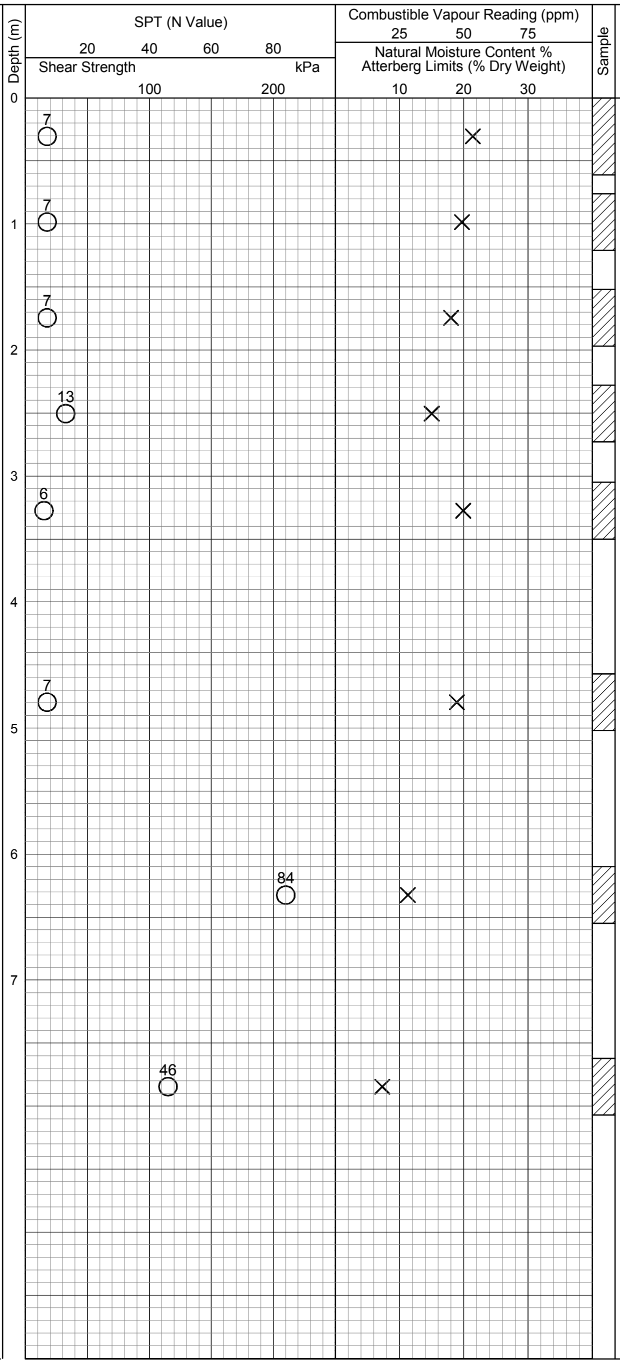
Date Drilled: April 26, 2017

Drill Type: CME 55-Track

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	▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)	Natural Unit Weight kN/m^3
		~125 mm Topsoil over **FILL:** Sandy silt, trace clay, trace gravel, clayey silt pockets, brown, moist.	300.85	0	
				1	21.0
					20.4
		SANDY SILT TILL: Trace gravel, trace clay, brown oxidized fissures, moist to wet, compact to loose.	~298.9	2	21.5
				3	21.3
				4	
		SILTY SAND: Medium grained, brown, moist, very dense.	~296.1	5	
				6	
				7	
		END OF BOREHOLE.	~292.8		



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	7.16

Log of Borehole 2

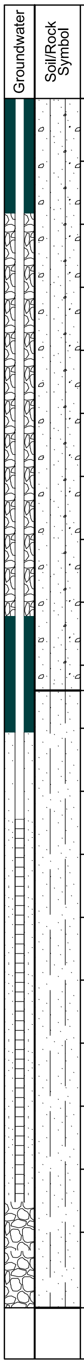
Project No.	BRM-00235186-D0	Drawing No.	3
Project:	Geotechnical Investigation	Sheet No.	1 of 1
Location:	Airport Road and Cranston Drive		

Date Drilled: April 27, 2017

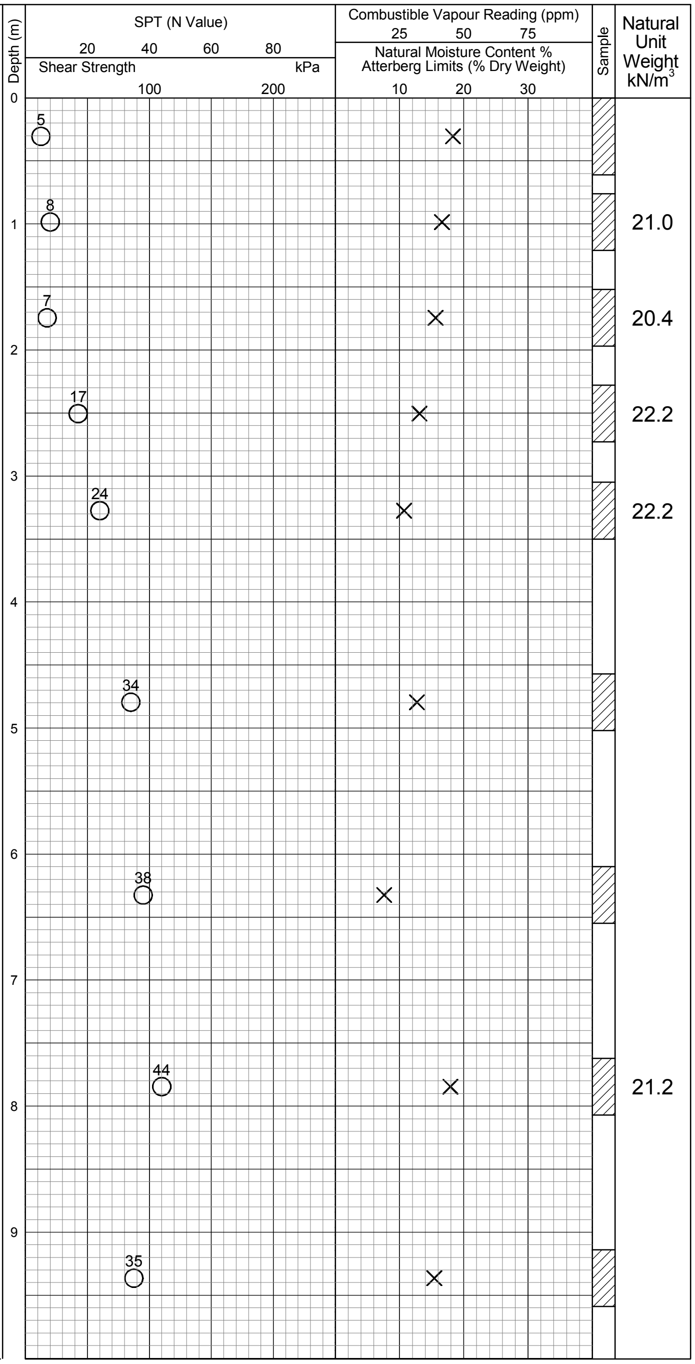
Drill Type: CME 55-Track

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
~250 mm Topsoil over **SANDY SILT TILL:** Fine sand seams, trace gravel, trace clay, occasional boulder fragments, brown, wet, loose.	302.06
Becoming compact, moist.	~300.0
SILTY SAND: Fine to medium grained, brown, moist with wet layers, dense.	~297.4
END OF BOREHOLE.	~292.5



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion May 15, 2017 May 19, 2017	Dry 8.82 8.77	9.14

exp.

EXPLOGBRAMPTON AIRPORT ROAD AND CRANSTON DRIVE GINT LOGS - COPY.GPJ NEW.GDT 5/6/17

Log of Borehole 3

Project No. BRM-00235186-D0

Drawing No. 4

Project: Geotechnical Investigation

Sheet No. 1 of 1

Location: Airport Road and Cranston Drive

Date Drilled: April 27, 2017

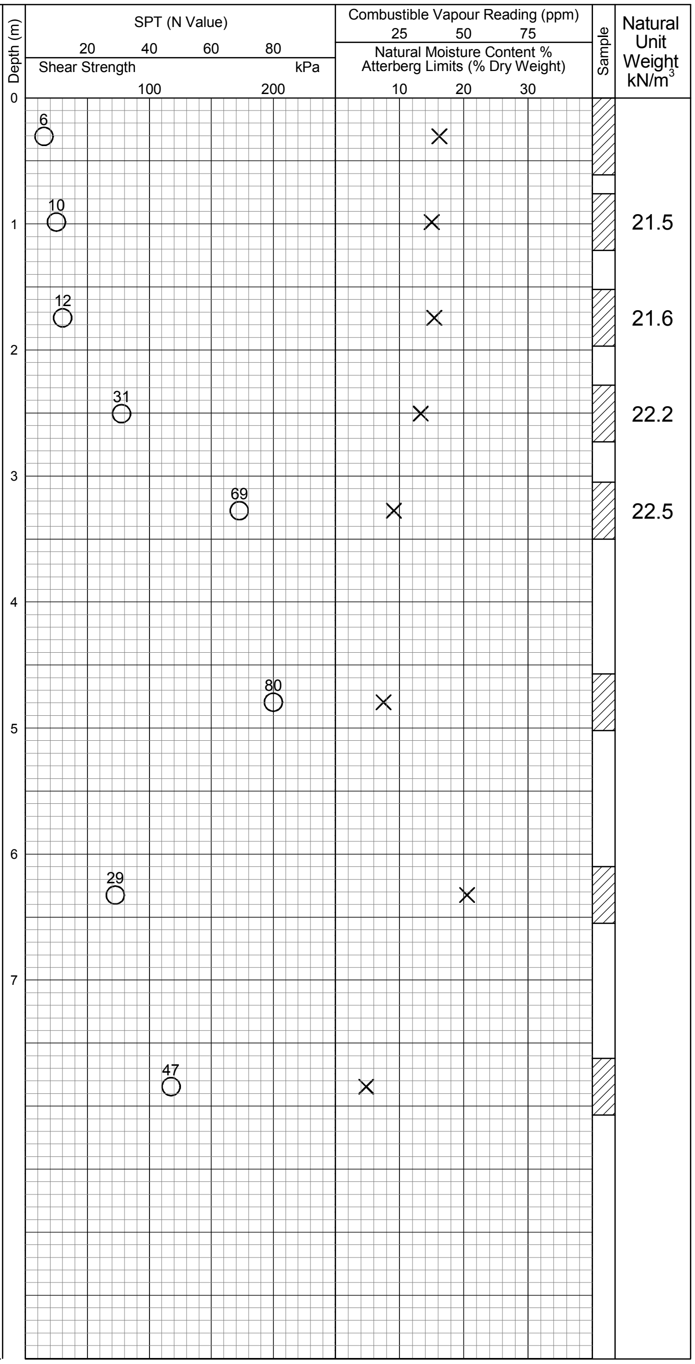
Drill Type: CME 55-Track

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
~125 mm Topsoil over **SANDY SILT TILL:** Fine sand seams, trace gravel, occasional boulder and shale fragments, brown, moist, compact.	300.99
Becoming dense to very dense.	~298.9
SILTY SAND: Fine grained, brown, moist, very dense.	~297.0
Becoming compact, wet.	~295.4
Becoming dense, moist.	~293.9
END OF BOREHOLE.	~292.9



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	7.47

Log of Borehole 4

Project No. BRM-00235186-D0

Drawing No. 5

Project: Geotechnical Investigation

Sheet No. 1 of 1

Location: Airport Road and Cranston Drive

Date Drilled: April 27, 2017

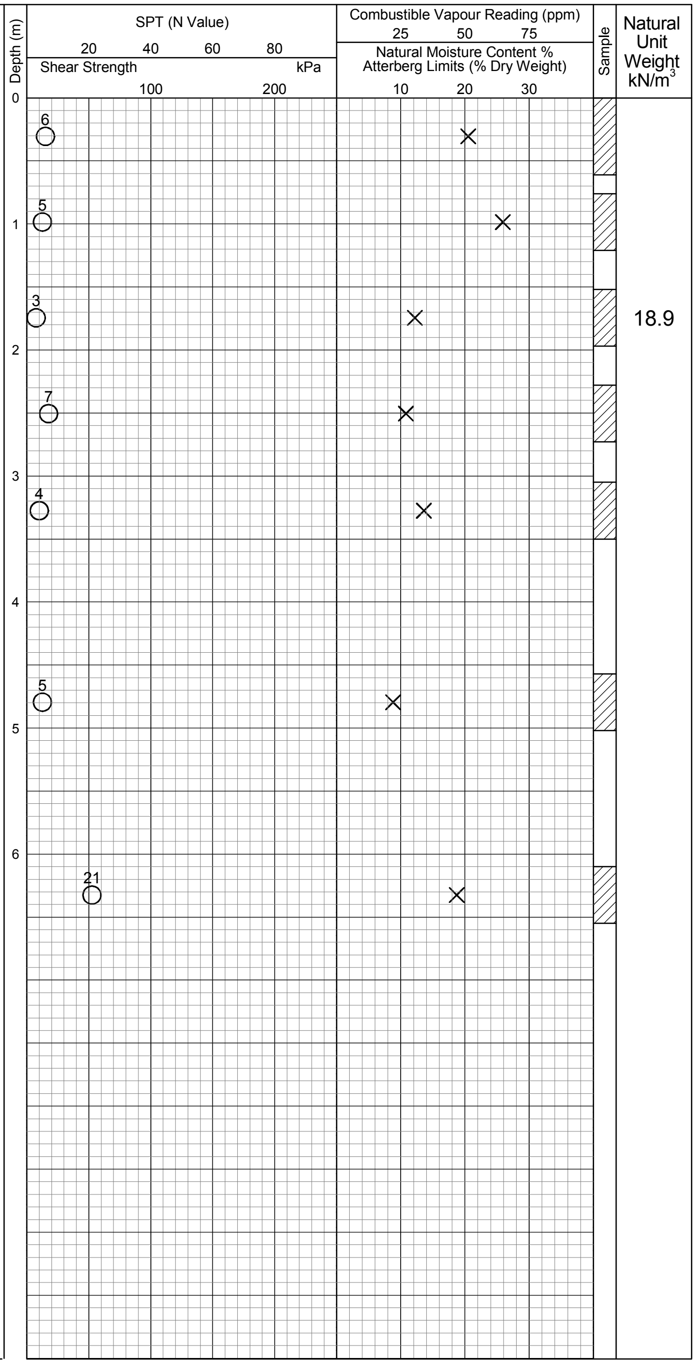
Drill Type: CME 55-Track

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	▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m
		~100 mm Topsoil over **SANDY SILT TILL:** Trace gravel, brown, wet, loose.	296.65
		SILTY SAND: Fine to medium grained, brown, moist, loose.	~294.6
		Becoming wet, compact.	~291.7
		END OF BOREHOLE.	~290.1



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	5.79

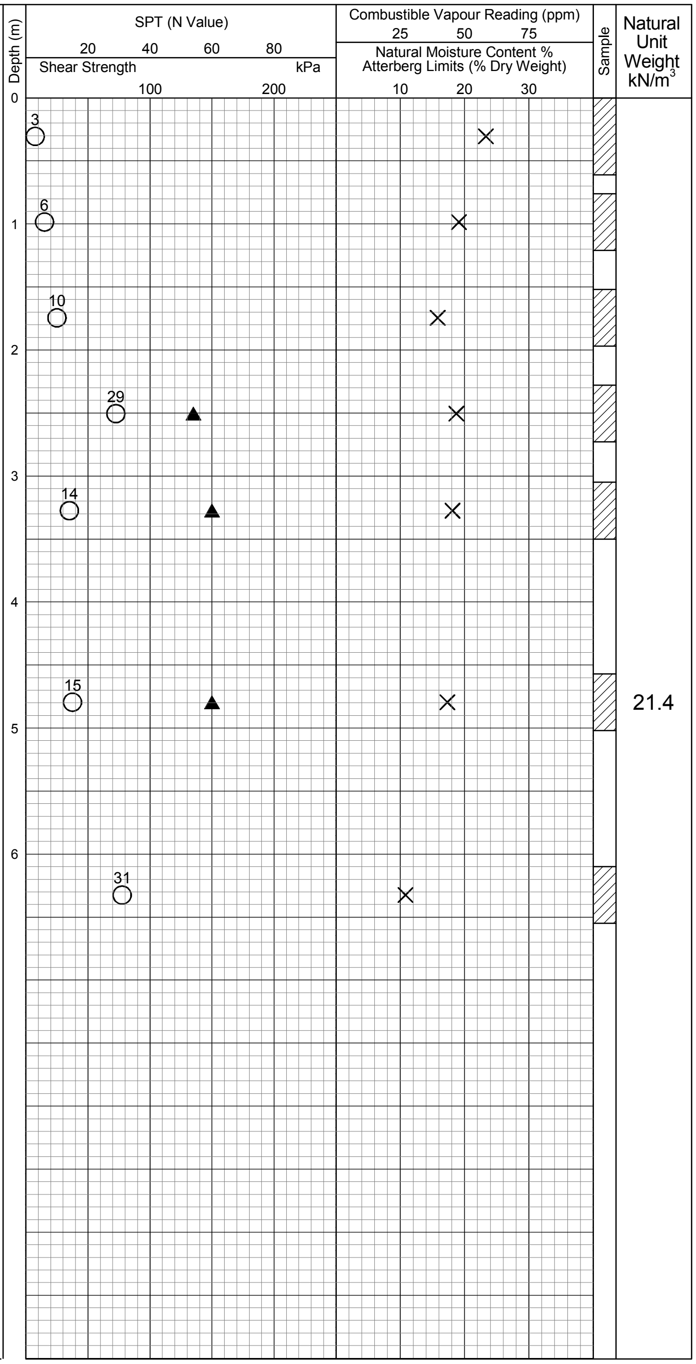
Log of Borehole 14

Project No. BRM-00235186-D0
Drawing No. 15
Project: Geotechnical Investigation
Sheet No. 1 of 1
Location: Airport Road and Cranston Drive

Date Drilled: May 2, 2017
Drill Type: CME 55-Track
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	▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m
			294.85
		~450 mm Topsoil over **SAND:** Medium to coarse grained, trace gravel, brown, wet, loose to compact.	
		CLAYEY SILT TILL: Fine sand seams, trace gravel, brown, wet, stiff to very stiff.	~292.7
		Becoming grey, wet.	~290.9
		SANDY SILT TILL: Medium grained sand seams, trace gravel, brown, wet, dense.	~289.3
		END OF BOREHOLE.	~288.3



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	6.55

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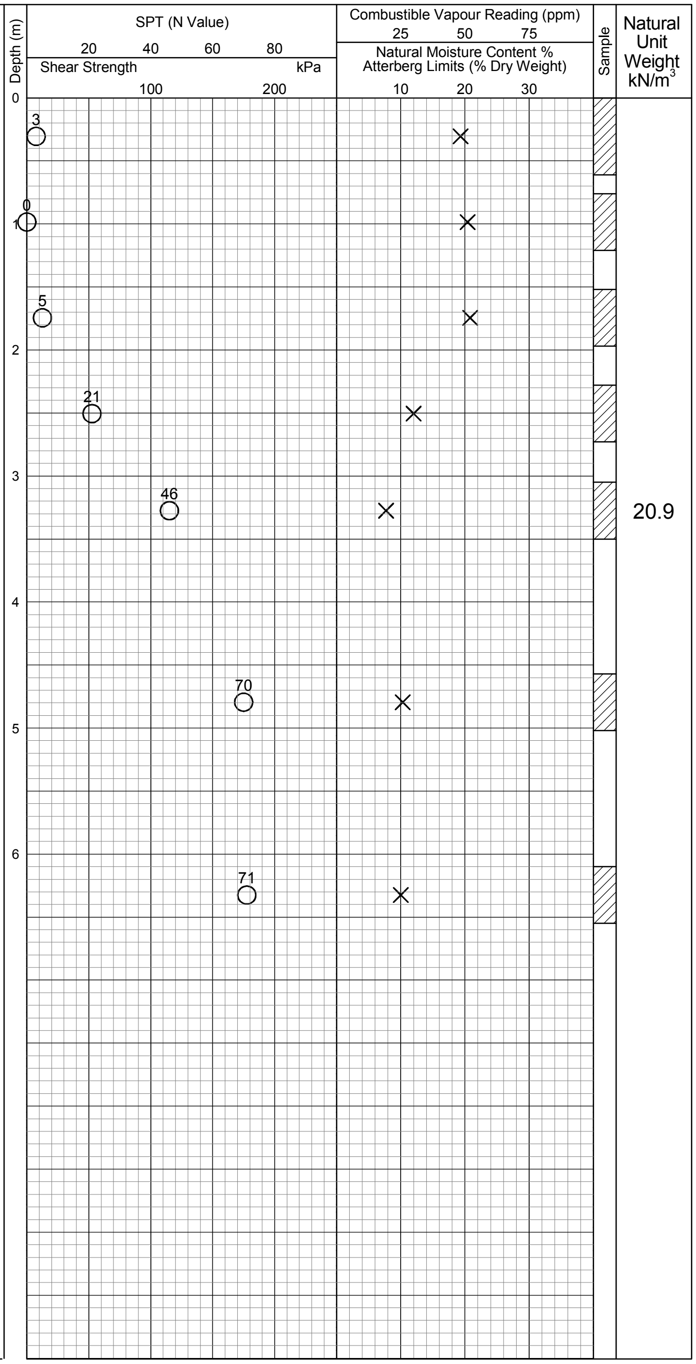
Log of Borehole 61

Project No. BRM-00235186-D0
Drawing No. 62
Project: Geotechnical Investigation
Sheet No. 1 of 1
Location: Airport Road and Cranston Drive

Date Drilled: May 16, 2017
Drill Type: CME 55-Rubber Track
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
~75 mm Topsoil over **FILL:** Silty sand, trace clay, dark brown, wet.	306.60
SANDY SILT TILL: Fine sand seams and layers, trace gravel, brown, moist, compact.	~304.7
SILTY SAND: Fine grained, cemented zones, silt seams and layers, brown, moist, dense to very dense.	~303.7
END OF BOREHOLE.	~300.0



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	5.99
May 17, 2017	Dry	
May 19, 2017	Dry	

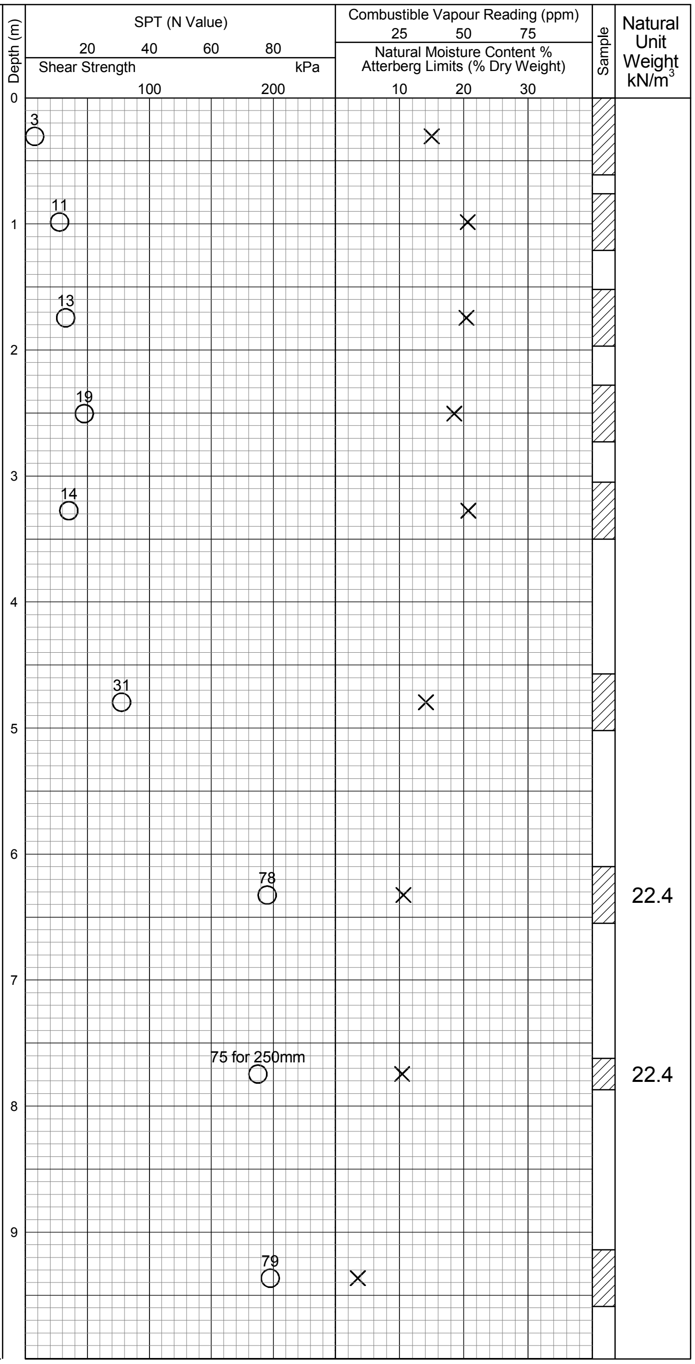
Log of Borehole 62

Project No. BRM-00235186-D0
Drawing No. 63
Project: Geotechnical Investigation
Sheet No. 1 of 1
Location: Airport Road and Cranston Drive

Date Drilled: May 16, 2017
Drill Type: CME 55- Rubber Track
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	▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m
		~200 mm Topsoil over **SILTY SAND:** Fine grained, silt layers, brown, wet, compact.	307.21
		SANDY SILT TILL: Fine sand seams and layers, trace gravel, occasional boulder fragments, brown, moist, dense to very dense.	~303.2
		SILTY SAND: Fine grained, cemented zones, brown, moist, very dense.	~300.1
		END OF BOREHOLE.	~297.6



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	3.05

exp.

Log of Borehole 64D

Project No. BRM-00235186-D0

Drawing No. 65

Project: Geotechnical Investigation

Sheet No. 1 of 2

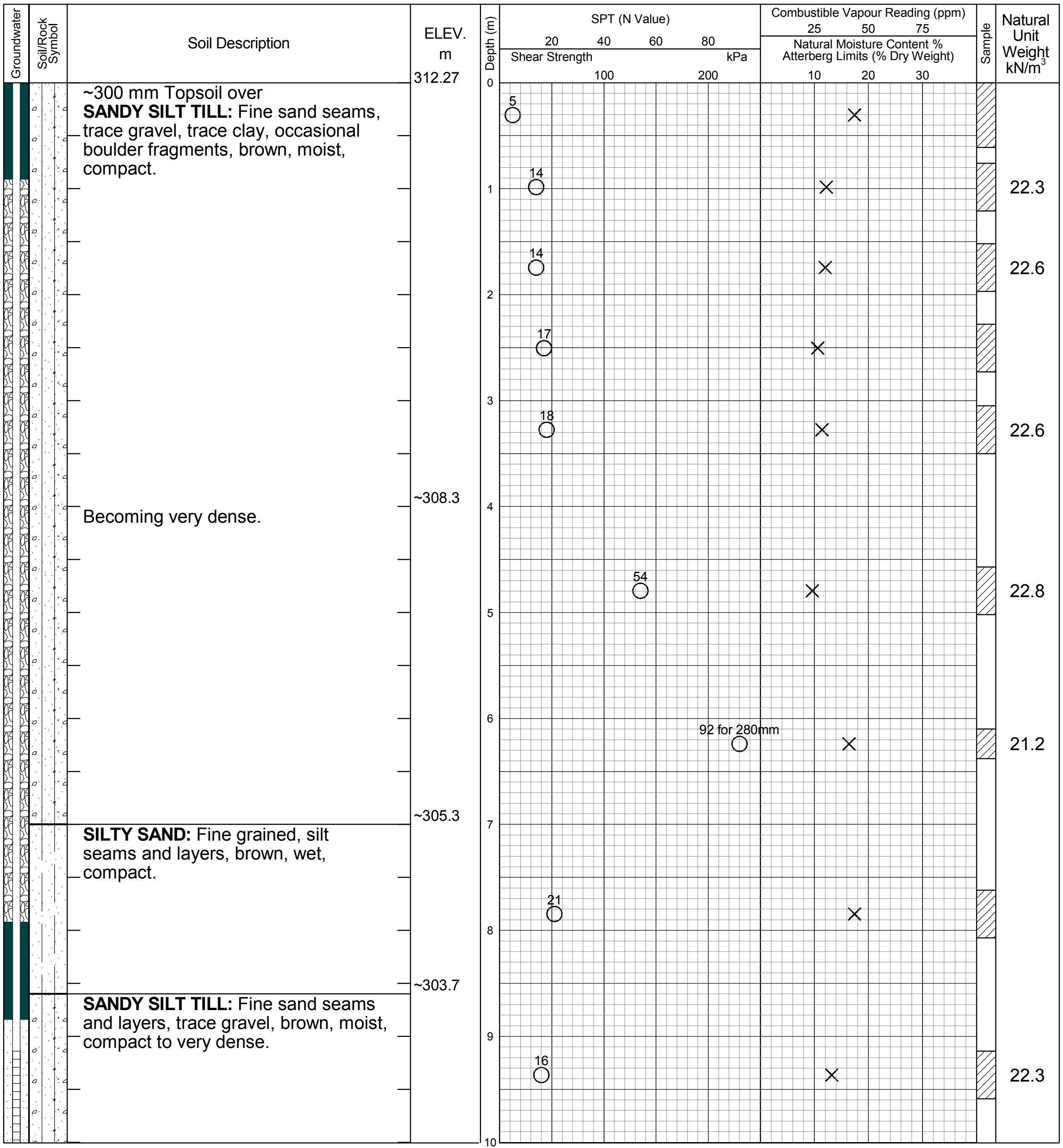
Location: Airport Road and Cranston Drive

Date Drilled: May 17, 2017

Drill Type: CME 55-Rubber Track

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
	312.27
~300 mm Topsoil over **SANDY SILT TILL:** Fine sand seams, trace gravel, trace clay, occasional boulder fragments, brown, moist, compact.	
Becoming very dense.	~308.3
SILTY SAND: Fine grained, silt seams and layers, brown, wet, compact.	~305.3
SANDY SILT TILL: Fine sand seams and layers, trace gravel, brown, moist, compact to very dense.	~303.7

Continued Next Page

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion May 19, 2017	Dry 12.05	12.19

Log of Borehole 64D

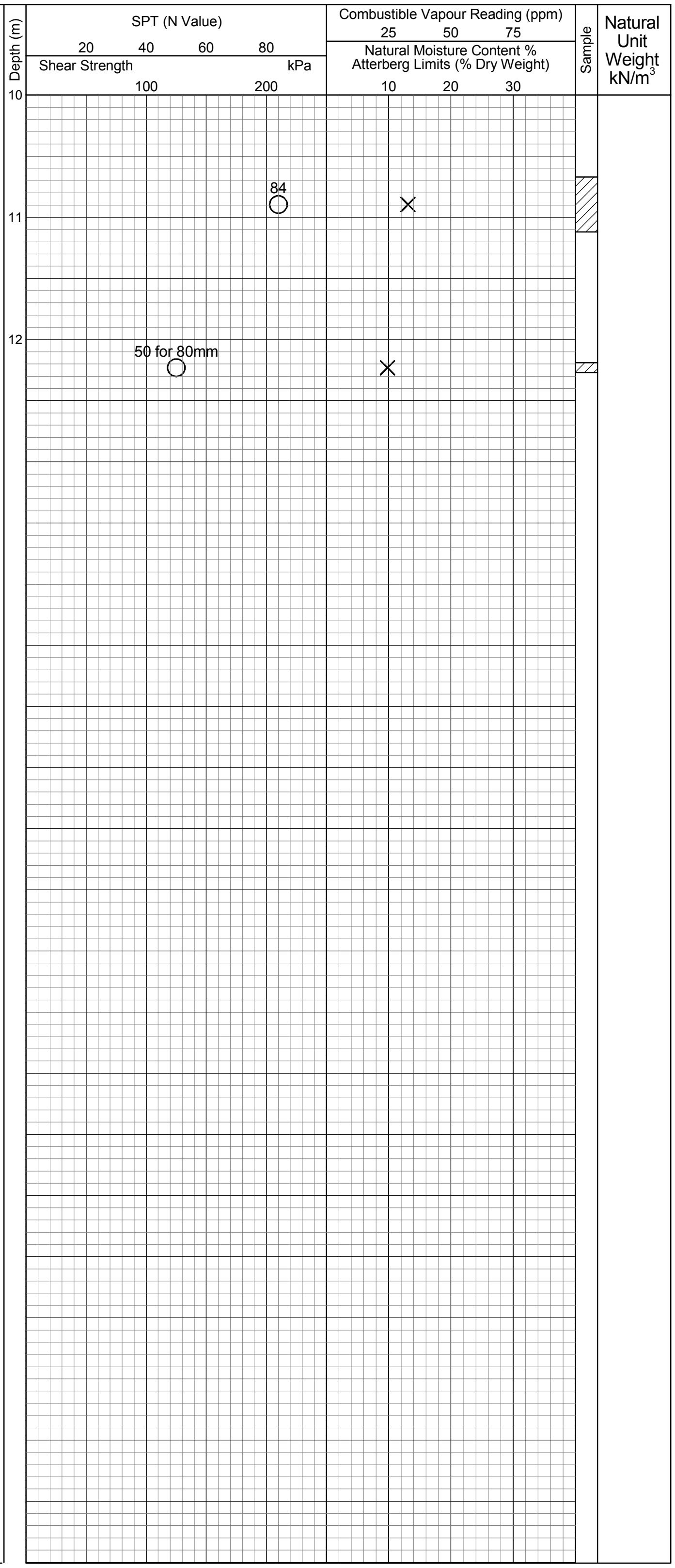
Project No. BRM-00235186-D0

Drawing No. 65

Project: Geotechnical Investigation

Sheet No. 2 of 2

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m
			302.27
		END OF BOREHOLE.	~300.0



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion May 19, 2017	Dry 12.05	12.19

exp.

Log of Borehole 64S

Project No. BRM-00235186-D0

Drawing No. 65A

Project: Geotechnical Investigation

Sheet No. 1 of 1

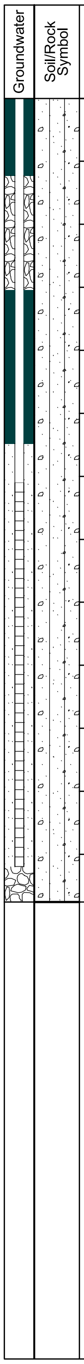
Location: Airport Road and Cranston Drive

Date Drilled: May 17, 2017

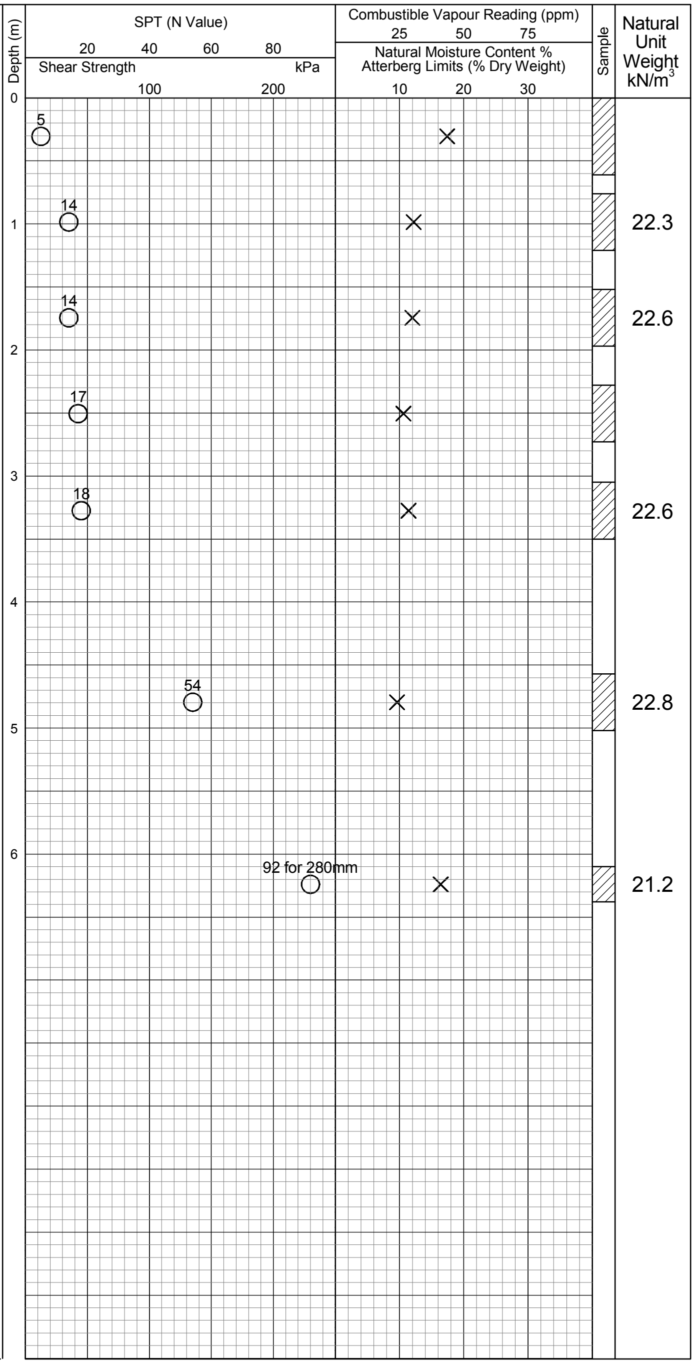
Drill Type: CME 55-Rubber Track

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	▲



ELEV. m	Soil Description
312.27	~300 mm Topsoil over **SANDY SILT TILL:** Fine sand seams, trace gravel, trace clay, occasional boulder fragments, brown, moist, compact.
~308.3	Becoming very dense.
~305.9	**END OF BOREHOLE.**



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	6.10
May 19, 2017	Dry	

exp.

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Log of Borehole 65

Project No. BRM-00235186-D0

Drawing No. 66

Project: Geotechnical Investigation

Sheet No. 1 of 1

Location: Airport Road and Cranston Drive

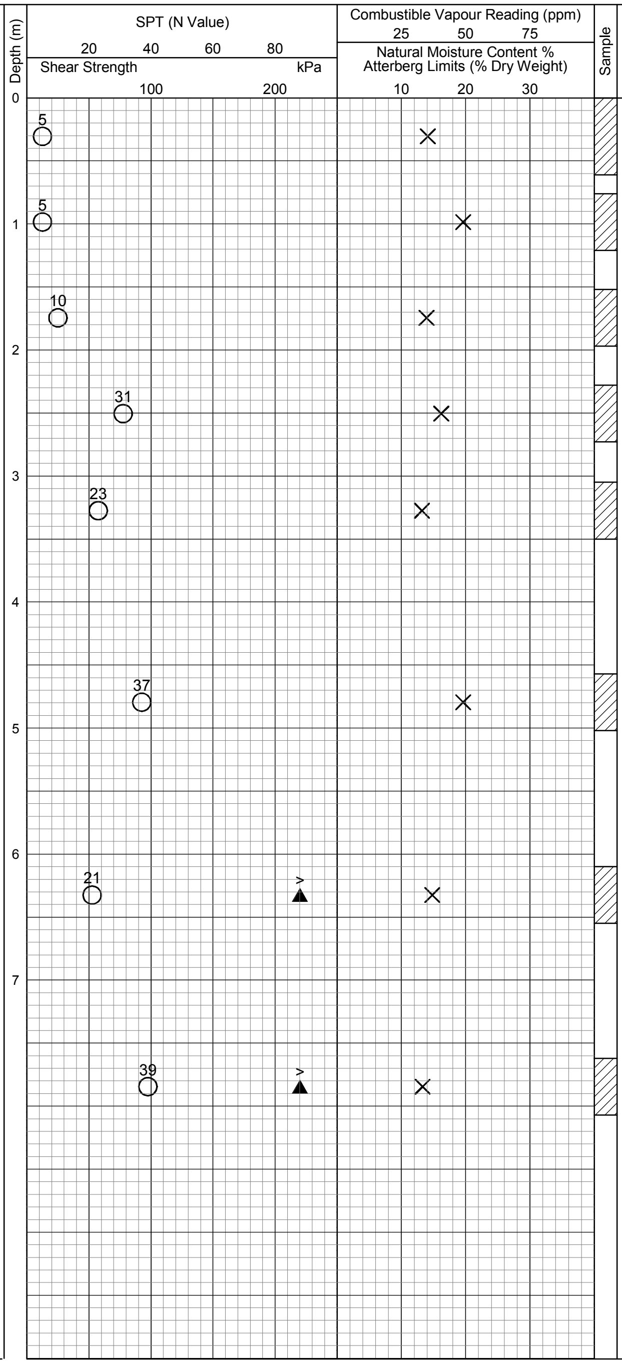
Date Drilled: May 11, 2017

Drill Type: CME 55 - Rubber Track

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
	311.56
~165 mm Topsoil over **FILL:** Clayey silt, trace gravel, brown to dark brown, moist.	
SANDY SILT TILL: Fine sand seams and layers, trace gravel, occasional boulder fragments, brown, moist, compact to dense.	~310.2
SILTY SAND: Fine grained, brown, wet, dense.	~307.6
CLAYEY SILT TILL: Fine sand seams, trace gravel, brown, moist, hard.	~306.0
END OF BOREHOLE.	~303.5



Natural Unit Weight kN/m³
19.9
21.8
22.8
22.7
22.7
22.2

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	8.53

Appendix B:
General Slope Stability Analysis Results

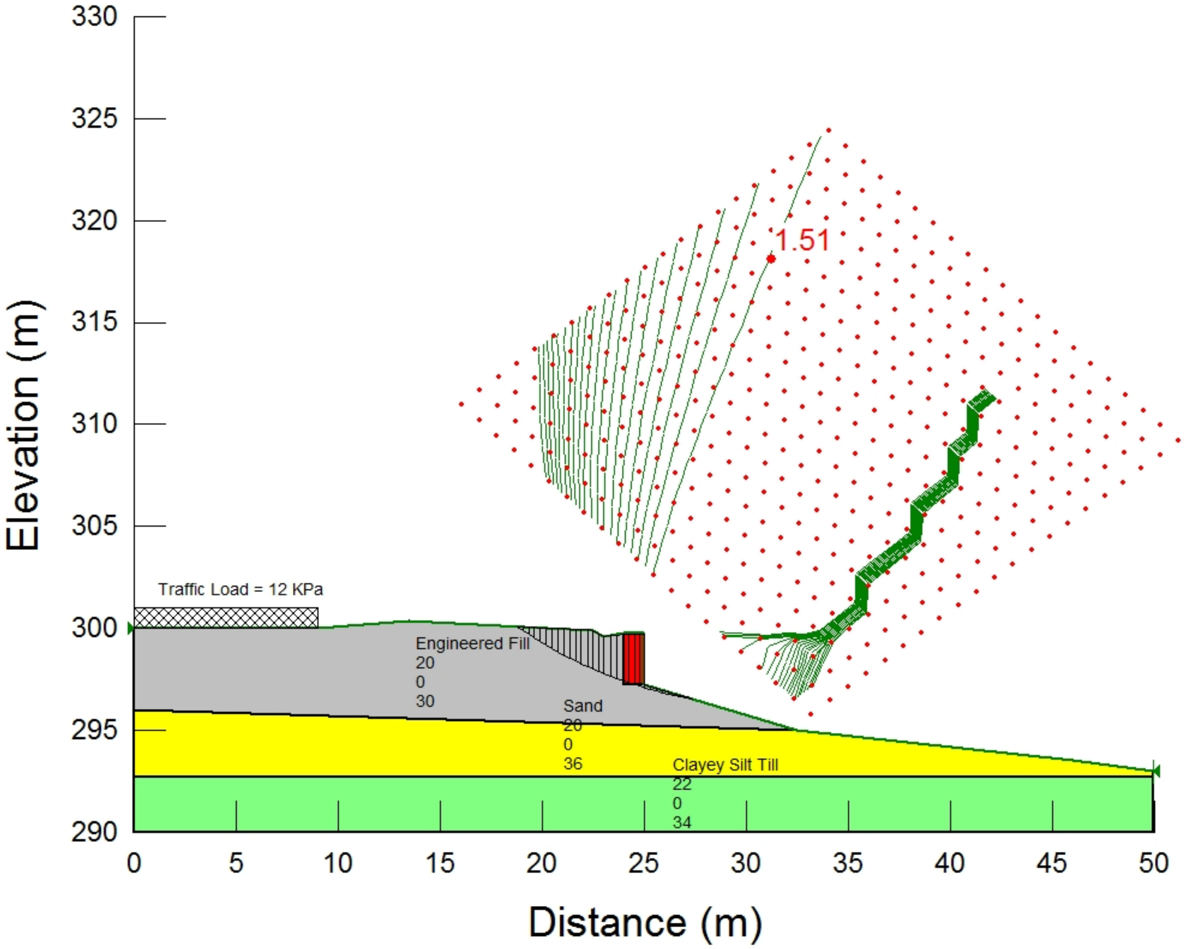


Figure 1
Section 2 After Construction (Static)

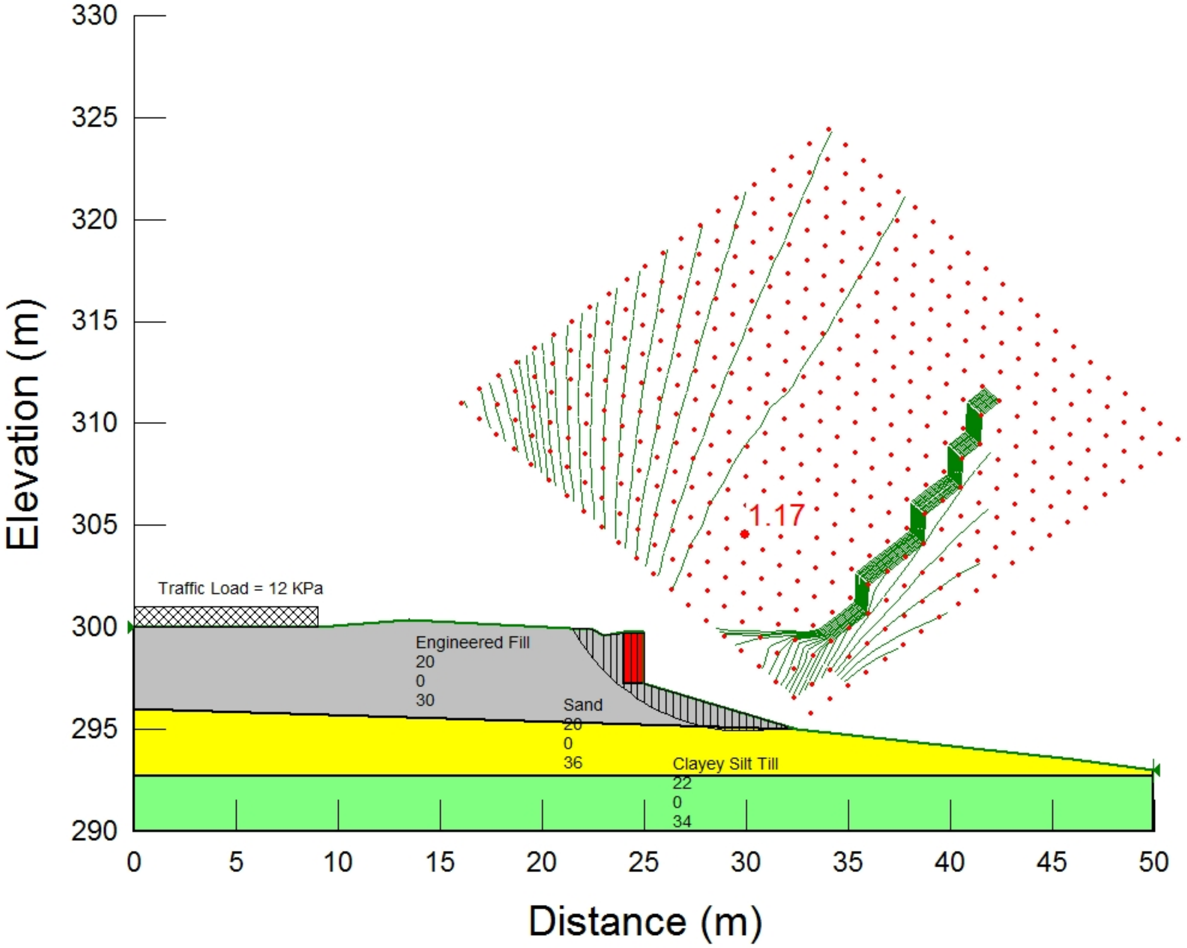


Figure 2
Section 2 After Construction (Seismic)

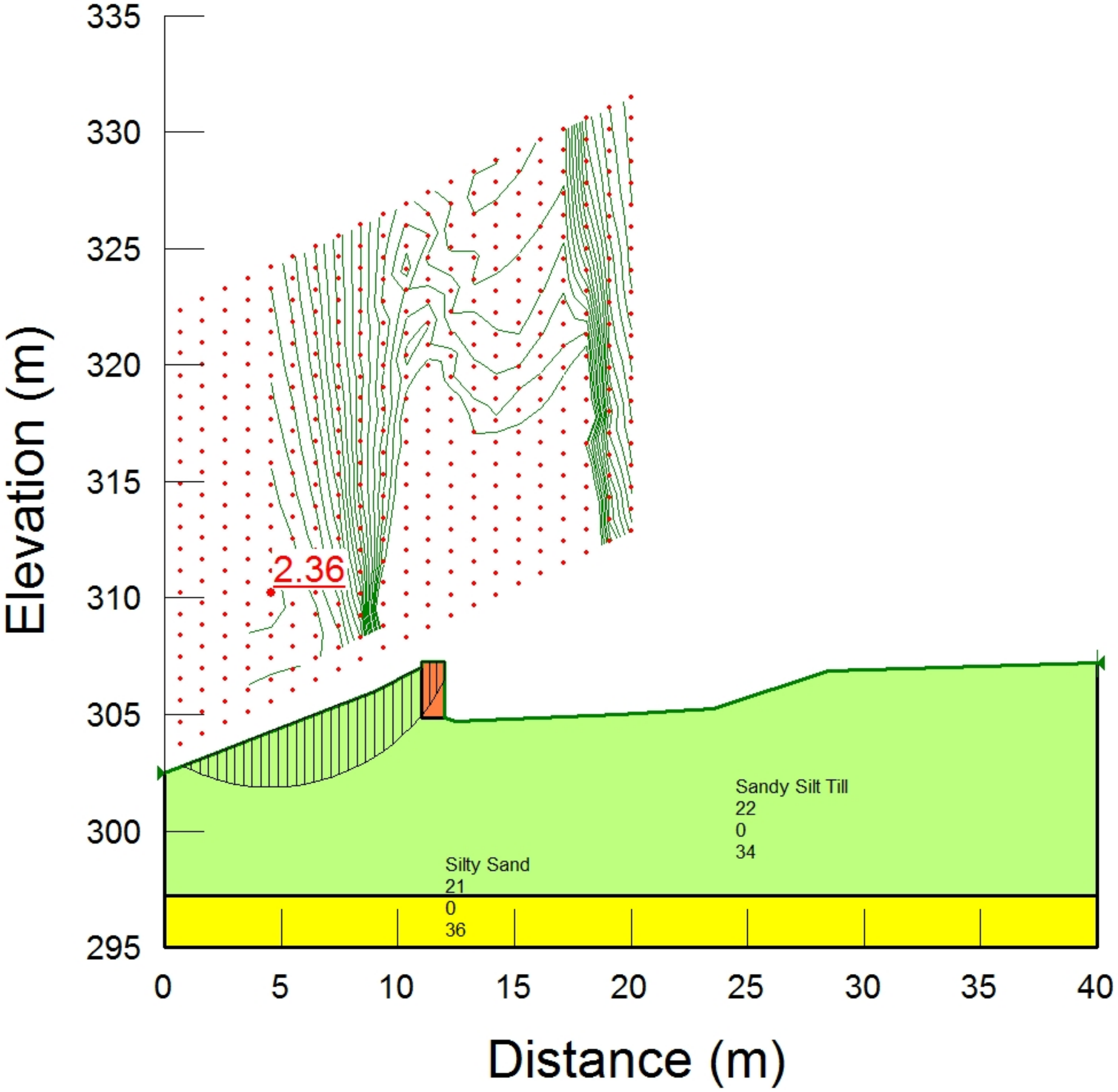


Figure 3
Section 9 After Construction (Static)

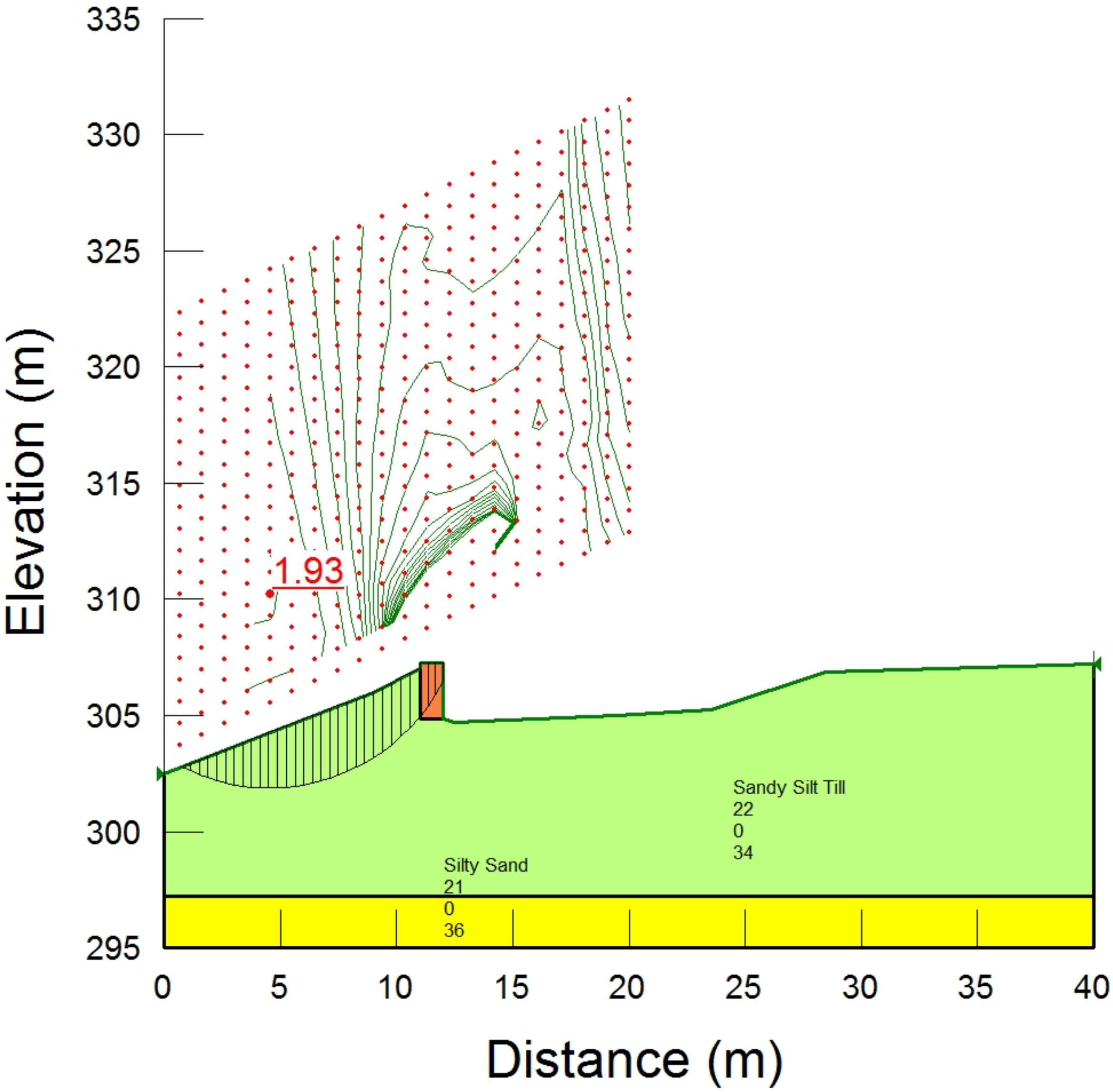


Figure 4
Section 9 After Construction (Seismic)

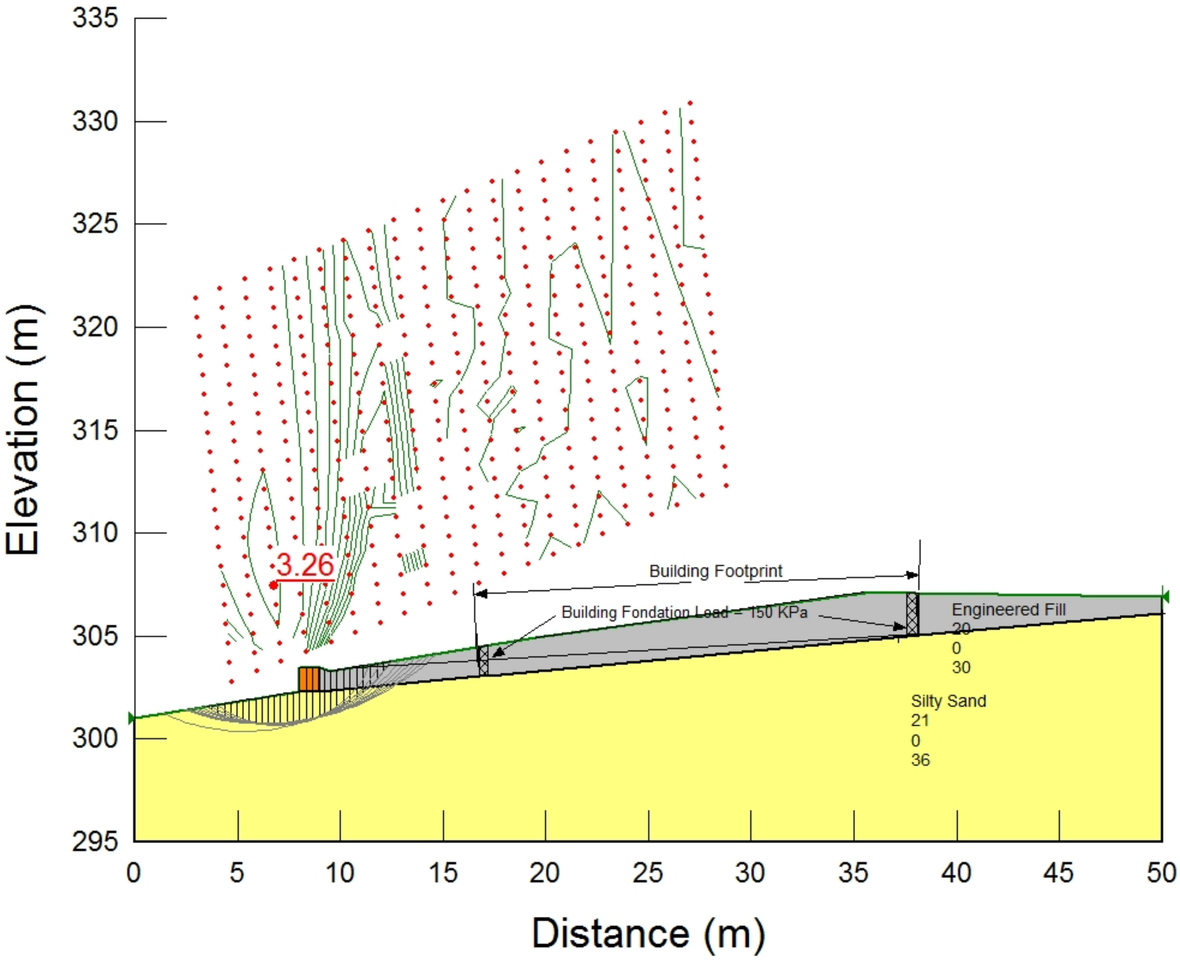


Figure 5
Section 10 After Construction Condition (Static)

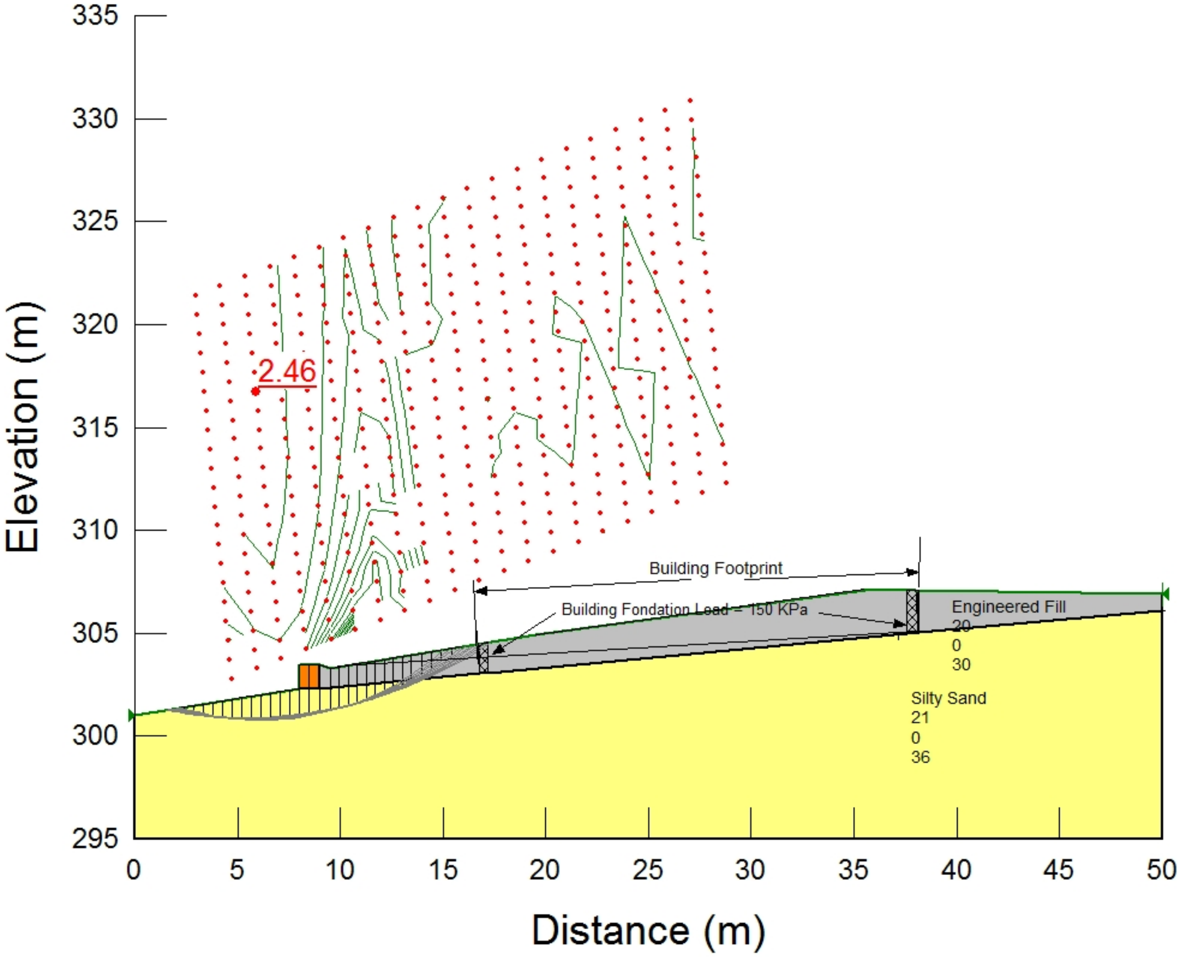


Figure 6
Section 10 After Construction Condition (Seismic)

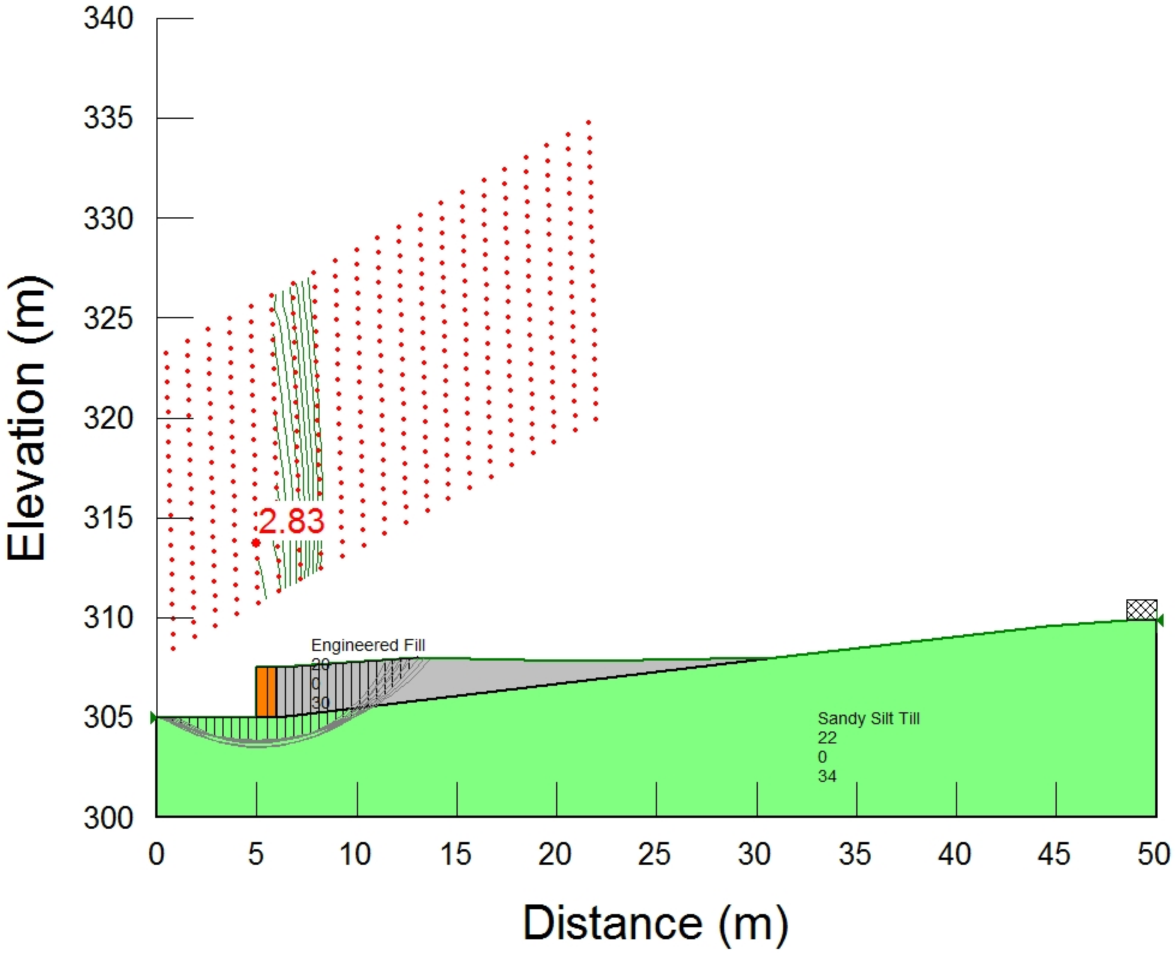


Figure 7
Section 12 After Construction (Static)

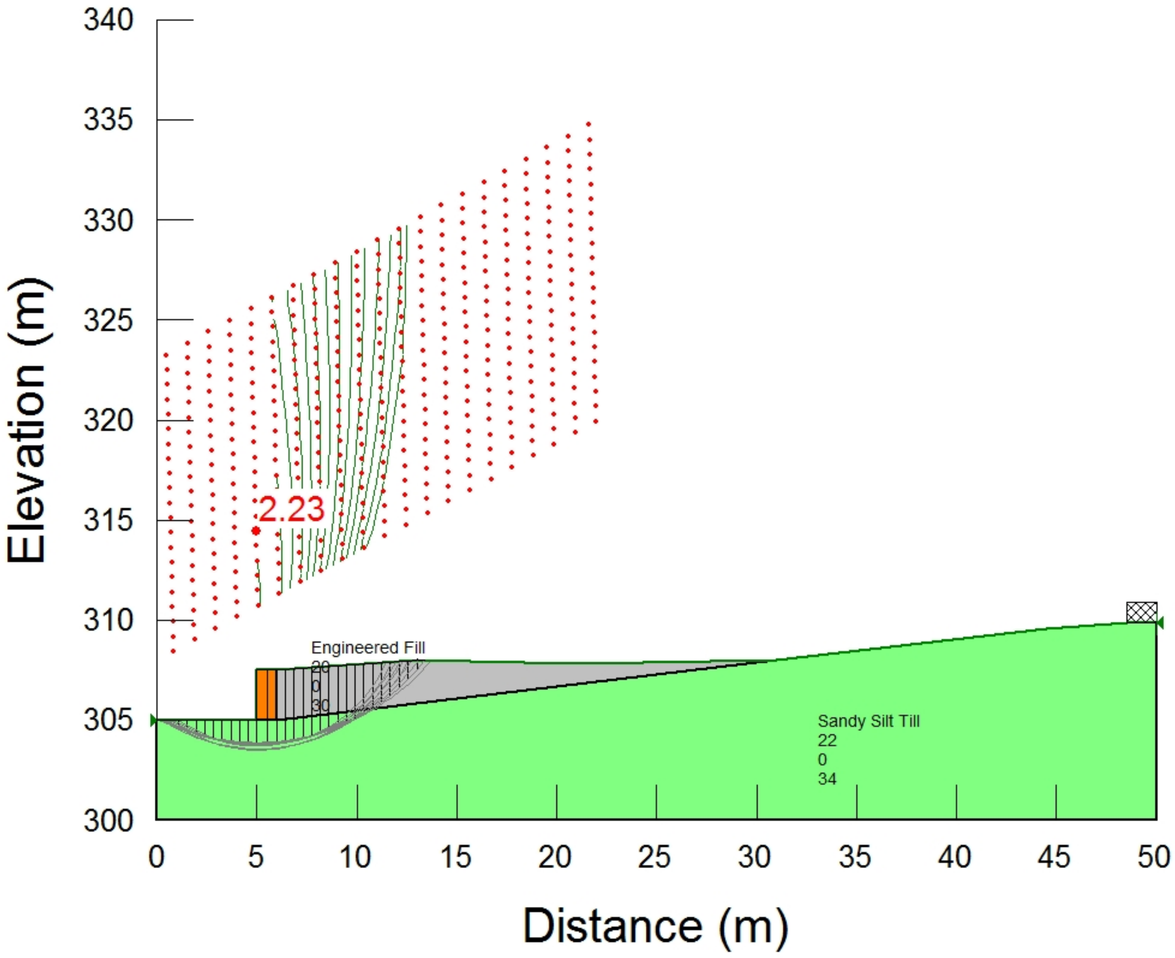


Figure 8
Section 12 After Construction (Seismic)

Appendix C:
Photographs

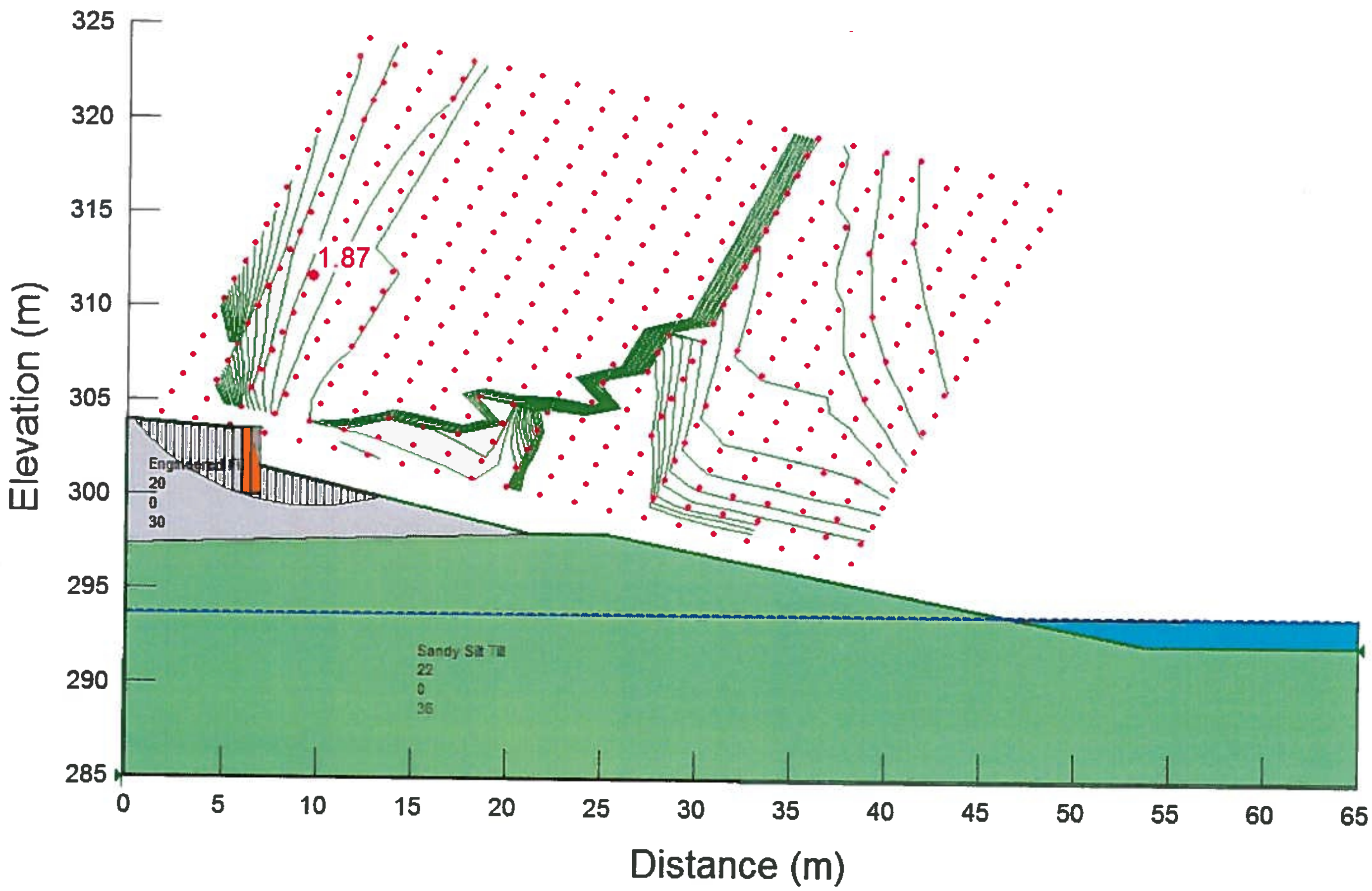
Photo 1. General View of Section Existing Slope

Photo 2. General View of Existing Slope

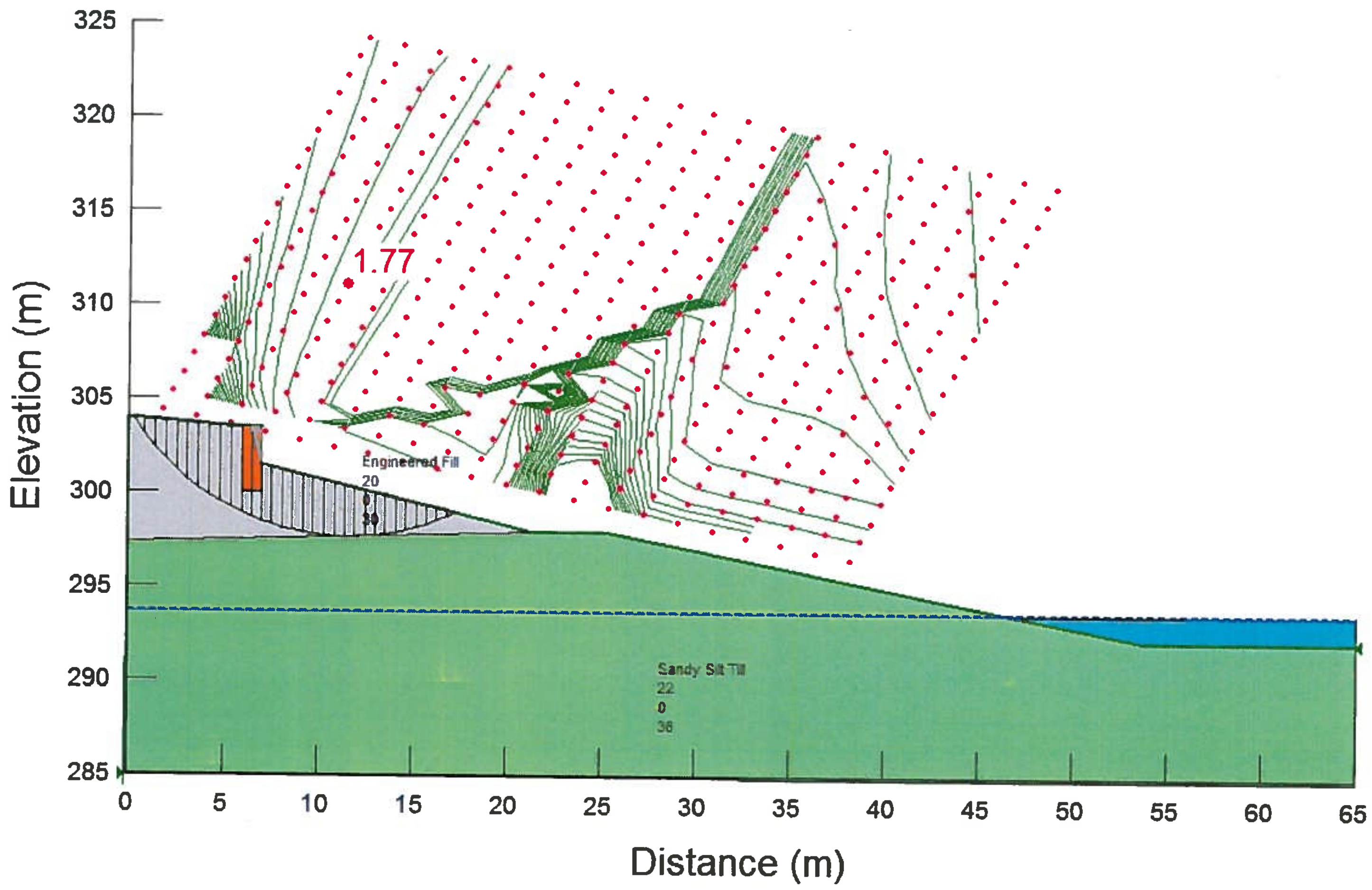
Photo 3. General View of Existing Southside Slope

Photo 4. General View of Existing Slope along the Valewood Drive

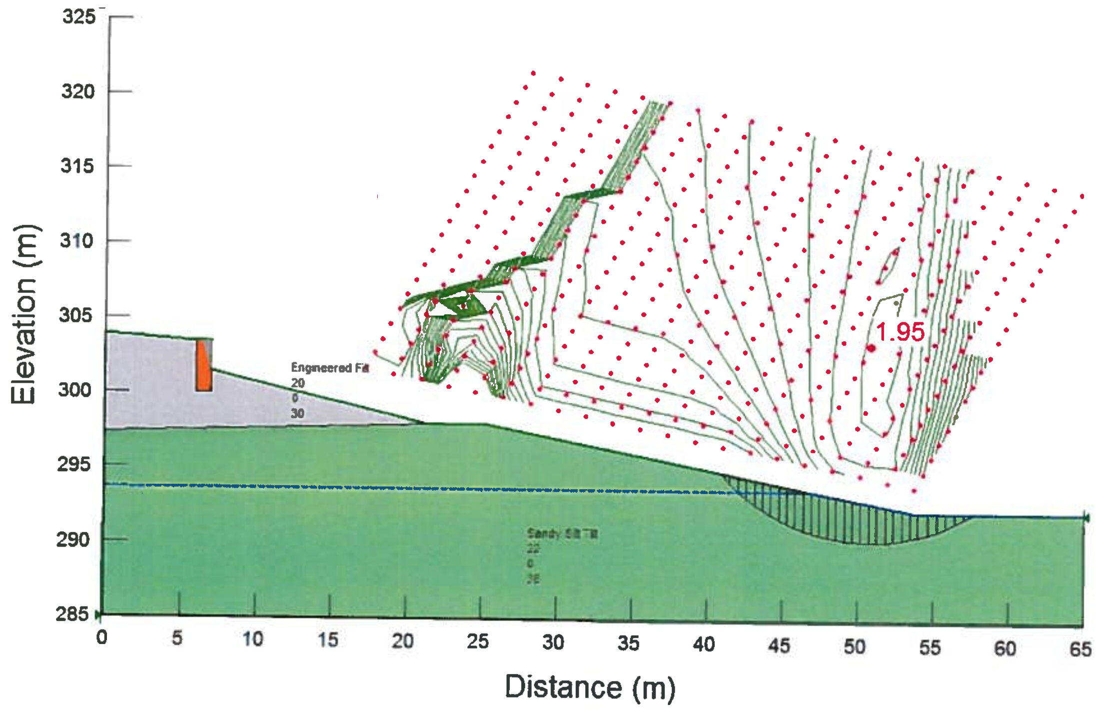
Appendix D:
SWMP Slope Stability Analysis Results



Project: Proposed Triple Crown Residential Subdivision, Town of Caledon, Ontario	
Analysis Description: SWMP (Section 2-2) – Static Condition	
Drawing No: D-1	*Company:* **exp** Services Inc.
Date: September 6, 2018	*File Name:* Slope Stability Analysis – Triple Crown



exp.	*Project:* Proposed Triple Crown Residential Subdivision, Town of Caledon, Ontario	
	Analysis Description: SWMP (Section 2-2) – Seismic Condition	
	Drawing No: D-2	*Company:* **exp** Services Inc.
	Date: : September 6, 2018	*File Name:* Slope Stability Analysis – Triple Crown



Project: Proposed Triple Crown Residential Subdivision, Town of Caledon, Ontario

Analysis Description: SWMP (Section 2-2) – Rapid Drawdown

Drawing No: D-3

Company: **exp** Services Inc.

Date: : September 6, 2018

File Name: Slope Stability Analysis – Triple Crown