REPORT ON
Geotechnical Investigation
Proposed Building
128 Lakeshore Road East
Mississauga, Ontario

PREPARED FOR:

Black Tusk Group Inc.

Project No: 21-090-100
Date: October 19, 2021

DS CONSULTANTS LTD.
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

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1. INTRODUCTION

DS Consultants Ltd. (DS) was retained by Black Tusk Group Inc. to carry out a geotechnical investigation for the proposed development located at 128 Lakeshore Road East in the City of Mississauga, Ontario.

It is understood that the proposed development will consist of eleven (11) storey building with three (3) levels of basement. The finished basement floor elevation of P3 is not known to us at the time of writing this report. It is assumed that P3 will be about 9m below ground surface.

The purpose of this geotechnical investigation was to determine the subsurface conditions at three (3) borehole locations and from the findings at the boreholes to make geotechnical recommendations for the following:

1. Foundations
2. Floor slabs and permanent drainage
3. Excavations and groundwater control
4. Earth pressures
5. Temporary Shoring
6. Earthquake considerations

This report deals with the geotechnical aspects of the site only. DS also carried out a hydrogeological investigation at the subject site and the findings are documented under separate covers.

This report is provided on the basis of the terms of reference presented above and, on the assumption, that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations can cater to the changed design.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Black Tusk Group Inc. and their architect and designers. Use of this report by third party without DS Consultants Ltd. consent is prohibited.

2. FIELD AND LABORATORY WORK

Three (3) boreholes (BH21-1 to BH21-3, see Drawing 1 for borehole locations) were drilled to depths ranging from 7.7 to 14.6 m below the existing grade.

Boreholes were drilled with solid stem continuous flight auger equipment by a drilling sub-contractor under the direction and supervision of DS personnel. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N and dropping 760 mm in accordance with the Standard Penetration Test (SPT) method. The samples were logged in the field and returned to the DS laboratory for detailed examination by the project engineer and for laboratory testing.

As well as visual examination in the laboratory, all the soil samples were tested for moisture contents and results are presented on the respective borehole logs. Selected soil sample were subjected to grain size analyses and results are presented on Drawing 5. Atterberg Limits tests were carried out on selected soil samples and results are presented on the respective borehole logs.

Shale bedrock was cored in BH21-1 with HQ-2 double tube wireline equipment providing 63mm dia. rock core sampler. The coring was carried out under the full-time supervision of a representative from DS who identified and described the rock samples, noting and recording the percentages of total and solid rock core recovery, RQD values, fracture index and the percentage and thicknesses of hard layers.

Water level observations were made during drilling and in the open boreholes at the completion of the drilling operations. Monitoring wells of 50mm dia. were installed in all boreholes to allow for groundwater level monitoring and hydrogeological testing.

3. SITE AND SUBSURFACE CONDITIONS

3.1 Soil and Bedrock Conditions

The borehole location plan is shown on Drawing 1. General notes on sample description are provided on Drawing 1A. The subsurface conditions in the boreholes are presented in the individual borehole logs presented on Drawings 2 to 4.

Asphalt/Fill Materials: Boreholes were drilled on the paved surface and encountered 50 to 100 mm of asphalt.

Fill material was found in all boreholes extending to a depth of 1.5m below ground surface. The fill material was consisted of silty sand, sandy silt and clayey silt. The fill was found to be in a loose state/very soft to firm consistency with measured SPT 'N' values ranging from 2 to 6 blows per 300 mm penetration. Traces of organics and brick pieces were also observed in fill material.

Clayey Silt: Below fill in BH21-1, cohesive deposit of clayey silt was encountered and extended to a depth of 2.3m below ground surface. This deposit was found to have a stiff consistency with measured SPT 'N' values of 14 blows per 300mm of penetration.

Clayey Silt Till: Cohesive deposits of clayey silt till were encountered in boreholes and extended to depths ranging from 7.6 to 8.2m below ground surface. These deposits were generally found to have a very stiff to hard consistency, with occasional stiff layers, with measured SPT 'N' values ranging from 14

to 47 blows per 300mm of penetration. Occasional cobble/boulders and sand seams were encountered within this deposit.

One selected soil sample from clayey silt till deposit (BH21-2/SS8) was subjected to grain size analysis and gradation curve is presented on Drawing 5 and summarized below:

Clay: 14%

Silt: 48%

Sand: 18%

Gravel: 20%

Atterberg Limits Tests of one clayey silt sample (BH21-2/SS8) was conducted. The result is shown on the borehole logs.

Clayey Silt Till/Shale Complex: This deposit was encountered in Borehole BH21-1 overlaying shale bedrock and found to have a hard consistency with measured SPT 'N' values of 36 blows per 300mm penetration. Occasional cobble and boulders should be expected in the till deposit. The clayey silt till/shale complex consists of clayey silt till mix with highly weathered shale and contains properties of hard till and shale bedrock.

One soil sample from clayey silt till/ shale complex deposit (BH21-1/SS8) was subjected to grain size analysis and gradation curve is presented on Drawing 5 and summarized below:

Clay: 15%

Silt: 49%

Sand: 20%

Gravel: 16%

Shale Bedrock: Shale bedrock belonging to Georgian Bay Formation was found at approximate depths varying from 7.6 to 9.1m below the existing surface, corresponding to elevations varying from 70.5 to 70.8m, as presented in Table 1 below.

Because of the method of drilling and sampling, the surface elevations of the bedrock can be different than indicated on the borehole logs. With augering, the auger may penetrate some of the highly weathered shale and the coring may therefore begin below the bedrock surface. Commonly the overburden overlying the shale contains slabs of limestone which would give a false indication of the bedrock level. Similarly, the depth of weathering cannot be determined accurately due to the presence of limestone layers.

Table 1: Depth and Elevation of Shale Bedrock Surface

Borehole No.	Depth of Shale Bedrock Surface below Existing Ground (m)	Approximate Elevation of Shale Bedrock Surface (m)	Notes
BH21-1	9.1	70.8	Bedrock was cored from 9.2 to 14.6m
BH21-2	8.2	70.8	Bedrock was augered
BH21-3	7.6	70.5	Bedrock was augered

Shale bedrock was cored in BH21-1. General comments on shale bedrock in Toronto area are presented in Appendix A. Photographs of recovered bedrock cores are presented in Appendix B.

Total Core Recovery (TCR): The total core recovery indicates the total length of rock core recovered, expressed as a percentage of the actual length of the core run. The total core recovery in the coreholes ranged from 95 to 100%. Generally, less core recovery was experienced only near the surface of the rock, where the formation is slightly weathered and was almost full as depth increased.

Solid Core Recovery (SCR): The solid core recovery is the total length of solid, full diameter rock core that was recovered, expressed as a percentage of the length of the core run. Solid core recovery ranged from 79 to 97%, and also appears to generally improve with depth. The SCR index was generally influenced by the orientations of the fractures. SCR was low when fractures oblique to the borehole axis were intercepted.

Rock Quality Designation (RQD): The rock quality designation index is obtained by measuring the total length of recovered rock core pieces which are longer than 100mm and expressing their sum total length as a percentage of the length of the core run. RQD is a function of the frequency of joints, bedding plane partings and fractures in the rock cores. While the use of double tube core barrels provided reasonably good protection of the core during drilling and core retrieval, the fissile nature of the shale greatly influences the RQD values of the rock cores. Consequently, it is believed that the RQD values recorded underestimate the rock quality classification of the laminated fissile shale. On the basis of the recorded RQD values which range from 62% to 96%, the rock quality is estimated to be “fair” to “excellent” quality.

Hard Layers: Based on the visual examination of the rock cores, an attempt was made to identify and record the thickness and percentages of the relatively harder siltstone and limestone layers. The percentage of the “hard layers” per core run ranges between 0 and 16%. The thickness of these layers varied but was generally between 60 to 150mm but generally less than 150mm, occasional layers of thickness more than 200 mm were also encountered in the coreholes. The thicker layers have been observed to be as much as 750 to 900 mm at other sites. The layers are actually lenses and they can vary significantly in thickness over short distance. Encountering such thick layers should be anticipated. It is also common to encounter closely spaced groupings of thin strong limestone/siltstone layers which individually may only be 25 to 50mm thick but collectively can be 1m in thickness.

Methane Gas: Methane gas is expected in the bedrock as indicated in Appendix A. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly for caissons.

3.2 Groundwater Conditions

Monitoring wells of 50mm dia. were installed in all boreholes for the long-term groundwater monitoring. Stabilized groundwater measured on September 1, 2021 and October 12, 2021 was found at depths ranging from 6.4 to 8.2m below the existing grade, corresponding to Elev. 71.4 to 71.7m, as listed on Table 2:

Table 2: Groundwater Levels Observed in Monitoring Wells

Monitoring Well No.	Ground Surface Elevation (m)	Date of Observation	Groundwater Table Depth (m)	Elevation of Groundwater Table (m)
BH21-1	79.7	September 1, 2021	5.2	74.4
		October 12, 2021	8.2	71.5
BH21-2	79.0	September 1, 2021	7.6	71.4
		October 12, 2021	7.6	71.4
BH21-3	78.1	September 1, 2021	6.5	71.6
		October 12, 2021	6.4	71.7

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events.

4. FOUNDATIONS

It is understood that the proposed development will consist of eleven (11) storey building with three (3) levels of basement. The finished basement floor elevation of P3 is not known at the time of writing this report. It is assumed that P3 will be about 9m below ground surface. Footings are expected to be 1m to 2m below the P3 basement slab and will be in shale bedrock.

Shale bedrock was found at approximate depths varying from 7.6 to 9.1m below the existing surface, corresponding to elevations varying from 70.5 to 70.8m.

Based on the information from boreholes, the proposed development with three (3) levels of basement can be supported by conventional spread and strip footings / mat foundations founded on weathered shale 0.3m into the bedrock from the top of bedrock for a bearing pressure of 2.5 MPa at SLS, and a factored geotechnical resistance of 5.0 MPa at ULS.

The proposed development with three (3) levels of basement can be supported by conventional spread and strip footings / mat foundations founded on sound shale, at minimum 1.2 m below the shale bedrock surface for a bearing pressure of 5.0 MPa at SLS, and a factored geotechnical resistance of 7.5 MPa at ULS.

Foundations designed to the specified bearing capacity at the serviceability limit states (SLS) are expected to settle less than 25 mm total and 19 mm differential.

Where it is necessary to place footings on bedrock at different levels, the upper footing must be founded below an imaginary 1 horizontal to 1 vertical line (1H:1V in bedrock) drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing.

The shale bedrock weathers rapidly between wetting and drying cycles. In view of this, it is suggested that a lean concrete mat slab be placed immediately after the excavation is complete to keep the shale intact, unless the footings are cast immediately after excavating.

It should be noted that the recommended bearing capacities have been calculated by DS Consultants Ltd. from the borehole information for the preliminary design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by DS Consultants Ltd. to validate the information for use during the construction stage.

5. FLOOR SLAB AND PERMANENT DRAINAGE

With three (3) levels of basement, the floor slab will be on bedrock and can be cast as slab-on-grade provided a 200 mm layer of clear crushed stone (19 mm maximum size) is placed between the underside of the floor slab and the exposed bedrock surface.

A perimeter and underfloor drainage system will be required around the exterior basement walls. Typical drainage and backfill recommendations are illustrated on Drawings 6 and 7 for shored excavation system.

6. FROST PROTECTION

All footings exposed to seasonal freezing conditions must have at least 1.2 metres of soil cover for frost protection.

There is no official rule governing the required founding depth for footings below unheated basement floors. Certainly, it will not be greater than the 1.2 m required in Southern Ontario for exterior footings. Un-monitored experience indicates that a shallower depth ranging from 0.82 to 0.9 m for interior column footings and 0.4 m for wall footings has been successful where 2 or more basement levels apply. The 0.82 m depth is believed to be close to the minimum structural requirement for interior column footings. Adjacent to air shafts and entrance and exit doors, a footing depth of 1.2 m below floor level is required or, alternatively, insulation protection must be provided.

It is also emphasized that underfloor drainage and/or an adequate free draining gravel base is required to minimize the risk of floor dampness. Floor dampness could lead to temporary icing and the risk of accidents.

7. EARTH AND ROCK PRESSURES

The design of basement walls can incorporate the conventional design in the overburden using the earth pressure coefficient K_1=0.40. In the rock, the earth pressure coefficient K can be reduced to K_2=0.20.

The lateral earth/rock pressure acting at any depth on basement walls can be calculated as follows:

In soil: $p = K_1 (\gamma_1 h_1 + q)$

In rock: $p = K_2 (\gamma_1 H_1 + q + \gamma_2 h_2)$

where p = lateral earth pressure in kPa acting at depth h_1 or h_2

K_1 = earth pressure coefficient K_1=0.4 for overburden soil

K_2 = earth pressure coefficient K_2=0.20 for rock

γ_1 = unit weight of overburden soil assuming 21 kN/m^3

γ_2 = unit weight of rock assuming 25 kN/m^3

h_1 = depth in overburden soil

H_1 = thickness of soil above rock

h_2 = depth in rock (depth below rock surface)

q = value of surcharge in kPa

The above expression assumes that the perimeter drainage system prevents the build-up of any hydrostatic pressure behind the wall. If water is not drained, then the wall should be designed for hydrostatic pressure. If the foundation wall is poured against the caisson wall, then the foundation wall as well as the caisson wall should be designed for hydrostatic pressure.

8. EXCAVATION AND GROUNDWATER CONTROL

Excavations in the overburden can be carried out with heavy hydraulic backhoe. Excavation of the shale can be carried out using heaviest available single tooth ripper equipment. The limestone beds are frequent and may overlie the shale bedrock surface at some locations. It may be necessary at some locations to utilize jackhammer type equipment to “open” the limestone layers for the ripper.

Based on the boreholes, no major problems with groundwater are anticipated for installation of the foundations. Some seepage from fill material and from the bedrock should be expected which can be controlled by conventional methods pumping from collection sumps and ditches.

DS is carrying out the hydrogeology study at the subject site. More comments regarding the type and extent of groundwater control required will be provided in the hydrogeology report, regarding groundwater control from overburden and bedrock.

It should be noted that the glacial till soils may contain boulders. Large obstructions in the fill material are anticipated. Provisions must be made in the excavation contract for the removal of boulders in the till and large obstructions in the fill material.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the fill material and stiff clayey soils can be classified as Type 3 soil above groundwater and Type 4 Soil below groundwater or in perched water. The very stiff to hard clayey soils can be classified as Type 2 Soil above the groundwater table and as Type 3 below the groundwater table.

The native soils free from topsoil and organics can be used as general construction backfill, provided its moisture content is within 2 percent of the optimum moisture content. Loose lifts of soil, which are to be compacted, should not exceed 200 mm. Depending on the time of construction and weather, some excavated material may be too wet to compact and will require aeration prior to its use.

Imported granular fill, which can be compacted with hand held equipment, should be used in confined areas. The excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

It should be noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should be compacted at the surface or be covered with tarpaulins to minimize moisture uptake.

9. TEMPORARY SHORING

The proposed excavation may be supported by a temporary shoring system consisting of timber lagging and soldier piles. A caisson wall may be required to support adjacent structures. The requirement for caisson walls to support adjacent structures is given on Drawing 8.

The shoring system must be designed in accordance with the 4th Edition of the Canadian Foundation Engineering Manual. The surcharge loading from adjacent structures must be considered. The soil parameters estimated to be applicable for this design are as follows:

1) Earth Pressure Coefficient for shoring:

   (a) where movement must be minimal K=0.45

(b) where minor movement (.002H) can be tolerated K=0.30

(c) passive earth pressure for soldier piles (unfactored) Kp=4.0 for hard soils and bedrock

2) For stability check

$\phi = 30°$

C = 0

$\gamma = 21\ kN/m^3$

surcharge is to be determined by shoring contractor.

3) For rock anchors

A bond stress of 600 kPa (90 psi) can be used in sound bedrock for the design of anchors.

The values depend on anchor installation methods and grouting procedures. Gravity poured concrete can result in low bond values while pressure grouted anchors will give higher values and produce a more satisfactory anchor.

Casing will be required during the construction of the tiebacks to prevent caving of soils. The soldier piles should be installed in pre-augered holes taken below the deepest excavation. The holes should be filled with concrete below the excavation level and half bag mix above the base of the excavation. The concrete strength must be specified by the shoring designer. Temporary liners may be required to help prevent caving during the installation period. Positive measures may be required to prevent the loss of soil through the spaces between the lagging boards. This could probably be achieved by placing well-graded sand and gravel behind the lagging boards or by installing a geotextile filter cloth.

Soil anchors will be required to support the shoring. The anchors must be of a length that meets the Canadian Foundation Manual recommendations. It is important to note that the minimum length lies beyond the 45 - $\phi/2$ + .15H line drawn from the base of the soldier pile and the overall stability of the system must be checked at each anchor level, where H is the shoring height.

The top anchor must not be placed lower than 3.0 meters below the top of level ground surface. Anchors will require casing when penetrating through wet sand and silt layers. The bond values 600 kPa in sound shale are suggested but these values are preliminary since the contractor's installation procedures will determine the actual soil to concrete bond value. Hence, the contractor must decide on a capacity and confirm its availability. All anchors must be tested as indicated in the Foundation Manual, 4th edition.

Adhesion on the buried caisson shaft or behind the shoring system must be neglected when designing this shoring system.

Movement of the shoring system is inevitable. Vertical movements will result from the vertical load on the soldier piles resulting from the inclined tiebacks and inward horizontal movement results from earth and water pressures. The magnitude of this movement can be controlled by sound construction practices, and it is anticipated that the horizontal movement will be in the range of 0.1 to 0.25%H.

To ensure that movements of the shoring are within an acceptable range, monitoring must be carried out. Vertical and horizontal targets on the soldier piles must be located and surveyed before excavation begins. Weekly readings during excavation should show that the movements will be within those predicted; if not, the monitoring results will enable directions to be given to improve the shoring.

10. EARTHQUAKE CONSIDERATIONS

Based on the existing borehole information and according to Table 4.1.8.4.A of OBC 2012, the subject site for the proposed building with three (3) levels of basement (to be founded in sound shale bedrock) can be classified as "Class B" for seismic site response, provided field seismic shear wave velocity measurement is to be carried out at the site to confirm "Class B" classification.

11. GENERAL COMMENTS AND LIMITATIONS OF REPORT

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

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to DS at the time of preparation. Unless otherwise agreed in writing by DS, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to

determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. DS accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

DS CONSULTANTS LIMITED

LICENSED PROFESSIONAL ENGINEER
N. EHSAN
100169975
PROVINCE OF ONTARIO

Naeem Ehsan, M.Eng., P.Eng.

LICENSED PROFESSIONAL ENGINEER
S.S. BANDUKWALA
2219113

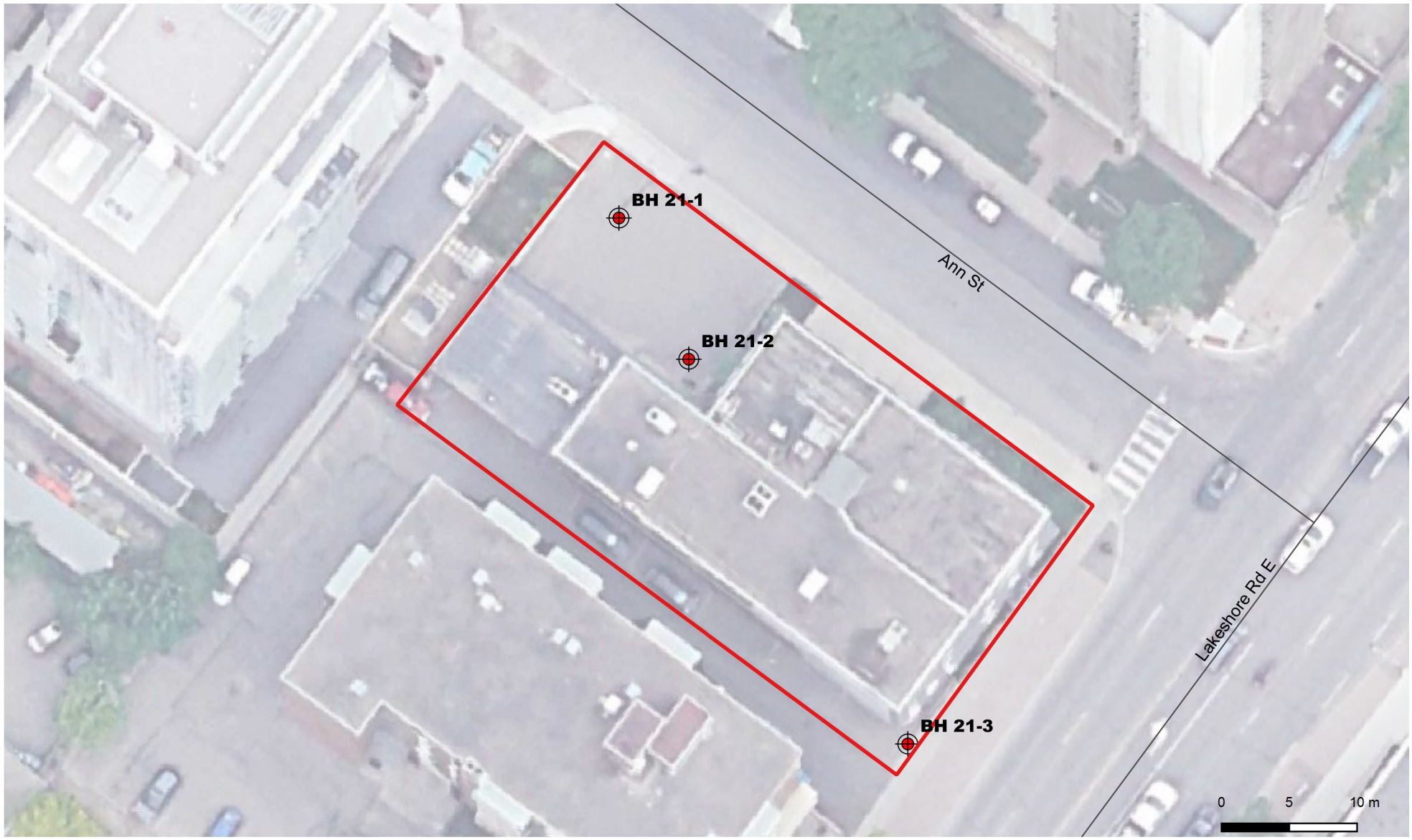
Shabbir Bandukwala, M.Eng., P.Eng.

LICENSED PROFESSIONAL ENGINEER
F. ZHU
PROVINCE OF ONTARIO

Fanyu Zhu, PhD., P.Eng.

Drawings

C:\0Sharon\21-090-100 128 Lakeshore Rd E\1-QGIS\Geo\Drawing 1 – Borehole and Monitoring Well Locations.qgs Sep-24 09:18



Legend

- Approx Property Boundary
- Monitoring Well

DS CONSULTANTS LTD.
6221 Highway 7, UNIT 16
Vaughan, Ontario L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project: GEOTECHNICAL INVESTIGATION
128 Lakeshore Road East, Misssissauga, ON

Title: **BOREHOLE AND MONITORING WELL LOCATIONS**

N

Client: BLACK TUSK GROUP

Size: 8.5 x 11	Approved By: N.E	Drawn By: S.Y	Date: September 2021
Rev: 0	Scale: As Shown	Project No.: 21-090-100	Drawing No.: 1
	Image/Map Source: *Google Satellite Image*		

Drawing 1A: Notes On Sample Descriptions

1. All sample descriptions included in this report generally follow the Unified Soil Classification. Laboratory grain size analyses provided by DSCL also follow the same system. Different classification systems may be used by others, such as the system by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). Please note that, with the exception of those samples where a grain size analysis and/or Atterberg Limits testing have 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.

ISSMFE SOIL CLASSIFICATION

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

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

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

UNIFIED SOIL CLASSIFICATION

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 preliminary 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.

DS CONSULTANTS LTD.
Geotechnical ◆ Environmental ◆ Materials ◆ Hydrogeology

LOG OF BOREHOLE BH21-1

PROJECT: Geotechnical Investigation - 128 Lakeshore Road East
CLIENT: BlackTusk Group Inc.
PROJECT LOCATION: 128 Lakeshore E, Mississauga, ON
DATUM: Geodetic
BH LOCATION: See Drawing 1 N 4823422.96 E 614461.17

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Aug-19-2021

REF. NO.: 21-090-100
ENCL NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.7 / 0.0	**ASPHALT:** 100mm					
79.6 / 0.1	**FILL:** sandy silt, trace gravel, brown, moist, loose	1	SS	5		
78.9 / 0.8	**FILL:** clayey silt, trace sand, brown, moist, firm	2	SS	4		
78.2 / 1.5	**CLAYEY SILT:** trace sand, silt seams, brown, moist, stiff	3	SS	13		
77.4 / 2.3	**CLAYEY SILT TILL:** sandy, some gravel, occasional cobble, brown, moist, very stiff to hard grey below 3.1m	4	SS	24		
		5	SS	29		
		6	SS	39		
		7	SS	22		
72.1 / 7.6	**CLAYEY SILT TILL/SHALE COMPLEX:** sandy, some gravel, grey, moist, hard	8	SS	35		16 20 49 15
70.6 / 9.1	**SHALE BEDROCK:** Gerogian Bay formation, grey, weathered	9	SS	54/ 25mm		
		R1	RC			
		R2	RC			
		R3	RC			
		R4	RC			
65.1 / 14.6	**END OF BOREHOLE:**					

Notes:
1) Augar refusal at 9.1m.
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings:

Date:	Water Level(mbgl):
Sept. 01, 2021	5.27
Oct. 12, 2021	8.22

GROUND WATER CONDITIONS: W. L. 71.5 m, Oct 12, 2021

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE & Sensitivity, × LAB VANE (20 40 60 80 100)
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF ROCK CORE BH21-1

PROJECT: Geotechnical Investigation - 128 Lakeshore Roadd, East
CLIENT: Black Tusk Group Inc.
LOCATION: 128 Lakeshore Road E, Mississauga, ON
DATUM: Geodetic
BH LOCATION: See Drawing 1 N 4823422.96 E 614461.17

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Aug-19-2021

REF. NO.: 21-090-100
ENCL NO.: 2A

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE NUMBER	CORE SAMPLE SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	WEATHERING INDEX	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cm³) E (GPa)
70.5	Rock Surface															
70.2	**GEORGIAN BAY FORMATION:** laminated to thinly bedded, dark grey to grey, very weak to medium strong, SHALE and LIMY SHALE (84 to 100%), interbedded with thinly laminated to medium bedded with slightly weathered to fresh, light grey, strong to very strong SILTSTONE and LIMESTONE (0 to 16%). Siltstone and limestone (hard) layers at the following depths: Depth(m) Thickness(mm) 14.4 40		1	HQ	95	79	0	62								
69.3			2	HQ	100	91	0	87								
67.7			3	HQ	99	96	0	96								
66.2			4	HQ	90	97	16	77								
65.1																
14.6	**END OF BOREHOLE:** Notes: 1) 50mm dia. monitoring well installed upon completion. 2) Water Level Readings: Date: Water Level(mbgl): Sept. 01, 2021 5.27 Oct. 12, 2021 8.22															

Weathering Index: W1-Fresh, W2-Slightly weathered, W3-Moderately weathered, W4-Highly weathered, W5-Completely weathered

θ = angle to the core axis

E = Modulus of Elasticity
*: UCS [Mpa] ≈ 24 $I_{S(50)}$

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LOG OF BOREHOLE BH21-2

PROJECT: Geotechnical Investigation - 128 Lakeshore Road East
CLIENT: BlackTusk Group Inc.
PROJECT LOCATION: 128 Lakeshore E, Mississauga, ON
DATUM: Geodetic
BH LOCATION: See Drawing 1 N 4823412.55 E 614466.31

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Aug-19-2021

REF. NO.: 21-090-100
ENCL NO.: 3

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.0 / 0.0	**ASPHALT:** 80mm					
78.9 / 0.1	**FILL:** sandy silt, trace organics, brown, moist, loose	1	SS	6		
78.2 / 0.8	**FILL:** clayey silt, trace sand, silt seams, brown, moist, firm	2	SS	4	78	
77.5 / 1.5	**CLAYEY SILT TILL:** some sand, some gravel, occasional cobble, brown, moist, very stiff to hard	3	SS	22	77	
	grey below 2.3m	4	SS	25		
		5	SS	40	76	
		6	SS	41	75	
		7	SS	25	74	
	shale fragments below 7.6m	8	SS	38	73	W. L. 71.4 m Oct 12, 2021 — 20 18 48 14
70.8 / 8.2	**SHALE BEDROCK:** Georgian Bay formation, grey, weathered	9	SS	50/ 150mm	72	
					70	
68.2 / 10.8	**END OF BOREHOLE:**	10	SS	50/ 25mm	69	

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings:

Date:	Water Level(mbgl):
Sept. 01, 2021	7.59
Oct. 01, 2021	7.62

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

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LOG OF BOREHOLE BH21-3

PROJECT: Geotechnical Investigation - 128 Lakeshore Road East
CLIENT: BlackTusk Group Inc.
PROJECT LOCATION: 128 Lakeshore E, Mississauga, ON
DATUM: Geodetic
BH LOCATION: See Drawing 1 N 4823383.99 E 614483.32

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Aug-19-2021

REF. NO.: 21-090-100
ENCL NO.: 4

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
78.1 / 0.0	**ASPHALT:** 50mm	1	SS	4	78
77.3	**FILL:** silty sand, trace brick pieces, brown, moist, loose				
0.8	**FILL:** silty clay, trace sand, brown to grey, moist, very soft	2	SS	2	77
76.6 / 1.5	**CLAYEY SILT TILL:** sandy, trace gravel, brown, moist, stiff to hard	3	SS	14	
		4	SS	47	76
	grey below 3.1m	5	SS	35	75
		6	SS	53	74
	shale fragments at 6.1m	7	SS	57	73
					72
70.5					71
70.4 / 7.7	**SHALE BEDROCK:** Georgian Bay formation, grey, weathered	8	SS		

W. L. 71.7 m
Oct 12, 2021

END OF BOREHOLE:
Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings:

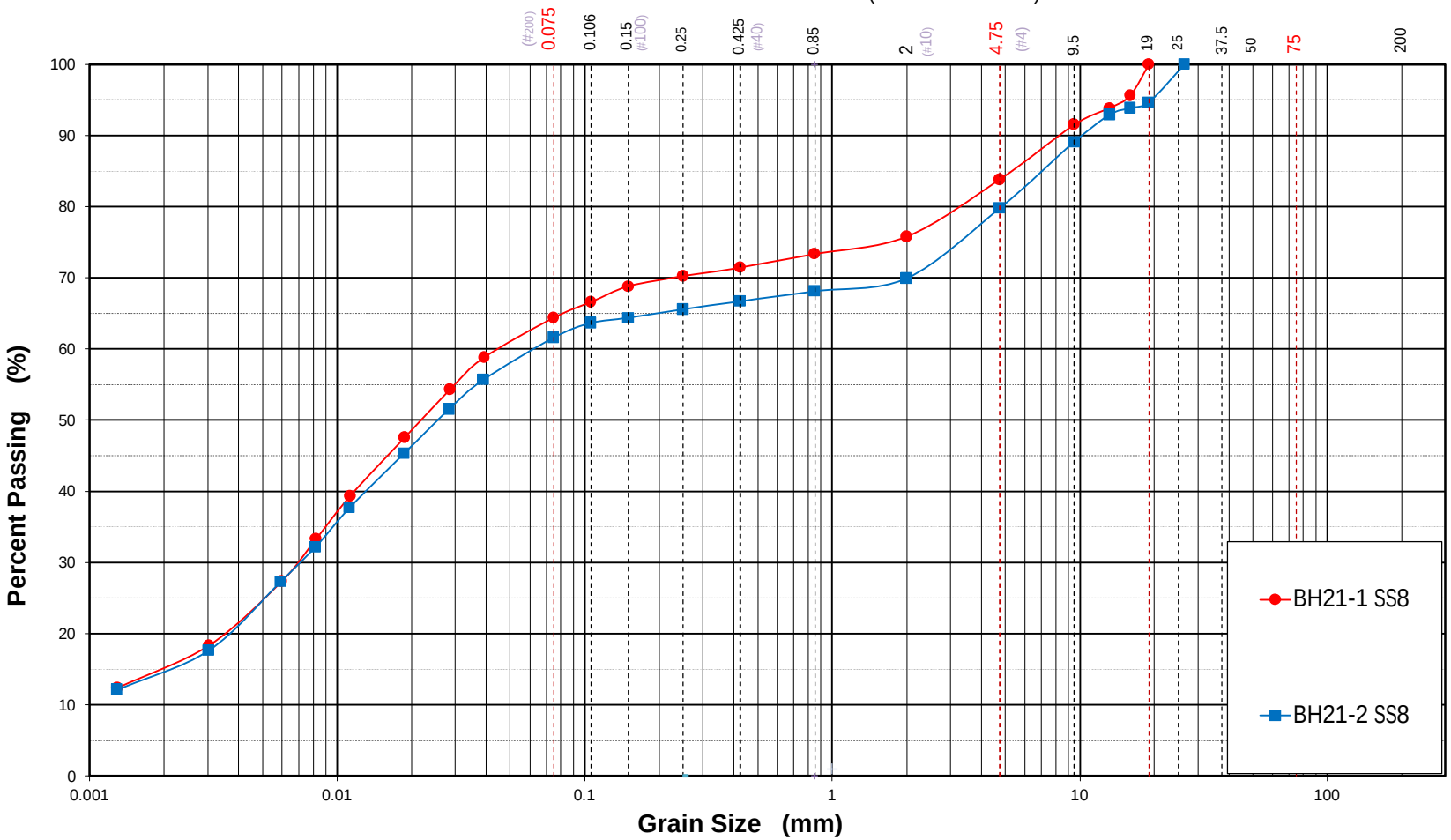
Date:	Water Level(mbgl):
Sept. 01, 2021	6.51
Oct. 12, 2021	6.46

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)
REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Particle Size Distribution (ASTM-D421/D422)



Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	

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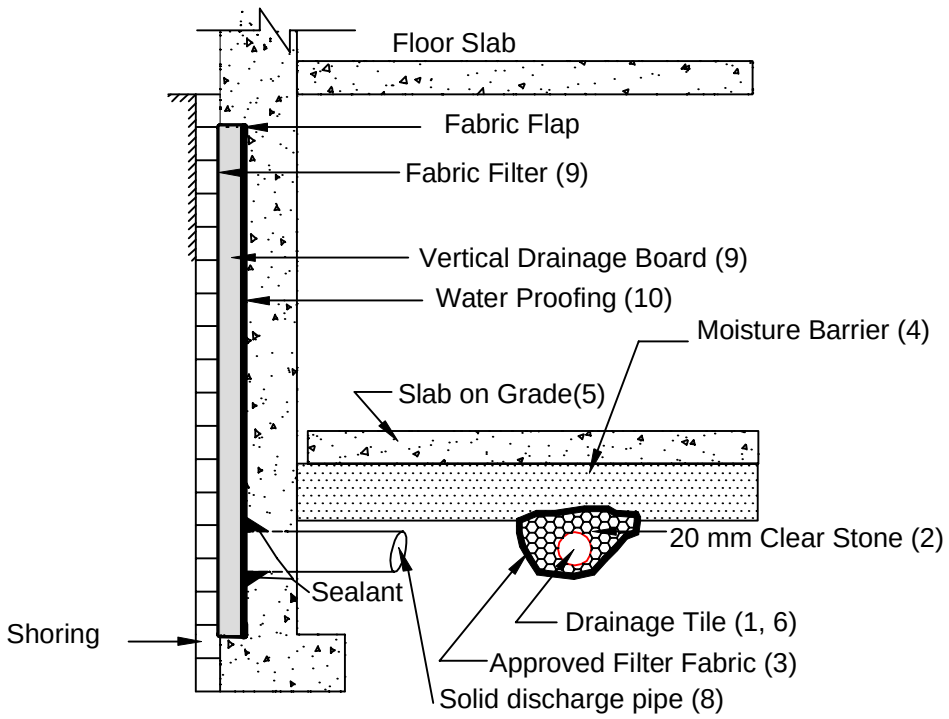
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project	128 Lakeshore Road East	Project No	21-090-100
Location	128 Lakeshore Road East, Mississauga, ON	Date	Sep-01-2021
Client	Black Tusk Group Inc.	Dwg. No	5

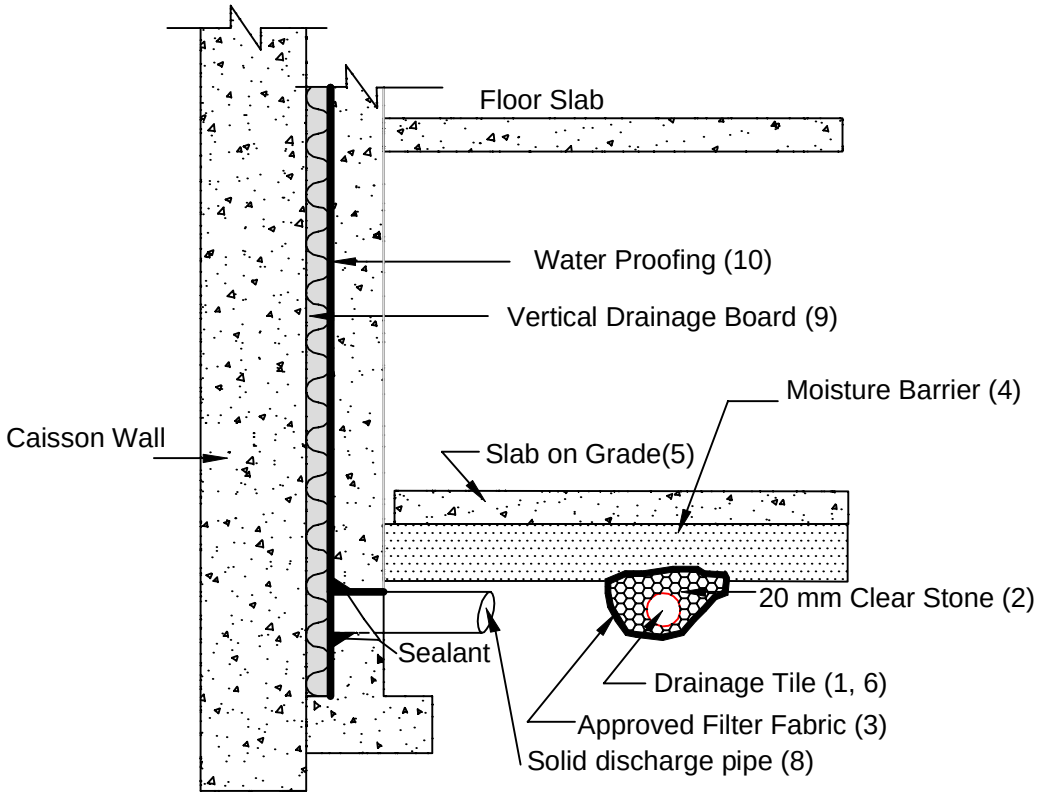


EXTERIOR FOOTING

Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet, spaced between columns.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place100 mm (4 inches) of stone below drain .
3. Wrap the clear stone with an approved filter membrane (Terrafix 270R or equivalent).
4. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
5. Slab on grade should not be structurally connected to the wall or footing.
6. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab. Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
7. Do not connect the underfloor drains to perimeter drains.
8. Solid discharge pipe located at the middle of each bay between the solider piles, approximate spacing 2.5 m, outletting into a solid pipe leading to a sump.
9. Vertical drainage board with filter cloth should be kept a minium of 1.2 m below exterior finished grade.
10. The basement walls should be water proofed using bentonite or equivalent water-proofing system.
11. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE RECOMMENDATIONS
Shored Basement wall with Underfloor Drainage System
(not to scale)



EXTERIOR FOOTING

Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet, spaced between columns.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place100 mm (4 inches) of stone below drain .
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5. Slab on grade should not be structurally connected to the wall or footing.
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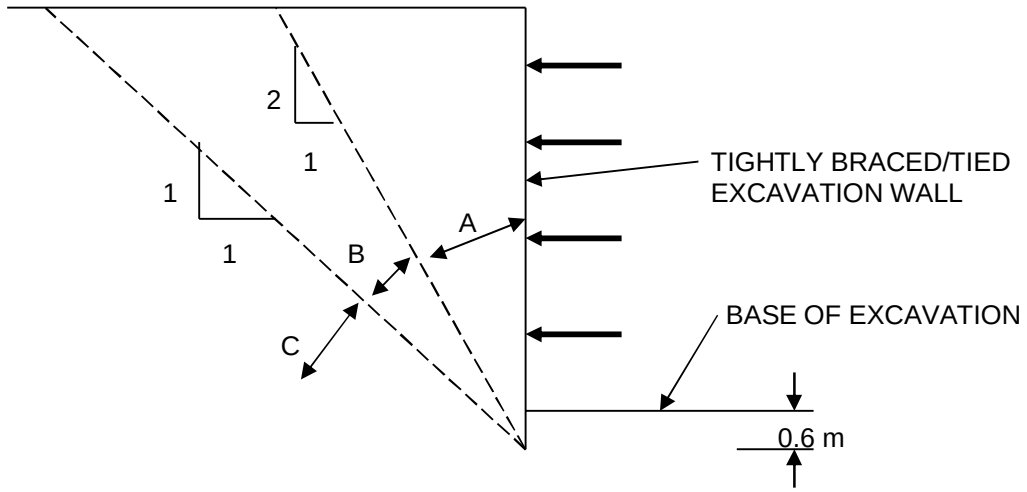
7. Do not connect the underfloor drains to perimeter drains.
8. Solid discharge pipe located at the middle of each bay between the solider piles, approximate spacing 2.5 m, outletting into a solid pipe leading to a sump.
9. Vertical drainage board mira-drain 6000 or eqivalent with filter cloth should be continous from bottom to 1.2 m below exterior finished grade.
10. The basement walls must be water proofed using bentonite or equivalent water-proofing system.
11. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE RECOMMENDATIONS
Shored Basement wall with Underfloor Drainage System
(not to scale)

Guidelines for Underpinning in Soil and Excavation Support

Existing foundations located within Zone A normally require underpinning, especially for heavy structures. For some foundations in Zone A, it may be possible to eliminate underpinning and control foundation movement by tightly braced excavation walls, such as caisson walls.



Zone A Foundations located within this zone normally require underpinning. Horizontal and vertical pressures on the excavation wall of non underpinned foundations must be considered

Zone B Foundations located within this zone normally do not require underpinning. Horizontal and vertical pressures on the excavation wall of non underpinned foundations must be considered

Zone C Underpinning to structures is normally founded in this zone. Lateral pressure from underpinning is not normally considered

(Reference: Figure 26.27 from Canadian Foundation Engineering Manual, 4th Edition)

Appendix A
General Comments - Bedrock in Greater Toronto Area

General Comments – Bedrock in Greater Toronto Area

The bedrock that makes spread footings or caissons a popular choice for high-rise foundation support is a shale or shale limestone composition. The highest member, the Queenston Formation, is generally found west of Toronto, while the Georgian Bay Formation underlies most of Metro Toronto, with the Collingwood and Whitby Formations east of Toronto. The Queenston is, relatively speaking, the weaker of the four formations that are likely to support caissons or footings.

The Georgian Bay as well as the Queenston and Collingwood/Whitby Formation are of Middle Ordovician Age. It is defined as the rock unit that overlies the bluish grey shales of the Collingwood Formation and is in turn overlain by the red shale of the Queenston Formation. The Georgian Bay Formation consists of bluish and grey shale with interbeds of sandstone, limestone and dolostone. Towards the west where the Georgian Bay formation underlies the Queenston Formation, the limestone content increases significantly and limestone and/or sandstone may comprise as much as 70 to 90 percent of the bedrock. The hard layers are usually less than about 100 to 150 mm thick but some layers are much thicker. The thicker layers have been observed to be as much as 750 to 900 mm at some sites. The layers are actually lenses and they can vary significantly in thickness over short distances.

The upper portion of the bedrock is commonly weathered for a depth of 600 to 1000 mm and within this weathered zone hard limestone layers or lenses are common. These hard limestone layers can result in contractual problems for augers, and can provide misleading bedrock elevations. Where the weathering is more extensive a shale till layer may be found above the bedrock. In the sound bedrock, the limestone, sandstone, dolostone is hard to very hard.

Stress relief features such as folds and faults are common in the bedrock. In these features, the rock is heavily fractured and sheared, and contains layers of shale rubble and clay. Weathering is much deeper than the surrounding rock in these features and often there is a lateral migration of the stress relief features resulting in sound unweathered bedrock overlying fractured and weather bedrock. The stress relief features are usually in the order of 4 to 6 m wide, but the depth can vary from 4 to 5 m to in excess of 10 m. These features occur randomly.

The bedrock contains significant high locked in horizontal stresses. These stresses can impose significant loads on tunnel walls but the slower rate of construction for basements allows for a relaxation of these stresses and they are not normally a problem for basement construction.

Groundwater seepage below the top 1000 mm is generally small, however, at several locations in Toronto and Mississauga large quantities have been encountered.

Bedding joints in the bedrock are very close-to-close, smooth planar in the shale and rough planar in the limestone. Significant vertical jointing is common.

Where the bedrock was cored, a detailed description of the rock core is appended to the borehole log.

Design features related to the bedrock are discussed in other sections of this report, and these general comments must be considered with these comments.

Methane gas exists in the bedrock, normally below the top 1000 mm and more concentrated with depth. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly caissons and tunnels.

Appendix B
Photographs of Bedrock Cores

21-090-100

BH-21-1

R1: ~30’ 3” ~34’ 3”
R2: ~34’ 3” ~ 39’1”
R3: ~ 39’1” ~ 44’ 2”
R4: 44’2” ~ 47’10”