UPDATED SLOPE STABILITY ASSESSMENT

Proposed Development
1260 & 1280 Dundas Street West, Oakville, ON

Client
Delmanor West Oak Inc.
4800 Dufferin Street
Toronto, ON, M3H 5S9

Project Number
BIGC-GEO-185E

Prepared By:
B.I.G. Consulting Inc.
12-5500 Tomken Road
Mississauga, ON, L4W 2Z4
T: 416.214.4880
www.bigconsultinginc.com

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1. Introduction

Delmanor West Oak Inc. (the "Client") has retained B.I.G. Consulting Inc. (BIG) to provide updated geotechnical, hydrogeological, infiltration rate and slope stability assessments to support a submission for Zoning By-Law Amendment application to the Town of Oakville for a site located at 1260 and 1280 Dundas Street West, Oakville, Ontario (hereinafter referred to as the "Site").

BIG previously completed a preliminary Geotechnical Investigation at the Site, dated December 4, 2019, a Slope Stability Assessment, dated December 5, 2019, and a Hydrogeological Investigation, dated December 13, 2019, which consists of analysis of the pond and central draw and estimation of construction and long-term dewatering rates based on the assumption of a mid-rise retirement residence(s) with potential one (1) level of basement. No building plan was available at the time of the previous studies.

Based on the drawings prepared by Icke Brochu for Delmanor West Oak Inspired Retirement Living, dated September 10, 2021 (Revision No. 2 dated March 2, 2022), at 1280 Dundas Street West, Oakville, Ontario, BIG understands that the Site will be developed to include a 8-storey seniors building with one (1) level underground structure (basement) and four (4) blocks of Independent Living Units (ILU). The proposed scope of development is shown on the Site Plan as Figure 1A.

With reference to the Draft Comments Report (Development Application Comments – 1st Submission) issued by the Town of Oakville dated June 21, 2021, Conservation Halton (CH) provided comments pertaining to the Slope Stability Assessment (December 5, 2019) prepared by BIG. In view of this, the purpose of this report is to update the previous assessment by incorporating and addressing the comments presented by CH in order to inform the extent of developable area for the proposed development.

As indicated above, BIG's mandate also includes updated geotechnical, hydrogeological and infiltration rate assessments. The findings of those assessments are issued under separate cover.

This report is provided on the basis of the project scope presented above. The report has been prepared for Delmanor West Oak Inc. Third party use of this report without BIG consent is prohibited.

2. Comments of Conservation Halton (CH) and Scope of Work

Based on the Town of Oakville's Draft Comments Report (Development Application Comments – 1st Submission) dated June 21, 2021, CH's comments are summarized below:

1. The 15 metre CH Regulatory Allowance from the Long-Term Stable Top of Slope (LTSTS) is required to be shown on all drawings. All proposed works on site must also be outside this area.
2. A geomorphic analysis is requested for the west valley system. The analysis will provide supporting documentation for the slope stability analysis and the Functional Servicing Report.
3. A revised slope stability analysis is requested. The analysis must include and/or consider the following components:
    a) A stable slope analysis is required for the valley sections as shown on Figure 1 included in Appendix A.
    b) The stable slope analysis must include the MNRF Table 8.1 – Slope Stability Rating Chart for each valley section (i.e. Sixteen Mile Creek valley, and west valley system).
    c) The submitted analysis includes a slip failure analysis for the over burden only. Sixteen Mile Creek is a highly active eroding system with slope failures from the toe to the crest. The analysis must consider the 100-year stable slope line based on the accepted angle of repose for each subsurface soil type. It is noted that CH accepts a minimum stable slope inclination for shale bedrock of 1.4H: 1V.
    d) Drawings showing the existing slope profile and the long-term stable slope based on the accepted angle of repose must be included.
    e) The west valley stable slope analysis must include a toe erosion setback. Further setbacks may be required based on a geomorphic analysis.
    f) A 15 m setback is required from the Long-Term Stable Top of Slope for Sixteen Mile Creek and its tributaries.

In accordance with the above noted comments, the current scope of work is as follows:

A detailed slope reconnaissance to determine any erosion issues or signs of visible slope instability. In addition, since CH also requested a geomorphic study of the west bank, GEO Morphix Ltd., a specialized consultant is retained by BIG to fulfill this requirement and to provide additional input pertaining to toe erosion allowance.

For the purpose of this updated slope stability assessment and as suggested by CH, three (3) additional deep Boreholes are drilled to a depth of approximately 20 m below ground surface (bgs). Given the relatively shallow depths of bedrock at the Site, rock coring is conducted in these 3 boreholes to determine the quality of the encountered bedrock and to provide comments related to a potential for deep seated slope failure within the bedrock formation. A monitoring well is installed in each advanced borehole.

Based on the information/soil parameters derived from the boreholes, a slope stability analysis of the existing slope including the locations requested by CH is carried out using Slope/W, the leading slope stability software established by Geoslope. Subsequently, an updated Slope Stability Assessment is provided in accordance with CH's requirements and provided comments.

3. Field Investigation Procedures

3.1 Slope Reconnaissance (Slope Stability Rating Chart) and Geomorphic Study

BIG understands that the Client is looking to determine the extent of buildable space on the subject property. The limiting factors are Sixteen Mile Creek valley and west valley system, from a slope stability standpoint. Halton Region personnel has staked the top of slope and the object of this study was to determine the safe top of slope/stable top of slope. On that basis, the Client will assess if these portions of the site have adequate buildable space for the proposed development subject to further development setback requirements by Conservation Halton (CH).

A site visit was conducted by representatives of BIG on August 26, 2021 to assess current site conditions including the Sixteen Mile Creek valley and west valley system. The slope reconnaissance survey involved reviewing and visual examination of the relevant site features in accordance with MNRF Table 8.1 – Slope Stability Rating Chart for each valley section (i.e. Sixteen Mile Creek valley, and west valley system).

Concurrent with our slope reconnaissance, BIG retained the services of GEO Morphix Ltd. to conduct a geomorphic study at the Site on August 26, 2021. The findings of the geomorphic study are summarized in Section 5 of this report. A copy of the report prepared by GEO Morphix Ltd. is included in Appendix A.

3.2 Drilling Program

3.2.1 Boreholes and Monitoring Wells (2018)

For the purpose of this slope stability assessment, seven (7) boreholes (BH1, BH/MW2 to BH/MW4, BH5, BH/MW6 and BH/MW7) were advanced to depths ranging from 6.2 to 12.6 m below ground surface (bgs) during the period between May 22 and 24, 2018. BH1, BH3 and BH6 were drilled and sampled to the bedrock surface. BH/MW2, BH/MW3 and BH/MW6 were drilled and sampled to the bedrock surface, i.e., depth of 7.4, 6.3 and 7.6 m bgs, respectively and then cored. BH/MW2, BH/MW3, BH/MW4, BH/MW6 and BH/MW7 had piezometers installed for long term groundwater level observations. Additionally, two boreholes, BH/MW103 and BH104 were advanced to a depth of 3.5 and 3.7 m bgs, respectively on November 13, 2019 to obtain further subsurface information at the west slope(s). BH/MW103 was equipped with a monitoring well for long term groundwater level observations. The approximate borehole/corehole locations established and drilled/cored at the Site are shown on Figure 1A .

The boreholes were advanced using truck mounted solid stem continuous flight auger equipment under the direction and supervision of BIG field personnel. Samples were retrieved at regular intervals of depth (0.76-1.5 m) with a 50 mm O.D. split-barrel sampler driven in accordance with the Standard Penetration Test (ASTM D1586). The samples were logged in the field and returned to the BIG laboratory for detailed visual examination by the project engineer and for laboratory testing of selected specimens for index properties (water content and plasticity).

At BH/MW2, BH/MW3 and BH/MW6, the bedrock was continually sampled (cored) for 1.9, 2.1 and 2 m lengths, respectively using the wire-line double barrel coring technique. An N-size coring barrel was used for rock coring. The recovered rock cores were preserved in core boxes and transported to BIG's laboratory for further evaluation.

Water level observations were made in the boreholes during and on completion of drilling as well as in the piezometers on June 13, 2018 and monitoring well on December 2, 2019.

The ground surface geodetic elevations at the borehole locations were surveyed by BIG personnel and referenced to Local Benchmark No. 1 taken from J.D. Barnes Topographic Plan "Reference No.: 17-30-187-00-TOPO" dated January 2nd, 2018. Benchmark description is as follows: "PK NAIL in asphalt sidewalk at Fourth Line Turn Around and Northeast Trail Entrance. A Benchmark Geodetic Elevation of 149.453 m (ASL) was taken from the J.D. Barnes Topographic Plan.

3.2.2 Boreholes and Monitoring Wells (2021)

In conjunction with the updated geotechnical investigation, the field work was carried out on September 16 to 23, 2021 that consisted of advancing a total of nine (9) boreholes.

For this updated slope stability assessment, three (3) boreholes, designated as BH/MW201, BH/MW202 and BH/MW209, were advanced to the surface of bedrock upon auger refusal at depths of between 7.6 m and 7.7 m bgs. Subsequently, the bedrock was cored using wire line diamond coring method to the depths of between 18.8 m to 20.3 m, to confirm the presence and quality of bedrock.

The other six (6) boreholes, designated as BH/MW203 to BH/MW208, were advanced to a depth of approximately 6.2 m below ground surface (bgs) for the purpose of the updated geotechnical investigation.

The approximate borehole/corehole locations established and drilled/cored at the Site are shown on Figure 1A.

The boreholes were advanced by using truck mounted, power operated solid stem continuous flight augers, supplied and operated by a specialized drilling contractor, working under the full-time supervision of experienced BIG geotechnical personnel. Mud rotary drilling method was also applied to advance the boreholes where rock coring was undertaken. Soil samples of the overburden were generally taken at 0.76 m or 1.5 m intervals while performing Standard Penetration Test (SPT) in accordance with ASTM D1586. This consisted of freely dropping a 63.5 kg hammer for a vertical distance of 0.76 m to drive a 51 mm outer diameter split-barrel (split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the ground by a vertical distance of 0.30 m was recorded as SPT 'N' value of the soil which indicates the consistency of cohesive soils or the relative density/compactness of non-cohesive soils.

The BIG's drilling supervisor examined and logged the overburden soil/rock-core samples as they were obtained from the boreholes/coreholes. The recovered soil samples were sealed in clean, airtight plastic bags and rock-core samples were placed in wooden boxes, and transported to the BIG's Mississauga laboratory for further examination and laboratory testing of selected specimens for index properties (water content, particle size distribution and Atterberg limits).

Groundwater observations were made in all boreholes during and immediately upon completion of drilling. In order to obtain the information on stabilized groundwater levels, all boreholes were equipped with monitoring wells, one in each borehole, upon completion of drilling for long term groundwater level observations and for environmental and hydrogeological assessment purposes. Monitoring wells installation details are presented on the Record of Borehole logs, and groundwater observations/measurements are summarized in Section 4.5.

The ground surface geodetic elevations at the current borehole locations were surveyed by BIG personnel and referenced to previously surveyed top of groundwater monitoring wells as Local Benchmarks.

It should be noted that the ground surface elevations at the borehole locations are approximate and should not be used for design and construction purpose. Contractors performing the work should confirm the elevations prior to construction. The borehole locations plotted on the Site Plan are based on the measurements of the Site features and should be considered to be approximate.

Record of Boreholes are included in Appendix B.

4. Subsurface Conditions

The borehole locations are shown on the site plan (Drawing 1A). Detailed subsurface conditions are presented on the Record of Boreholes in Appendix B. The soil boundaries indicated on the borehole logs and discussed herein are inferred from visual observations, auger resistance and laboratory test data. They should not be regarded as exact planes of geological change.

The subsurface conditions (strata) encountered in this investigation (2021) was generally consistent with that from the previous preliminary geotechnical investigation and slope stability assessment investigation. The soil conditions encountered at the Site are summarized as follows:

4.1 Topsoil

A surficial veneer of topsoil was encountered at all borehole locations. The thickness of the topsoil ranged from 50 mm to 180 mm. Topsoil across the site is expected to be variable and may vary in thickness. Exact topsoil thicknesses, when required are easily determined with a hand shovel.

4.2 Fill/Possible Fill

Fill was encountered below the surficial topsoil in BH1, BH/MW2 to BH/MW4, BH5 and BH104 and extended to a depth ranging from 0.8 to 2.3 m below ground surface (bgs) in the 2019 investigation.

The fill generally consisted of silty clay to clayey silt with inclusions of gravel and trace organic staining or some rootlets. A 75 mm thick black organic layer was present in the fill below 2.5 m depth. Below the surficial topsoil in BH/MW6 and BH/MW7, clayey silt with inclusions of gravel and organics and organic staining was present to 0.8 m depth. The layer had no readily apparent structure and may be possible fill used to fine grade the site.

A layer of fill materials consisting of silty clay to clayey silt with inclusions of gravel and trace organic staining or some rootlets was also encountered below the surficial topsoil in BH/MW201 and BH/MW203 to BH/MW209 and extended to depths of between 0.2 m and 1.5 m below ground surface (bgs) in the current investigation.

Standard Penetration Test ‘N’ values in the fill ranged from 3 to 14 blows/0.3 m indicating a soft to stiff consistency. Water contents are in the order of 10 to 27 percent. The elevated water content results in the fill are likely attributed by the presence of organic matter.

4.3 Clayey Silt/Silty Clay/Clayey Silt to Silty Clay (Glacial) Till

Clayey Silt/Silty Clay/Clayey Silt to Silty Clay (glacial) till was encountered below the surficial topsoil in BH/MW103 and BH/MW202 and below the fill/possible fill in the remaining sampled boreholes (i.e. BH1, BH/MW2, BH/MW3, BH/MW4, BH5, BH/MW6, BH/MW7, BH104, BH/MW201 and BH/MW203 to BH/MW209).

The till extended to depths ranging from 1.5 m to 7.6 m bgs, i.e., the inferred bedrock surface in the boreholes or turned into a till/shale complex transition zone. Sand and gravel sized particles, and weathered shale are present throughout the clayey silt to silty clay (glacial) till matrix.

The till/shale complex is the transition zone sometimes present above the shale bedrock and is characterized by a mixture of clayey silt till and highly weathered to weathered shale. The deposit is brown to reddish brown in colour and in a dry to moist state.

Standard Penetration Test ‘N’ values in the clayey silt/silty clay/clayey silt to silty clay (glacial) till ranged from 8 blows/0.3 m to in excess of 100 blows/0.3 m, indicating firm to hard consistency. However, the till was generally very stiff to hard. Water contents were in the order of 8 to 21 percent.

Laboratory Atterberg limits tests were performed on selected samples obtained from the clayey silt to silty clay (glacial) till. The respective plasticity charts are provided in Appendix C.

4.4 Shale Bedrock

Shale bedrock was contacted below the till and/or till/shale complex deposit in all boreholes. The bedrock was encountered at a depth of approximately 1.5 to 7.7 m below ground surface, which is consistent with the findings from previous investigations on the Site. Coring of the bedrock was carried out for 1.9, 2.1, 2 m, 10.8 m, 10.8 m and 11 m lengths at BH/MW2, BH/MW3, BH/MW6, BH/MW201, BH/MW202 and BH/MW209, respectively.

The shale on the site is of the Queenston Formation of Upper Ordovician Age. It is defined as the rock unit that overlies the bluish grey shales of the Georgian Bay Formation.

The rock can be penetrated by augering for various depths; however, the core recovery was very good. From the 2019 rock coring program, the rock quality was variable ranging from very poor to poor, i.e. Rock Quality Designation (RQD) of 22% between 9.1 and 9.6 m depth at BH/MW3 to RQD of 40% between 7.7 and 8.1 m depth at BH/MW6 to good to excellent quality, i.e. RQD ranging from 84% to 98% in the lower levels of BH/MW2, BH/MW3 and BH/MW6.

Similarly, in the current investigation where rock coring was undertaken in the 3 deeper boreholes, the rock quality was variable ranging from very poor to fair, i.e. Rock Quality Designation (RQD) of 10% between 9 m and 9.8 m depth at BH/MW202 to RQD of 71% between 8.1 m and 9.6 m depth at BH/MW201 to good to excellent quality, i.e. RQD ranging from 84% to 100% in the lower levels (below 12 m) of BH/MW201, BH/MW202 and BH/MW209.

The red shale had interbedded grey shale layers, some horizontal fractures along planes, minimal vertical cracking, minimal vertical fractures and some interbedded clayey silt seams at 9.1 m in BH/MW6, at depths between 9.5 m and 9.8 m bgs, 10.6 m and 10.8 m bgs in BH/MW201, between 9.1 m and 9.4 m bgs in BH/MW202, and between 9.5 m and 9.8 m bgs, 9.9 m and 10.2 m bgs in BH/MW209.

The upper portion of the bedrock is commonly weathered to 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 till/shale layer may be found above the bedrock, as was the case on this site. In the sound bedrock, the limestone, sandstone, dolostone inclusions are hard to very hard. Lenses of harder rock can have thicknesses as much as 750 to 900 mm as have been encountered on other site within the Queenston Shale. These lenses can vary significantly in thickness over short distances and should be anticipated on this site. It is also common to encounter closely spaced groupings of thin strong rock layers, which collectively can be as thick as 1.0 m or more.

The detailed core results for the boreholes are presented on the applicable Record of Boreholes in Appendix B.

4.5 Groundwater Conditions

Groundwater levels were monitored in the open boreholes during the course of the fieldwork and after completion.

The groundwater levels in the piezometers were noted to be at a depth of 2.0 to 3.0 m below ground surface or at about elevation 148.42 to 148.86 m asl on June 13, 2018 and a depth of 3.1 m bgs or about elevation 148.5 on December 2, 2019.

With the exception of BH/MW201, BH/MW202 and BH/MW209 where water was introduced to facilitate mud rotary drilling, groundwater levels were monitored in the remaining open boreholes during and after completion of drilling. BH/MW208 remained dry to a depth of approximately 5.9 m below ground surface (bgs) and groundwater levels were found at a depth of 3.7 m to 5.6 m bgs on completion of drilling.

The groundwater levels in the monitoring wells installed in the current boreholes (2021) were noted to be at a depth of 2.0 m to 5.5 m bgs or at about elevation 146.0 m to 149.5 m asl, on September 30, 2021.

The screening intervals and depths for piezometer and monitoring well installations are shown on the appended Record of Boreholes in Appendix B. In addition, the updated hydrogeological assessment provided by BIG under a separate cover should be referred to for groundwater data interpretations.

It should be noted that groundwater levels are subject to seasonal fluctuations and changes in the subsurface drainage domains near any site.

5. Stability Analyses of Slope

The stability analyses of the existing slopes at the Site was carried out using the program SLOPE/W with the Bishop's Method. The slope conditions and the results of stability analyses are presented as follows.

5.1 Site Conditions and Profiles

The Site is located south and west of Fourth Line, south of Dundas Street West, and west of Sixteen Mile Creek in Oakville, Ontario. There are two major slopes adjacent to the site, i.e., Sixteen Mile Creek Valley, located to the immediate east and the West Valley, located to the immediate west/southwest of the site. The conditions of two major slopes was examined during a site visit on May 15, 2018. For the purpose of this updated slope stability assessment, the conditions were also reviewed on August 26, 2021 by representative(s) of BIG. In accordance with Ontario Ministry of Natural Resources (MNRF) guidelines Table 8.1, the respective slope stability rating charts are presented in Appendix D for each valley section (i.e., Sixteen Mile Creek valley, and west valley system).

The Sixteen Mile Creek Valley Slope is located east of the Site and Fourth Line Road, and on the west side of Sixteen Mile Creek with an elevation between 150 m (ASL) at the top of bank to 114 m (ASL) at the toe of the slope. The West Valley Slope is located on the southwestern/western quadrant of the Site with an approximate elevation of 150 m ASAL at the top of bank to 140 m (ASL) at toe of the slope.

Sixteen Mile Creek Valley Slope

This northeast/east facing slope is divided into two sections by an asphalt paved walking path where approximately half the totality of the slope lies above the asphalt paved walking path, while one half lies below. Vegetation, including mature trees, young trees, small to large shrubs, and grass/shrubbery along the reviewed bank are growing vertical and upright indicating that the slope is generally stable. However, several surface erosion events of the slope in an eastward direction toward Sixteen Mile Creek were observed in the upper half of the slope, i.e. above the asphalt paved walkway. In the areas where surface erosion was observed, only young trees and shrubs were observed to have fallen over due to the said erosion of the slope, while mature trees were upright and heavily rooted into the face of the slope. The widths of the observed erosion planes were in the order of 8 m to 16 m. The general locations of erosion areas are provided on the site plan (Drawing 1B). The observed surface erosion and other slope features are on the photographs provided in Appendix E.

Gullies, or mild dips of the slope were observed in the half of the slope below the asphalt paved walking path and vegetation including mature trees, young trees, small to large shrubs, and grass were noted at the lower half of the slope. The vegetation was observed to be vertical and upright, with no evidence of movement of the slope, indicating the slope is generally stable. Sixteen Mile Creek is located adjacent of the toe of the slope. No signs of active toe erosion were noted along the toe of the slope.

Based on site reconnaissance, the height of the slope along the Sixteen Mile Creek Valley was in the order of 36±m. As noted earlier, the creek bed is located immediately adjacent to the toe of the slope and the Sixteen Mile Creek has steep slopes in the order of 1.5 horizontal to 1 vertical, Section A-A; 1.5 horizontal to 1 vertical, Section B-B and 2.1 horizontal to 1 vertical, Section C-C.

West Valley System Slope

The West Valley Slope is located on the southwestern/western quadrant of the Site and west of Fourth Line Road and is a west/south facing slope. This slope wraps around towards Fourth Line Road at the south end. A drainage ditch with free-flowing surficial runoff was observed at the toe of the reviewed slope. Vegetation, including mature trees, young trees, small to large shrubs, and grass along the banks of the slope are growing vertical and upright indicating that the slope is generally stable. Only what is to be considered minor surface erosion was occasionally observed. At the area where the slope wraps around towards Fourth Line Road, an approximately 16 m long gabion stone retaining wall is present.

The location of the west facing West Valley Slope is also provided on the site plan (Drawing 1A) and photos of the slope are provided in Appendix E.

For the slope stability analysis, three slope sections, Section A-A, B-B and C-C at the Sixteen Mile Creek Valley Slope and five slope sections, Section D-D, E-E, F-F, G-G and H-H at the West Valley System Slope as shown on the site plan (Drawing 1A) were analyzed using "Slope/W" slope stability program. This program uses the Bishop's Method for the stability analysis.

Effective stress analysis was carried out which is indicative of long-term stability. The profile of the slope at Cross-Sections A-A, B-B, C-C, D-D, E-E, F-F, G-G and H-H were obtained from the J.D. Barnes Topographic Plan and supplemented with ARC GIS Web Map for the subject slopes.

Based on the MNRF Table 8.1, the slope instability rating values total is 41 for both Sixteen Mile Creek valley and west valley system, indicative of moderate potential of instability requiring boreholes, piezometers, lab tests, surveying and detailed report as presented herein. It should, however, be noted that a conservative approach was taken for this assessment to assign a rating value of 9 under soil stratigraphy given the given the relatively shallow thickness of the encountered glacial till deposits at the Site. If consideration is given solely on the shale (bedrock), which is the predominant governing stratigraphy, the slope instability rating values will be reduced to between 25-35, indicative of slight potential of instability which do not require boreholes, piezometers, and lab tests.

With reference to the report prepared by GEO Morphix Ltd., a toe erosion allowance of 5 m is recommended for the small ravine that is central to the site. A 2 m toe erosion allowance should be applied to the larger tributary that flows along the southern edge of the study area. A smaller toe erosion allowance was assigned to the larger tributary due to the field observations of exposed shale in the channel banks, which will act to limit erosion at the bank toe. These recommendations are based on Table 3 of the MNR (2002) technical guide for erosion hazard limits.

For the purpose of the slope stability analysis, the following boreholes and applicable cross-section were used: Cross-Section A-A (BH/MW2); Cross-Section B-B (BH/MW4); Cross-Section C-C (BH/MW6); Cross-Sections D-D and E-E (BH7); Cross-Section F-F and G-G (BH104); and Cross-Section H-H (BH/MW103); Cross-Section I-I (BH/MW202) and Cross-Section J-J (BH/MW209).

The boreholes indicated that below a thin surficial topsoil veneer, the Site is covered with fill material at BH/MW2, BH/MW4, BH/MW6, BH7 and BH104 extending to 0.8 to 1.5 m depth.

A layer of fill materials consisting of silty clay to clayey silt with inclusions of gravel and trace organic staining or some rootlets was also encountered below the surficial topsoil in BH/MW201 and BH/MW203 to BH/MW209 and extended to depths of between 0.2 m and 1.5 m below ground surface (bgs) in the current investigation.

The fill materials were overlying clayey silt/silty clay/clayey silt to silty clay glacial till which extended to the surface of the bedrock at depths of 6.1 to 7.6 m at the applicable boreholes. At BH/MW103 and BH/MW202, the glacial till was contacted below the surficial topsoil layer.

The bedrock on the site is Queenston Shale which extended to the maximum depth explored in the applicable boreholes, i.e., 3.5 to 20.3 m below existing ground surface.

Groundwater was measured at a depth of 2.0 to 3.0 m below grade (elevation: 148.5 to 148.9 m asl) on June 13, 2018 (BH/MW2, BH/MW4 and BH/MW6 and on December 2, 2019 (BH/MW103). The groundwater levels in the monitoring wells installed in the current boreholes (2021) were noted to be at a depth of 2.0 m to 5.5 m bgs or at about elevation 146.2 m to 148.8 m asl, on September 30, 2021.

6. Soil Parameters

Based on the borehole information, soil parameters used in the slope stability analysis are given in the following Table 6-1.

Table 6-1: Soil Parameters for Slope Stability Analyses

Soil Type	Soil Density	Long-Term Strength	
	γ (kN/m³)	C' (kPa)	Φ' (degree)
Fill – clayey silt, trace gravel	18.5	0	26
Very Stiff to Hard Clayey Silt Till	20	10	28
Shale	23	600	30

7. Results of Slope Stability Analyses

Stability analyses of the slopes was carried out for the following scenarios and sections:

- **Scenario 1**: Section A-A.
- **Scenario 2**: Section B-B
- **Scenario 3**: Section C-C
- **Scenario 4**: Section D-D
- **Scenario 5**: Section E-E
- **Scenario 6**: Section F-F
- **Scenario 7**: Section G-G
- **Scenario 8**: Section H-H
- **Scenario 9**: Section I-I (**New additional analysis**)
- **Scenario 10**: Section J-J (**New additional analysis**)

Stability analyses of the slope for the above noted scenarios (See Figures 2 to 11) was conducted and the results are presented on Figures 12 to 21. The calculated factors of safety of the slope is summarized in Table 7-1.

Table 7-1: Results of Stability Analyses of the Slope

Analysis Scenario	Slope Profile	Minimum Factor of Safety (FS) (Long-Term Stability)	For Slope Stability Analysis Result
Scenario 1	Section A-A	1.544	See Figure 12
Scenario 2	Section B-B	1.518	See Figure 13
Scenario 3	Section C-C	2.386	See Figure 14
Scenario 4	Section D-D	1.996	See Figure 15
Scenario 5	Section E-E	2.059	See Figure 16
Scenario 6	Section F-F	4.069	See Figure 17
Scenario 7	Section G-G	4.681	See Figure 18
Scenario 8	Section H-H	4.303	See Figure 19
Scenario 9*	**Section I-I**	**2.266**	**See Figure 20**
Scenario 10*	**Section J-J**	**1.510**	**See Figure 21**

***Note** – Additional Sections & Slope Stability Analysis requested by Conservation Halton (CH)

8. Final Stable Slopes

As indicated above, based on the MNRF Table 8.1, the slope instability rating values total is 41 for both Sixteen Mile Creek valley and west valley system, indicative of moderate potential of instability requiring boreholes, piezometers, lab tests, surveying and detailed report as presented herein. It should, however, be noted that a conservative approach was taken for this assessment to assign a rating value of 9 under soil stratigraphy given the relatively shallow thickness of the encountered glacial till deposits at the Site. If consideration is given solely on the shale (bedrock), which is the predominant governing stratigraphy, the slope instability rating values will be reduced to between 25-35, indicative of slight potential of instability which do not require boreholes, piezometers, and lab tests.

Based on our assessment, the analyzed sections including the additional requested sections by Conservation Halton (CH) are stable in the long term given the factors of safety exceed the minimum acceptable safe value of 1.5. These findings are consistent with our previous analysis (2019).

In addition, based on the Rock Quality Designation (RQD) where rock coring was undertaken in the deeper boreholes advanced for this updated slope stability assessment, potential for deep seated failure to develop within the encountered rock formation on the subject slopes is negligible (Figure 12 to 21).

Based on the long-term stable top of slope at the analyzed sections, and our field observations, the recommended Long-Term Stable Top of Slope (LTSTS) line is shown on Figure 1C. It should be noted that for the proposed development, Conservation Halton (CH) will require additional setback from the LTSTS line. We understand that currently a 15 m setback is required from the Long-Term Stable Top of Slope for Sixteen Mile Creek and its tributaries. However, it is our opinion that a minimum 7.5 m setback is appropriate as required along the internal valley given the encountered soil conditions, higher minimum factors of safety ranging from 1.9 to 4.6 at the analyzed slope sections and supplemental geomorphic analysis by GEO Morphix Ltd.

For reference purpose, a 7.5 m development setback is presented on Figure 1C.

This must be reviewed and approved by the acceptance parties prior to implementation.

9. General Comments

The following additional comments related to the slope stability are provided in relation to future construction at the site:

1. With reference to the MNRF Table 8.1 Slope Stability Rating criteria, it should be noted that a conservative approach was taken herein. If consideration is given to the predominant shale bedrock stratigraphy, a lower rating which is indicative of slight potential of instability will be established.
2. Sixteen Mile Creek valley runs adjacent to the toe of the eastern slope, however, the start of the shale bedrock is much higher than the toe of the slope. Based on our assessment of the rock core samples and RQD indicative of generally good to excellent rock quality at lower depths, deep seated slope failure within the rock formation is not expected to occur at the Site.
3. Reference to the report by GEO Morphix Ltd. indicates that a toe erosion allowance of 5 m is recommended for the small ravine that is central to the site. A 2 m toe erosion allowance should be applied to the larger tributary that flows along the southern edge of the study area. A smaller toe erosion allowance was assigned to the larger tributary due to the field observations of exposed shale in the channel banks, which will act to limit erosion at the bank toe. These recommendations are based on Table 3 of the MNR (2002) technical guide for erosion hazard limits.
4. The vegetation on the existing slope surfaces must be preserved.
5. No additional surcharge (i.e. additional fill) can be placed on the existing slope surfaces or near the top of the slopes.
6. Where erosion planes are present, slope treatment such as rip-wrap drainage and/or geogrid reinforcement and seeding of the slope surface is recommended.

The content of this report is based on the information obtained from the project site and information from BIG's previous slope stability assessment and current geotechnical investigation. BIG 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, BIG will assume no responsibility for interpretation of the recommendations in the report.

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

The information in this report in no way reflects on the environmental aspects of the soil and has not been addressed in this report.

This report was prepared by BIG for the account of the Client and their representatives. The material in it reflects BIG's judgment considering the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. BIG accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

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

Respectfully submitted,

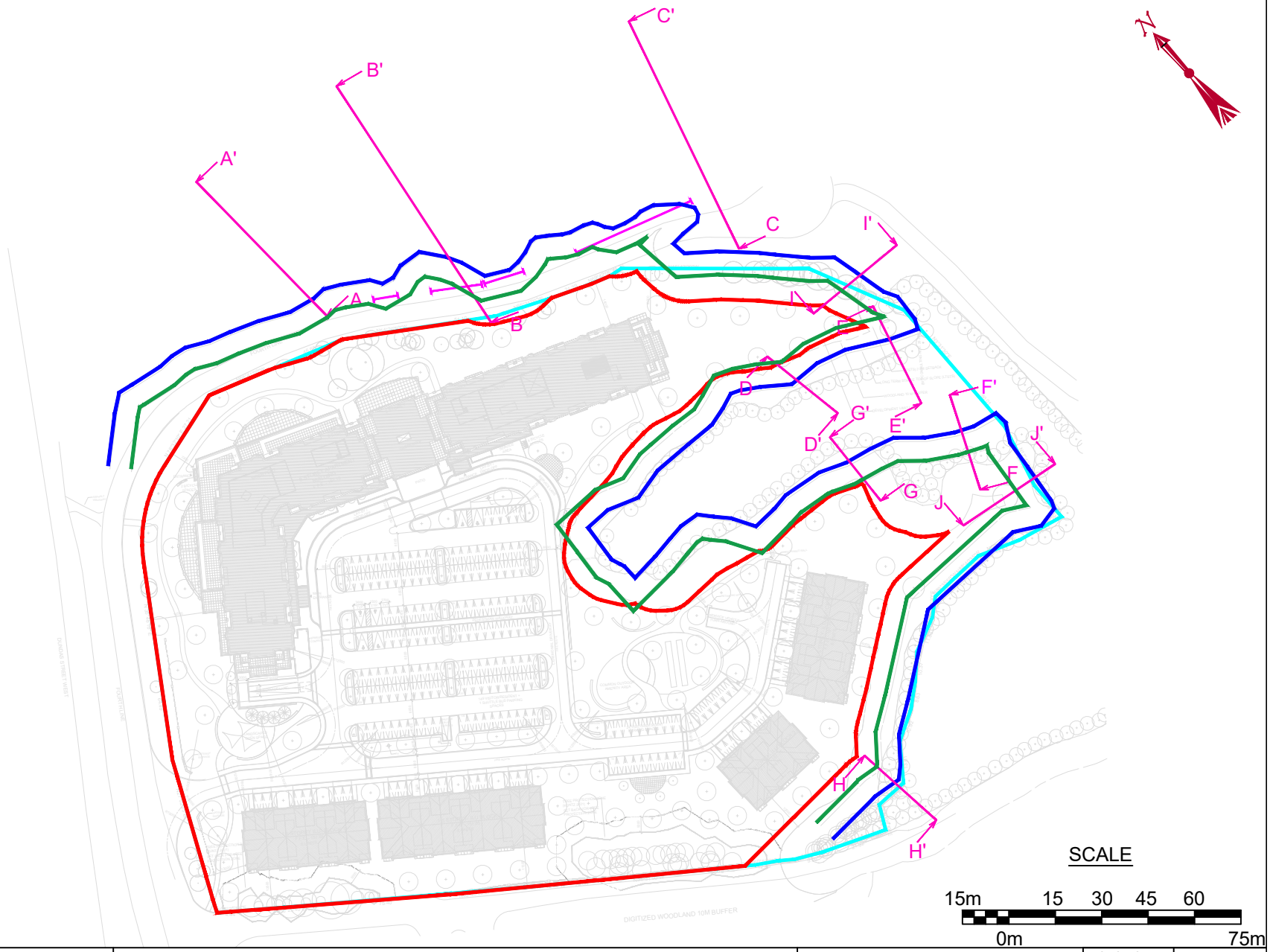
B.I.G. Consulting Inc.

Oswin Li, P.Eng.
Senior Project Manager

Darko Strajin, P.Eng.
Managing Partner

Figures: Site Plans, Analyzed Cross Sections
Slope Stability Analysis Results

B.I.G. Consulting Inc.



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LEGEND

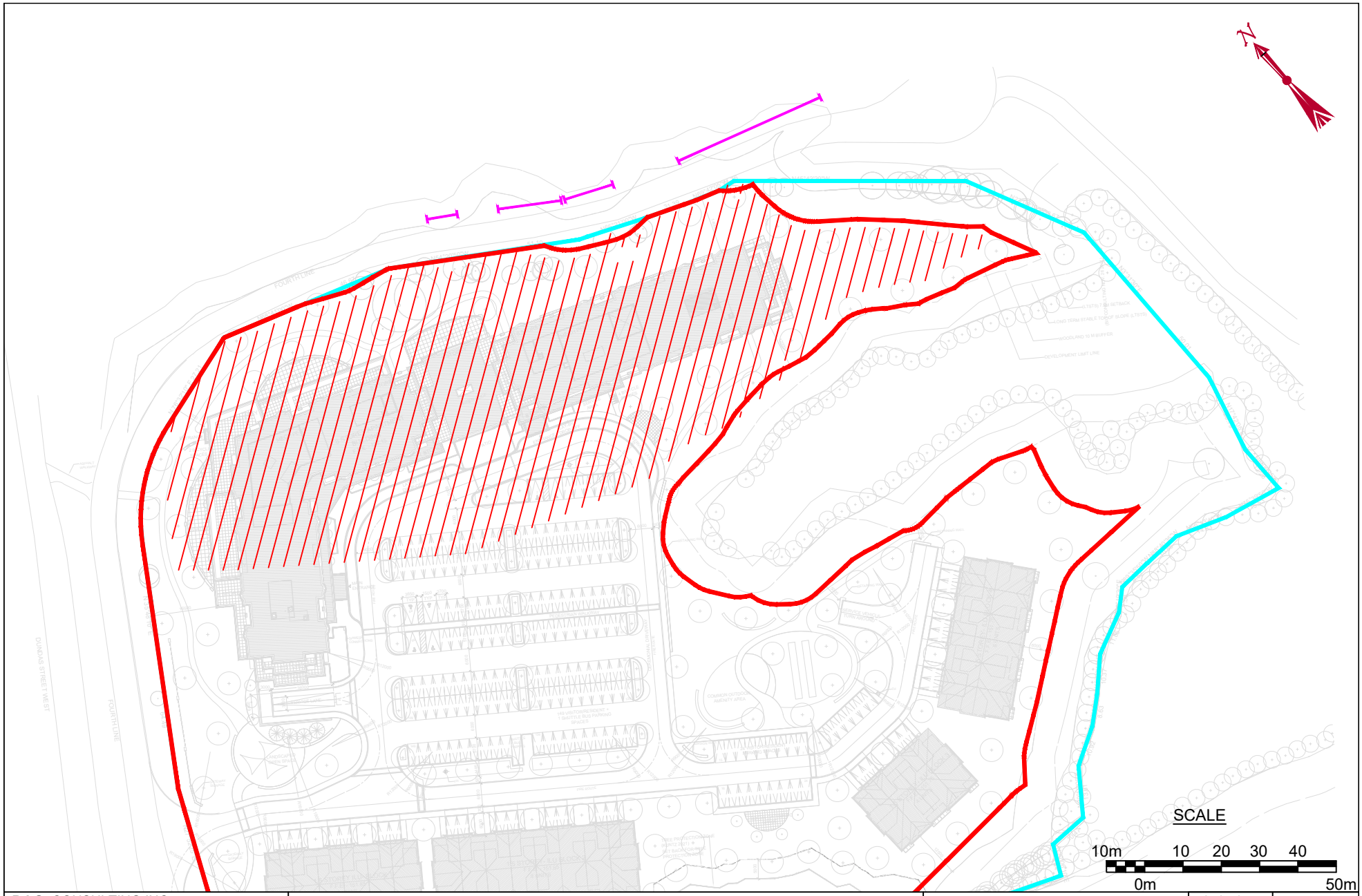
- UPDATED SITE BOUNDARY (MARCH 02, 2022)
- SITE BOUNDARY (JANUARY 02, 2018)
- EXISTING TOP OF BANK / LONG TERM STABLE TOP OF SLOPE (LTSTS)
- 7.5m SETBACK FROM EXISTING TOP OF BANK / LONG TERM STABLE TOP OF SLOPE (LTSTS)
- CROSS SECTION LINES

NOTE: IMAGERY OBTAINED FROM ICKE BROCHU ARCHITECTS INC., DRAWING NO. A101, REVISION 2, DATED MARCH 02, 2022

TITLE AND LOCATION

TOP OF BANK/SETBACK PLAN
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	O.A.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
MARCH 2022	1C



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LEGEND

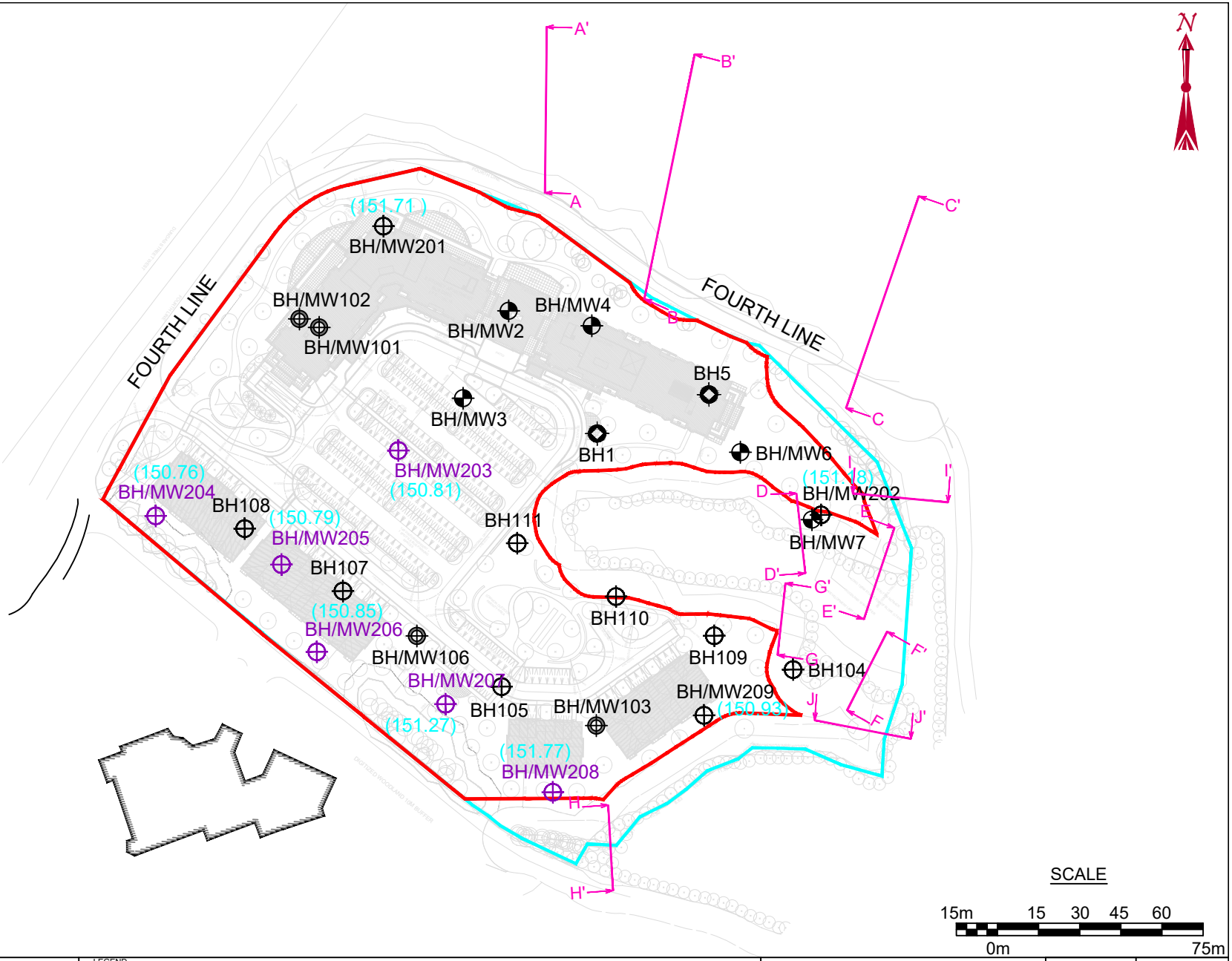
- UPDATED SITE BOUNDARY (MARCH 02, 2022)
- SITE BOUNDARY (JANUARY 02, 2018)
- OVERBURDEN EROSION PLANE

NOTE: IMAGERY OBTAINED FROM ICKE BROCHU ARCHITECTS INC., DRAWING NO. A101, REVISION 2, DATED MARCH 02, 2022

TITLE AND LOCATION

OVERBURDEN EROSION PLANE LOCATION PLAN
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	O.A.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
MARCH 2022	1B



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LEGEND

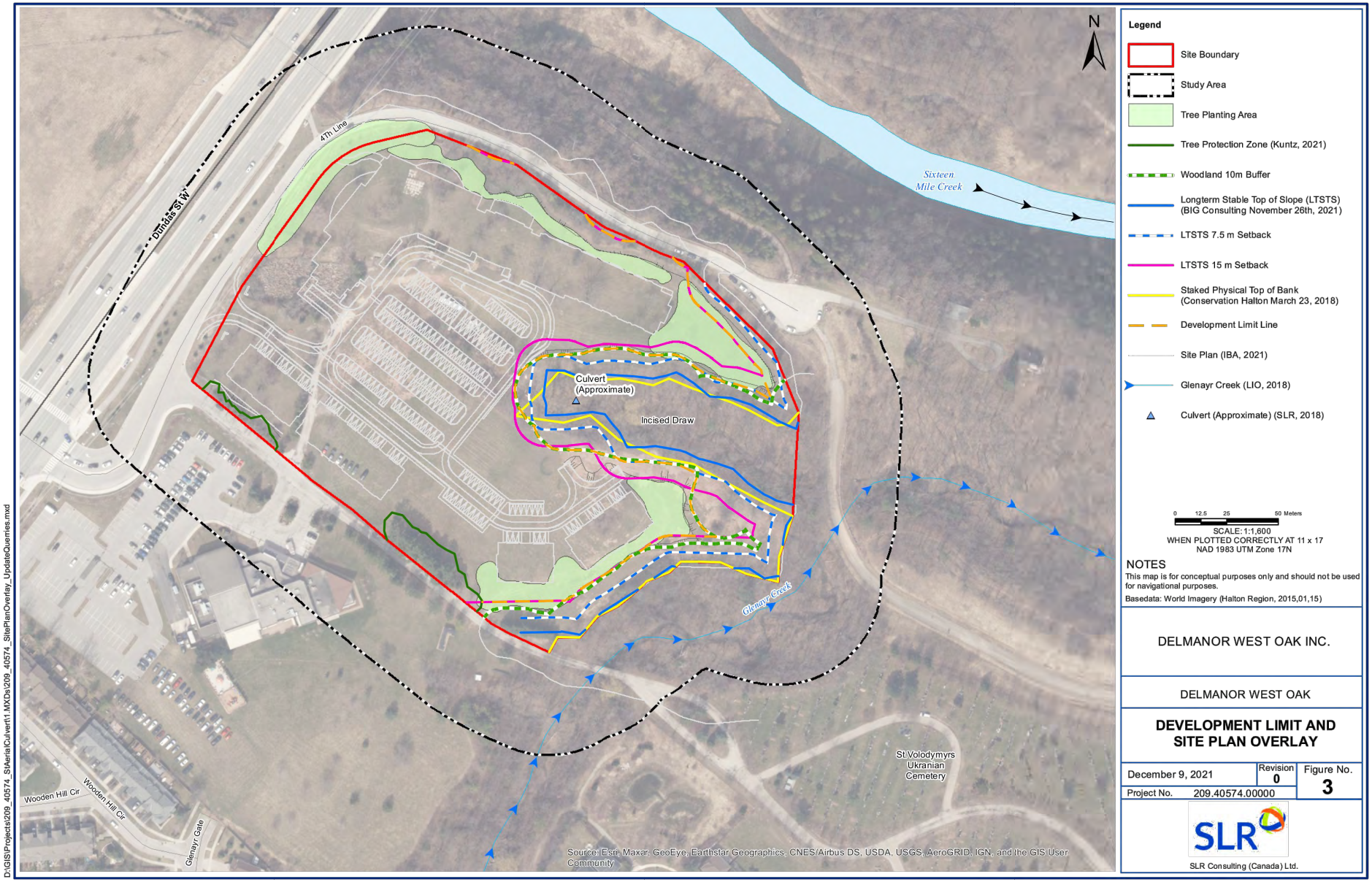
- UPDATED SITE BOUNDARY (MARCH 02, 2022)
- SITE BOUNDARY (JANUARY 02, 2018)
- EXISTING BUILDING
- APPROXIMATE BOREHOLE LOCATION (BIG, 2018)
- APPROXIMATE BOREHOLE/MONITORING WELL LOCATION (BIG, 2018)
- APPROXIMATE BOREHOLE LOCATION (BIG, 2019)
- APPROXIMATE BOREHOLE/MONITORING WELL LOCATION (BIG, 2019)
- APPROXIMATE BOREHOLE/MONITORING WELL LOCATION AT 6 MBGS (BIG, 2021)
- APPROXIMATE BOREHOLE/MONITORING WELL LOCATION AT 20 MBGS (BIG, 2021)
- (151.71) GROUND SURFACE ELEVATIONS IN METERS BELOW GROUND SURFACE (MBGS)
- CROSS SECTION LINES

NOTE: IMAGERY OBTAINED FROM ICKE BROCHU ARCHITECTS INC., DRAWING NO. A101, REVISION 2, DATED MARCH 02, 2022

TITLE AND LOCATION

SITE LAYOUT PLAN
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	O.A.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
MARCH 2022	1A



DELMANOR WEST OAK INC.

DELMANOR WEST OAK

DEVELOPMENT LIMIT AND SITE PLAN OVERLAY

December 9, 2021	Revision 0	Figure No. 3
Project No. 209.40574.00000		

SLR Consulting (Canada) Ltd.

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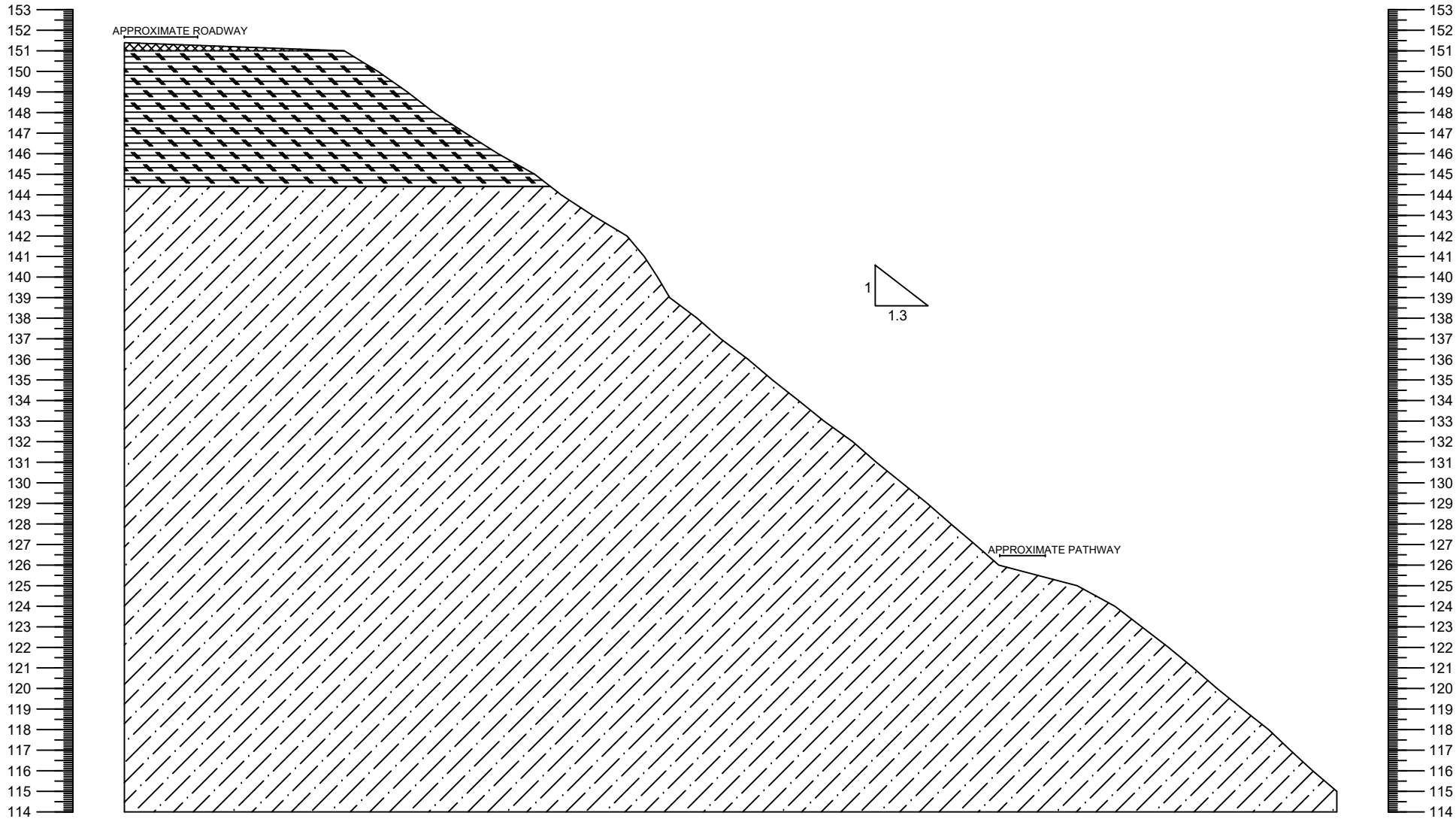
IMAGERY SOURCE: DEVELOPMENT LIMIT AND SITE PLAN OVERLAY BY SLR CONSULTING (CANADA) LTD. DATED DECEMBER 09, 2021

TITLE AND LOCATION

SITE PLAN OVERLAY (SLR CONSULTING (CANADA) LTD.)
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	O.A.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	1D



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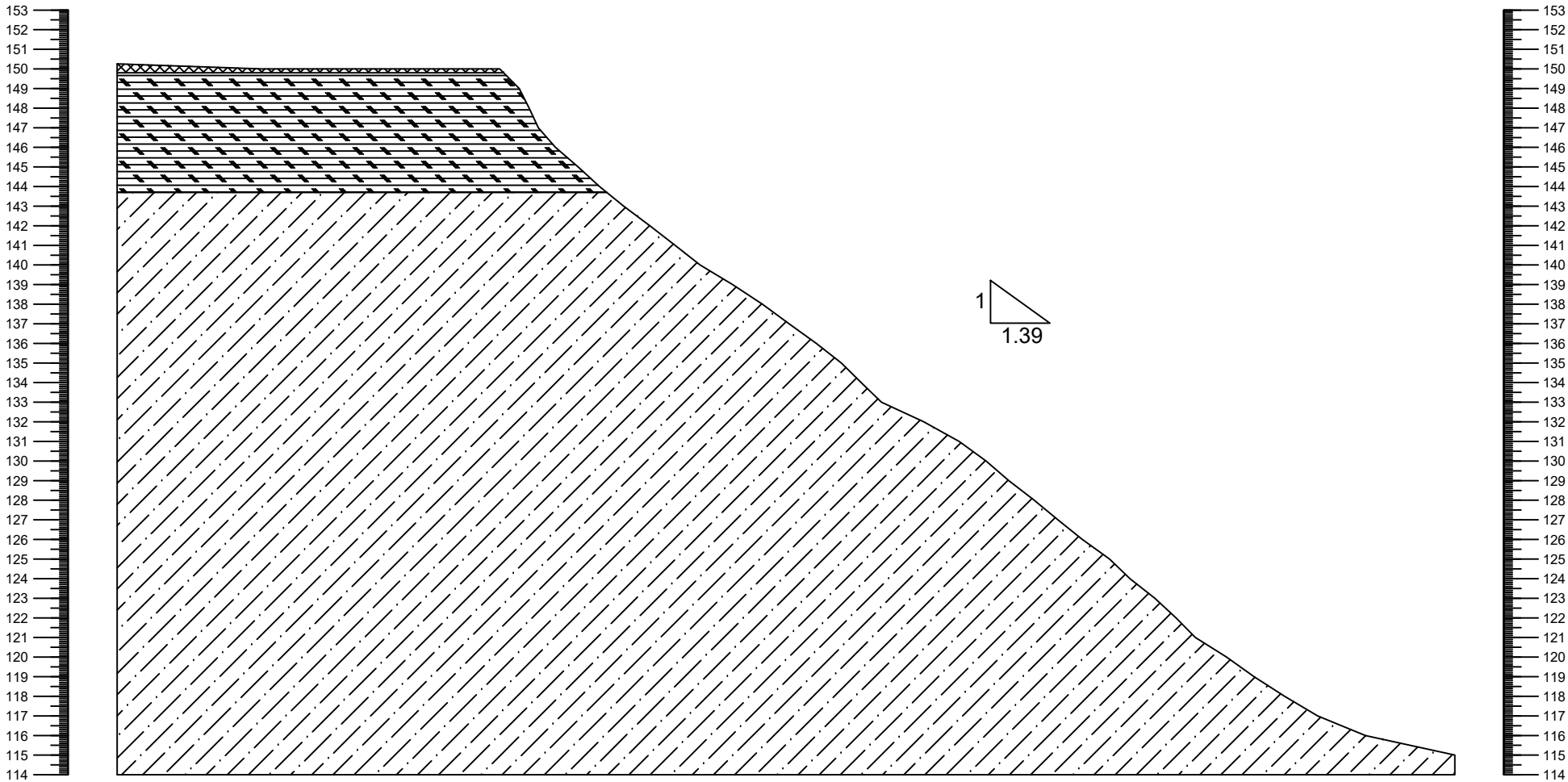
LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION A-A'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	2



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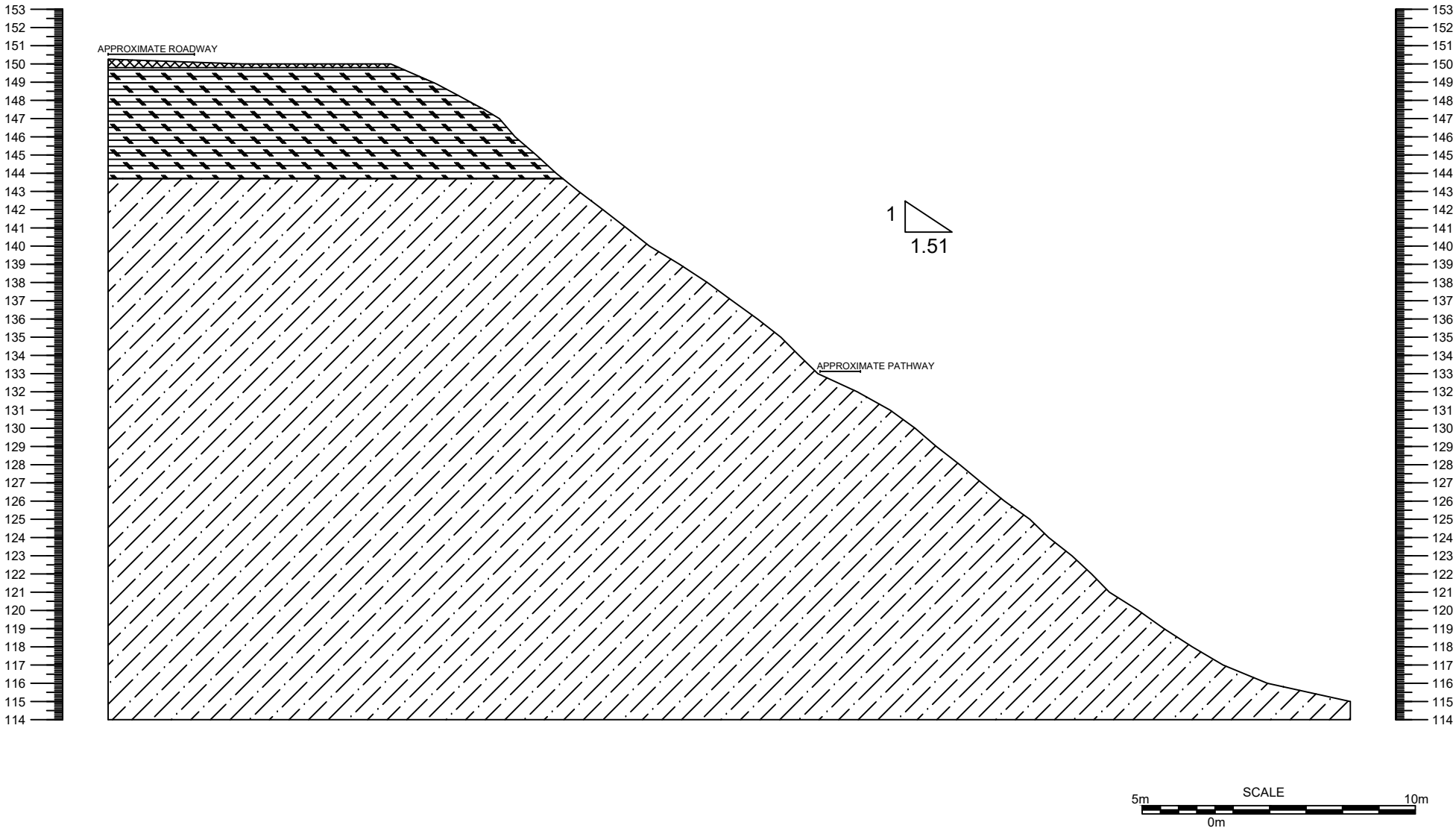
LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION B-B'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	3A



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LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

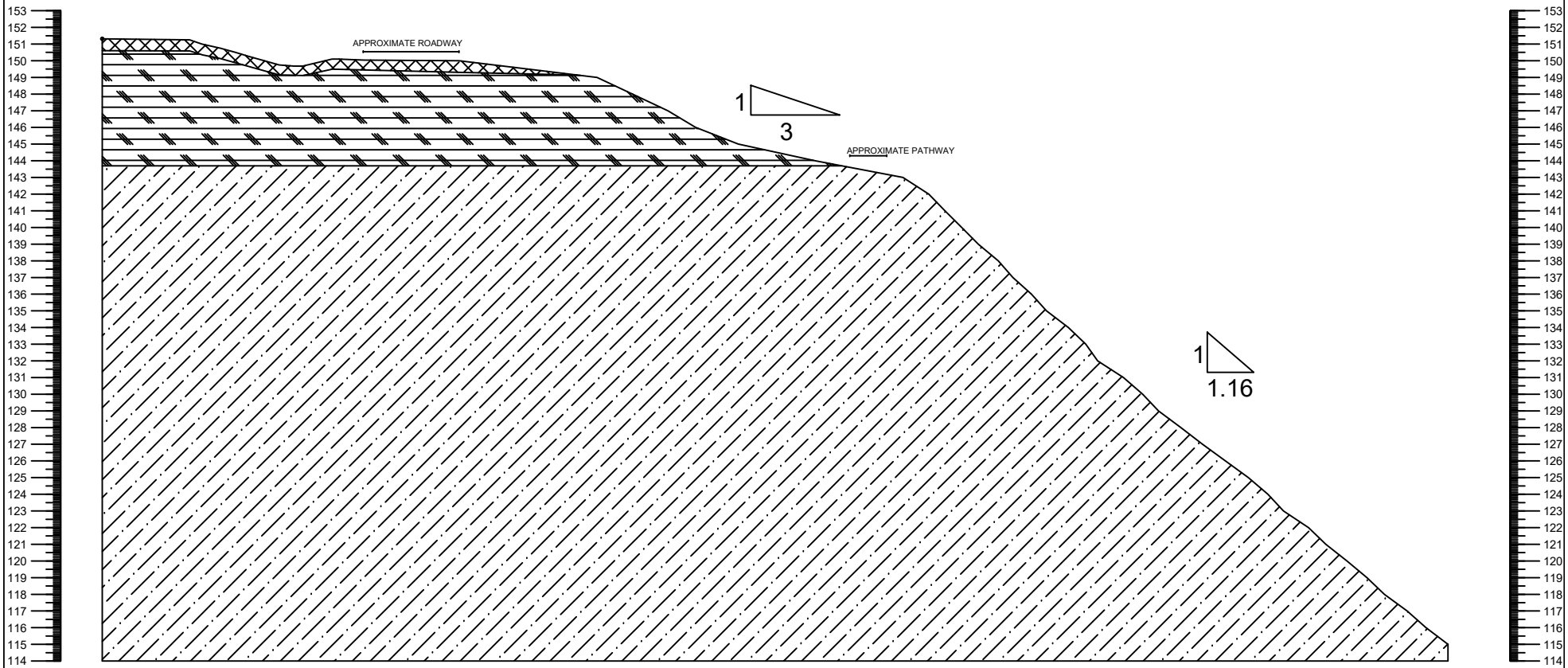
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION B-B' REVISED TOP OF BANK

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	3B



SCALE
5m 0m 10m

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LEGEND

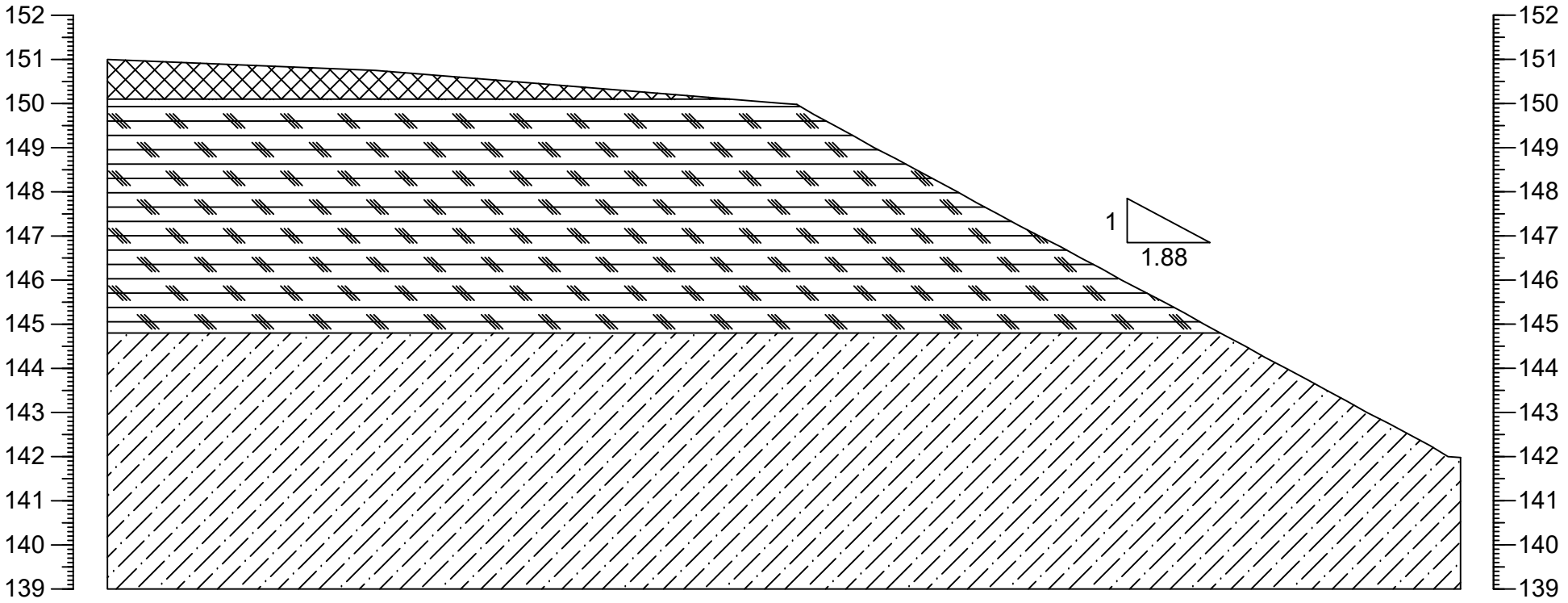
- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION C-C'

UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	4



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LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

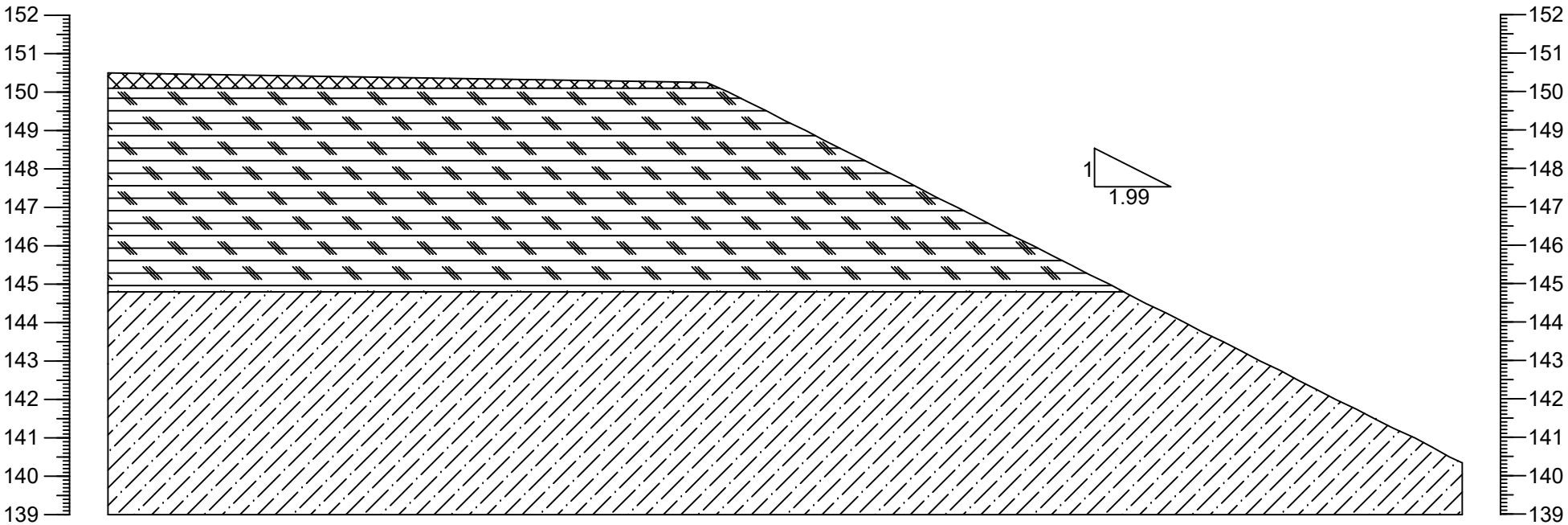
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION D-D'

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	5



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LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

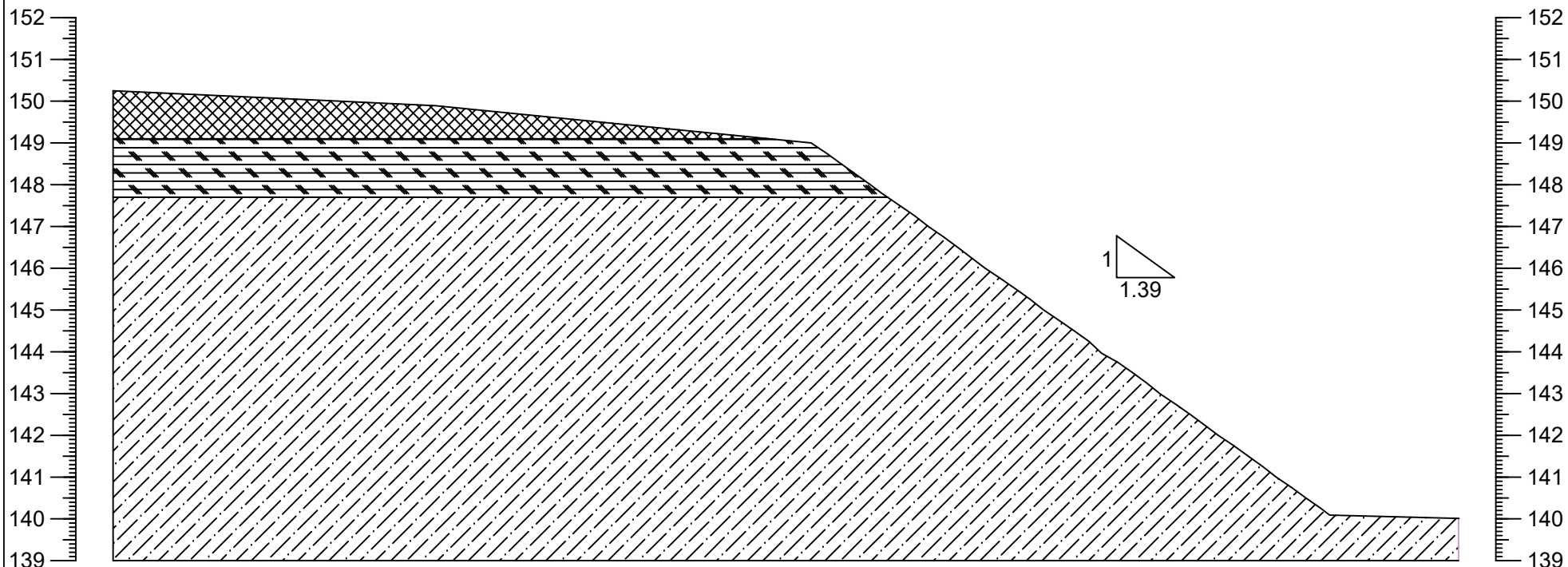
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION E-E'

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	6



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LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

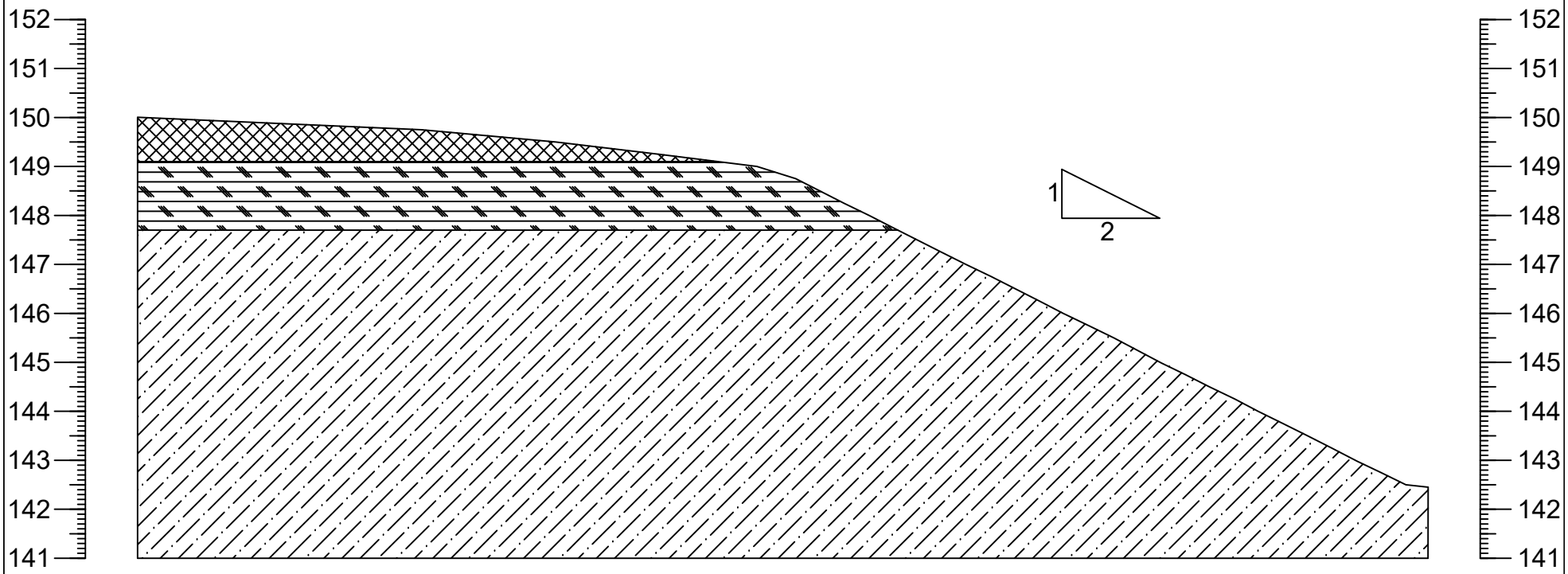
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION F-F'

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	7



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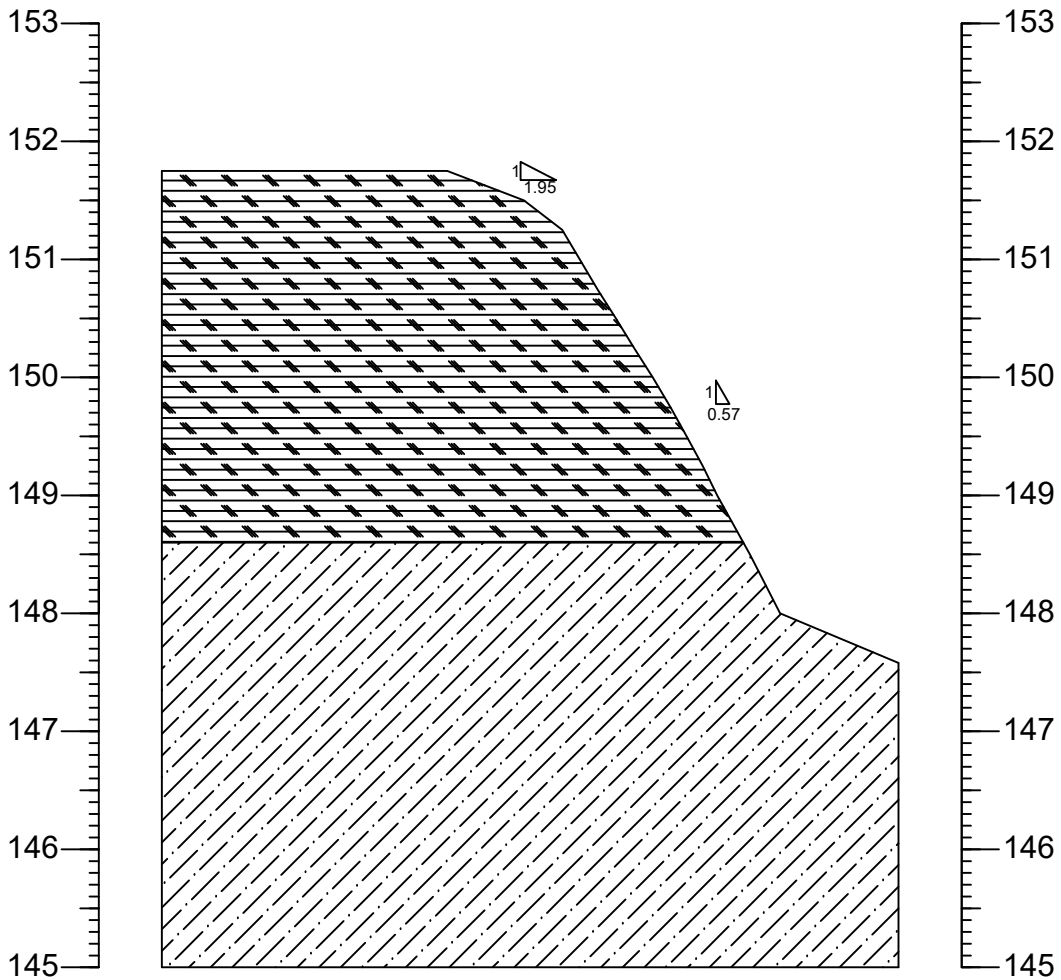
LEGEND

- FILL
- CLAYEY SILT/ SILTY CLAY TILL
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION G-G'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	8



SCALE
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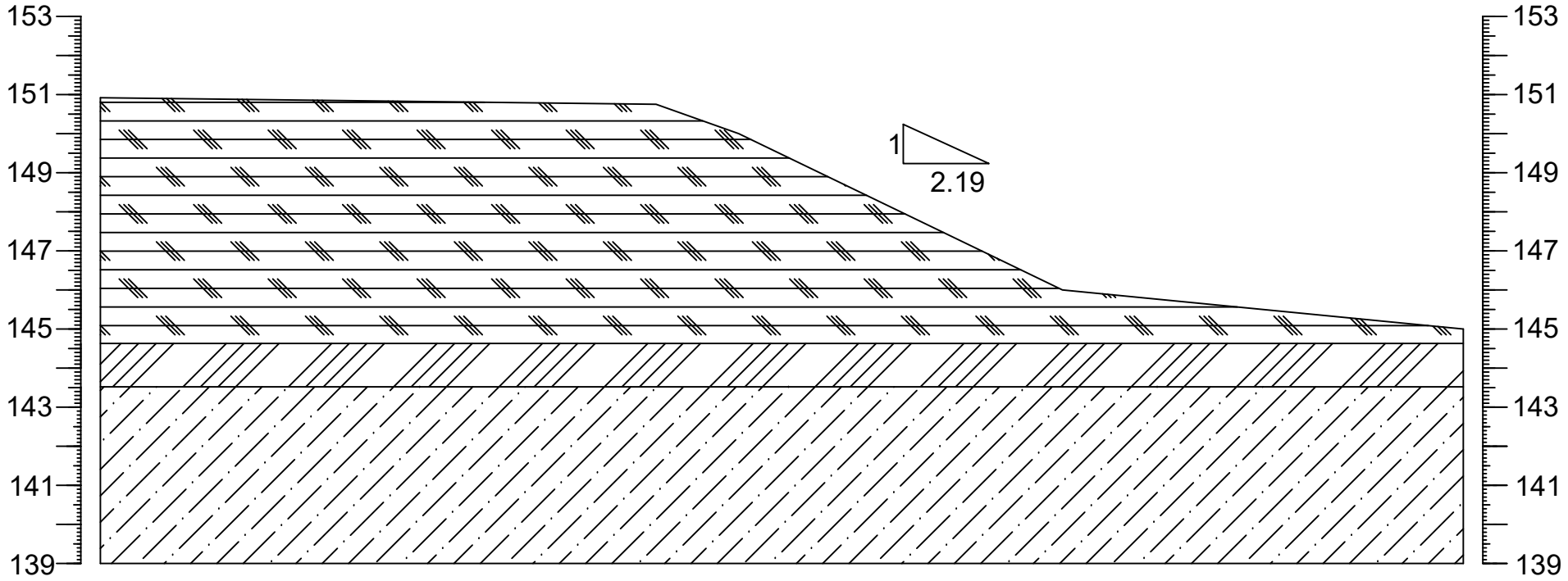
LEGEND

CLAYEY SILT/ SILTY CLAY TILL
SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION H-H'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	9



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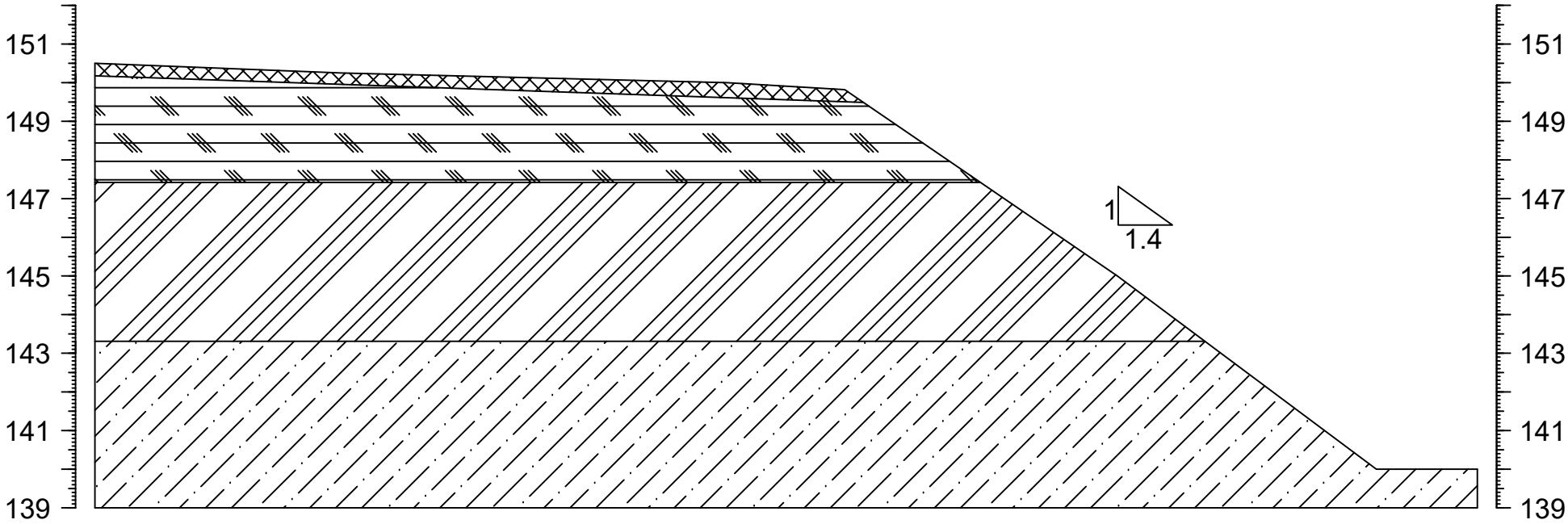
LEGEND

- CLAYEY SILT/SILTY CLAY TILL
- TILL/SHALE COMPLEX
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION I-I'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	10



SCALE
0m 5m
1m

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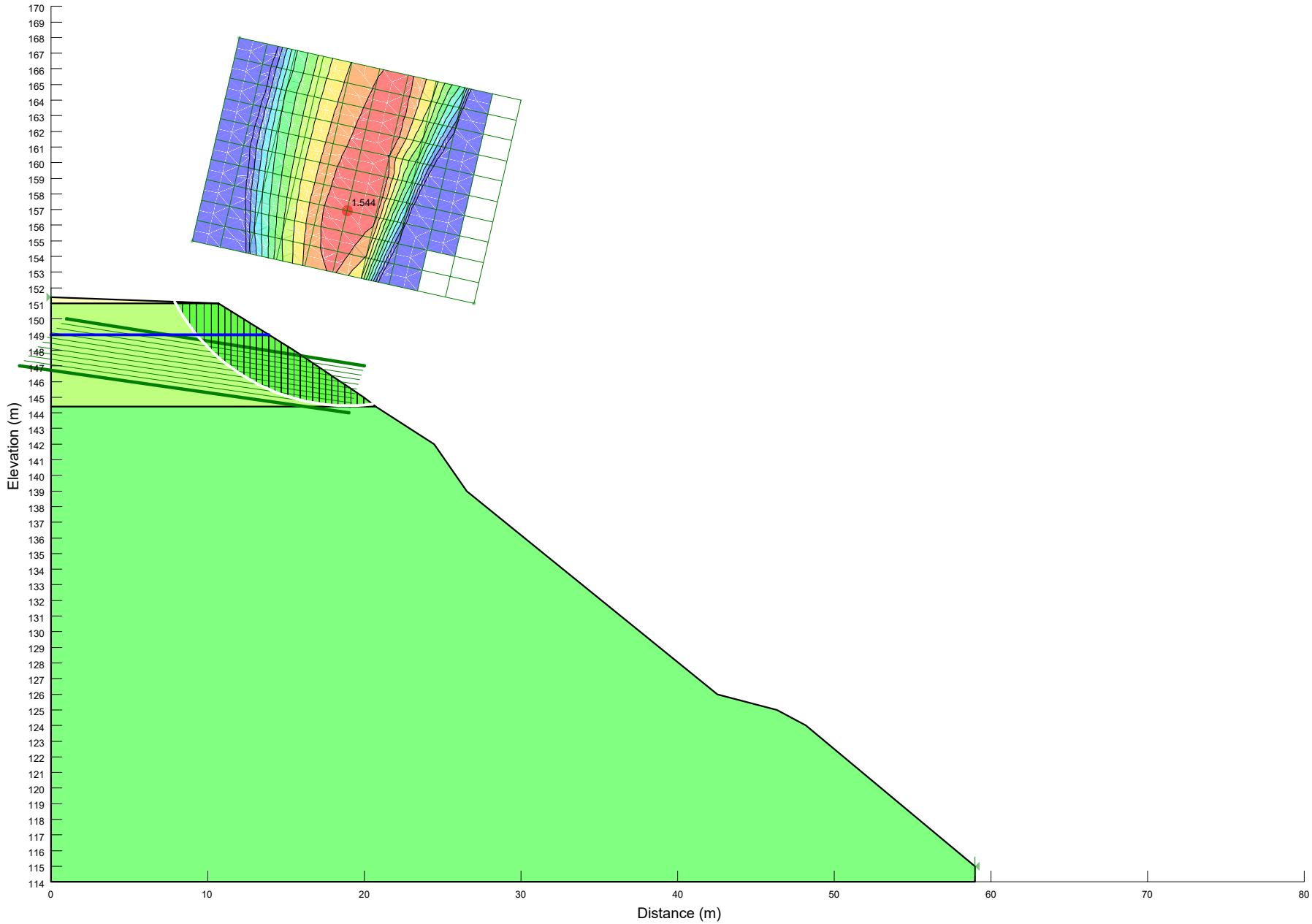
LEGEND

- FILL
- CLAYEY SILT/SILTY CLAY TILL
- TILL/SHALE COMPLEX
- SHALE

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION J-J'
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	11



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LEGEND

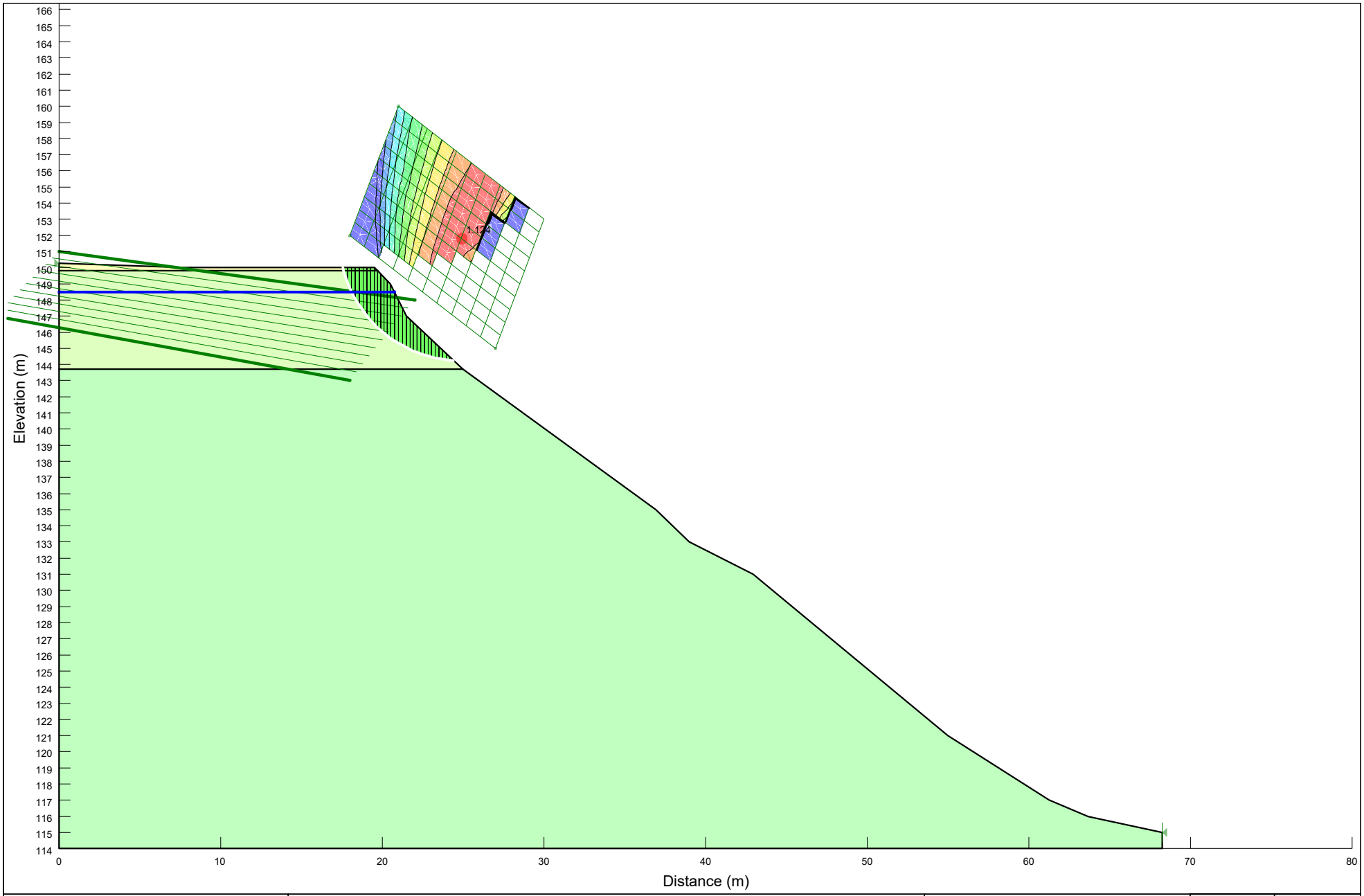
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION A-A' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	12



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LEGEND

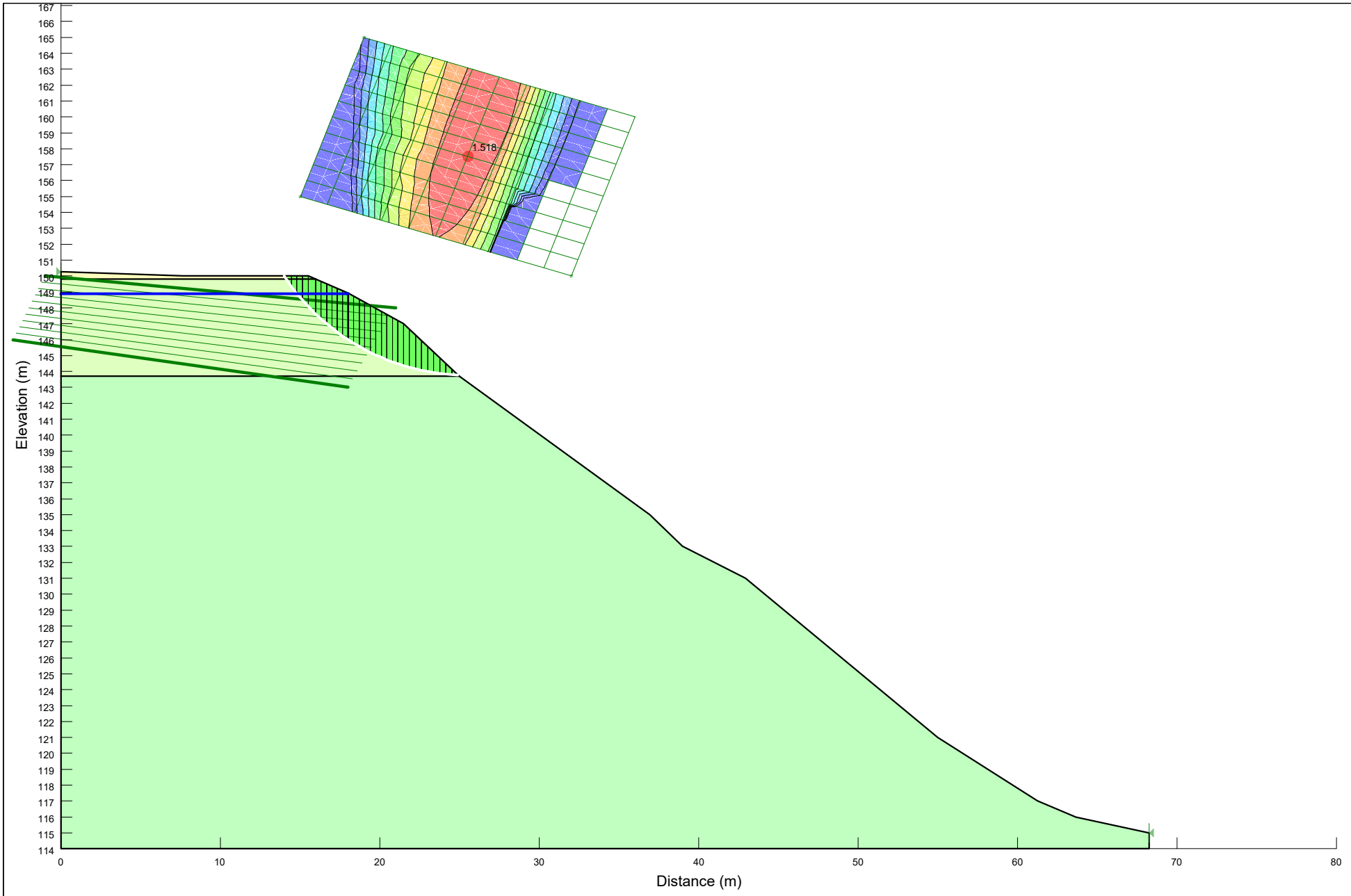
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION B-B' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	13A



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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

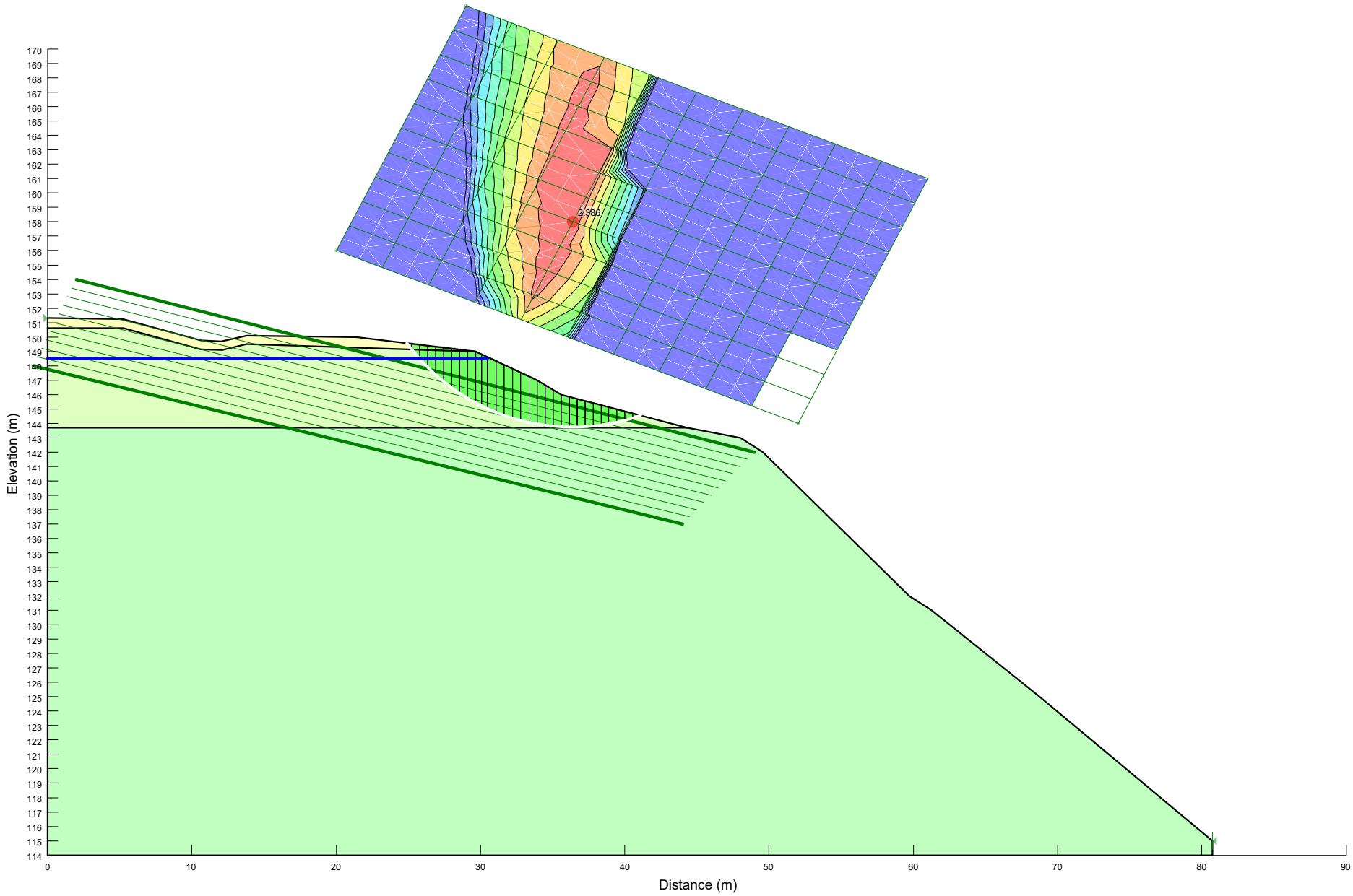
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION B-B' REVISED TOP OF BANK MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	13B



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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

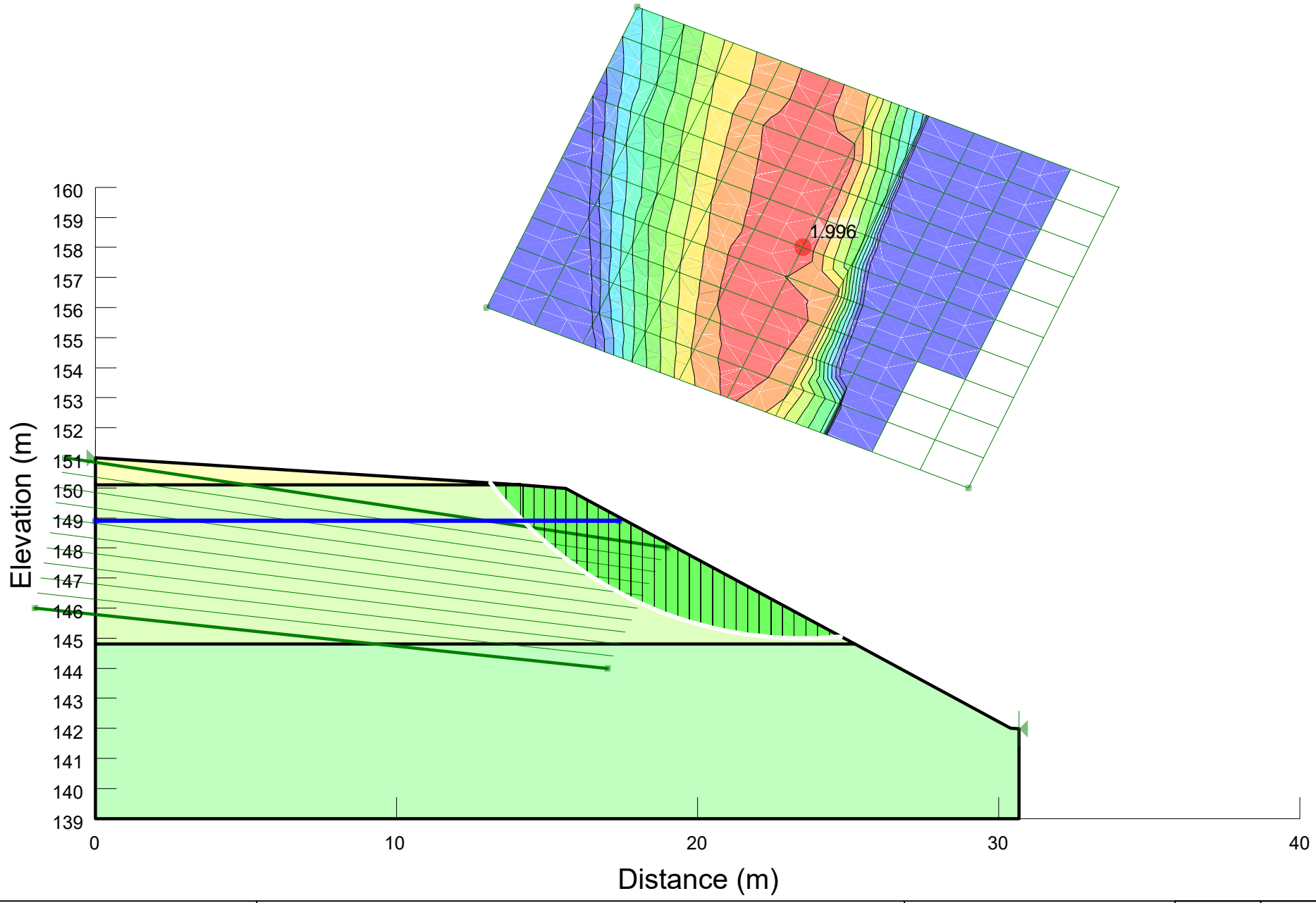
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION C-C' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	14



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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

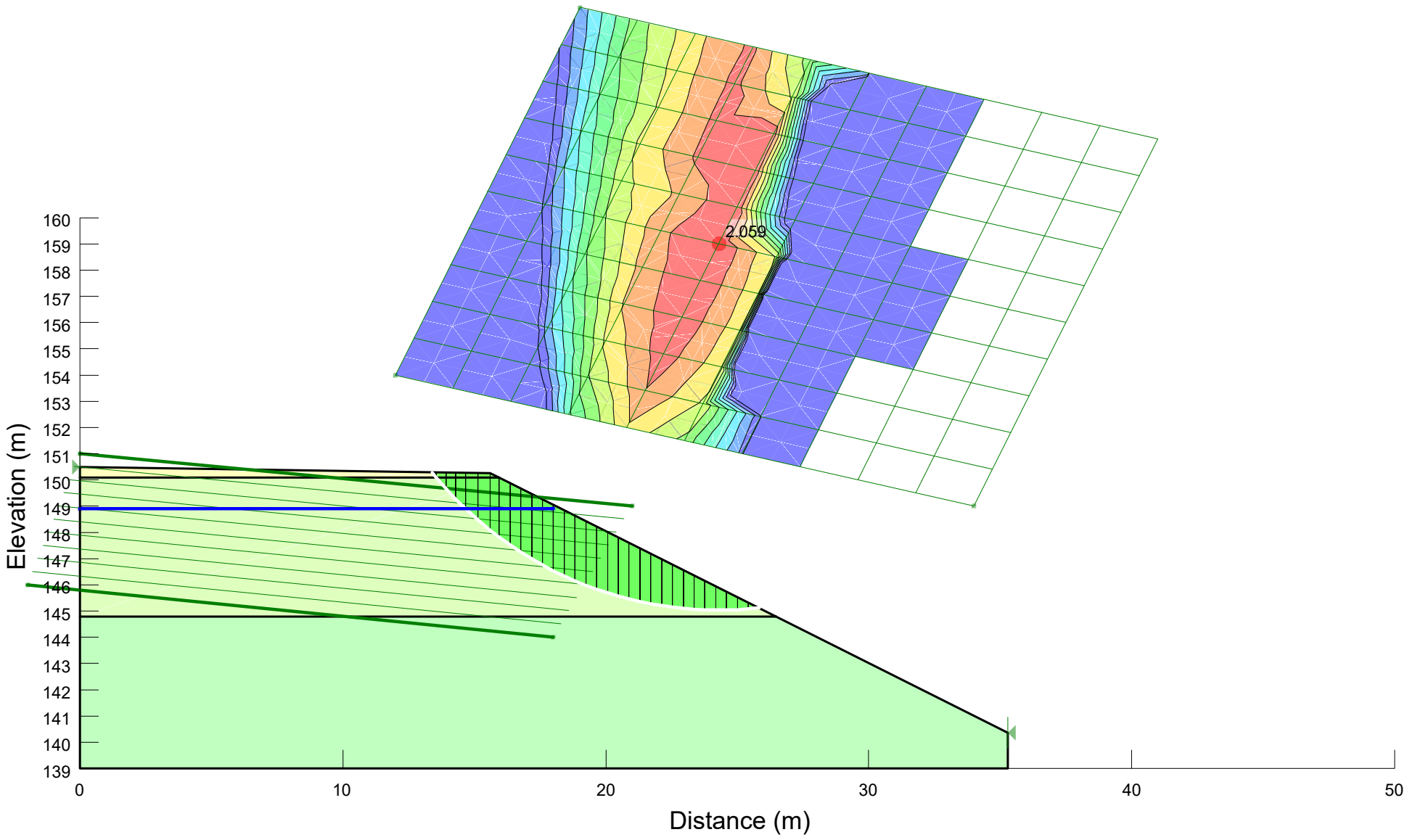
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION D-D' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	15



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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION E-E' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
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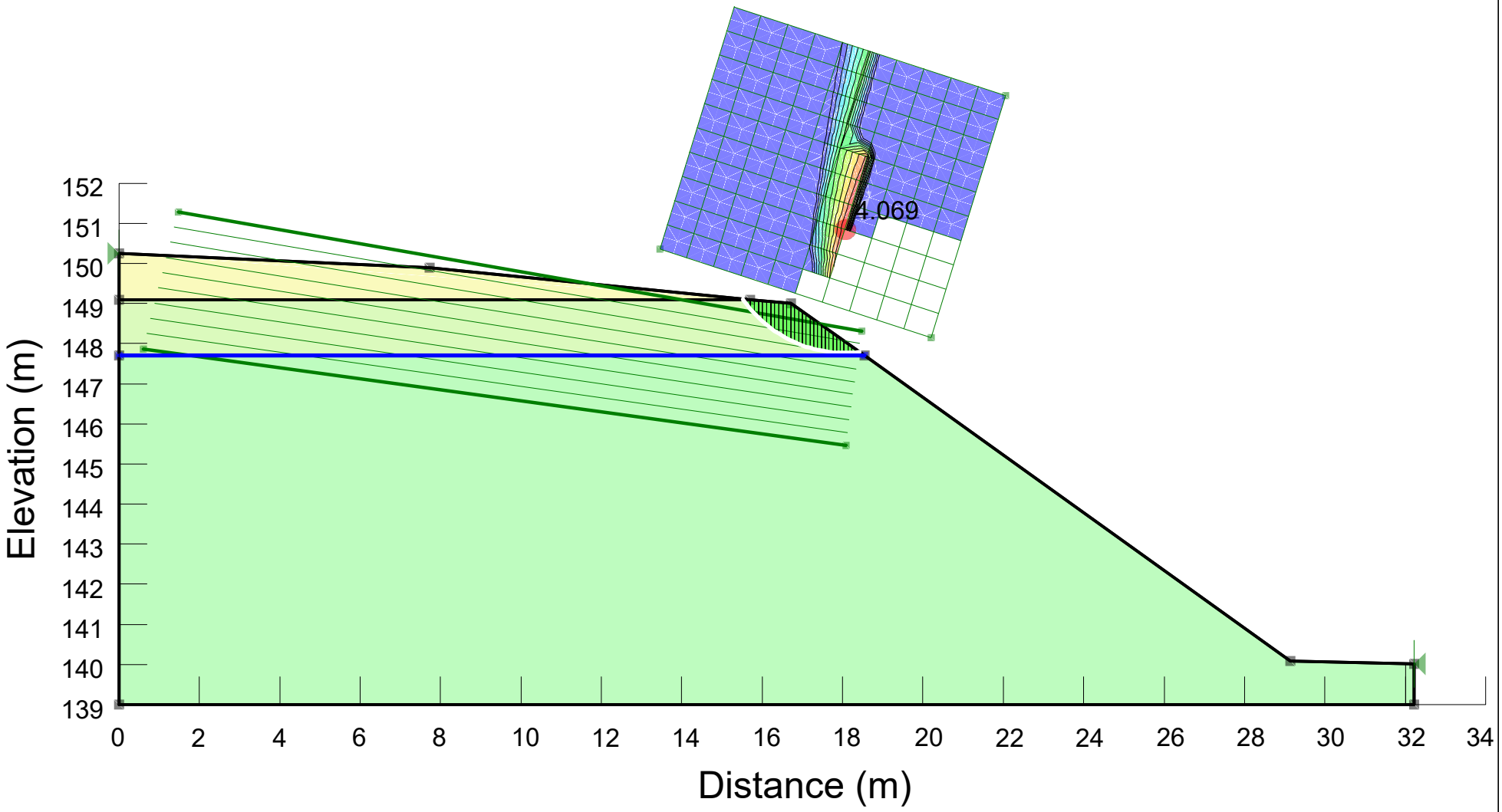

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Misissauga, ON L4W 2Z4
Canada

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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

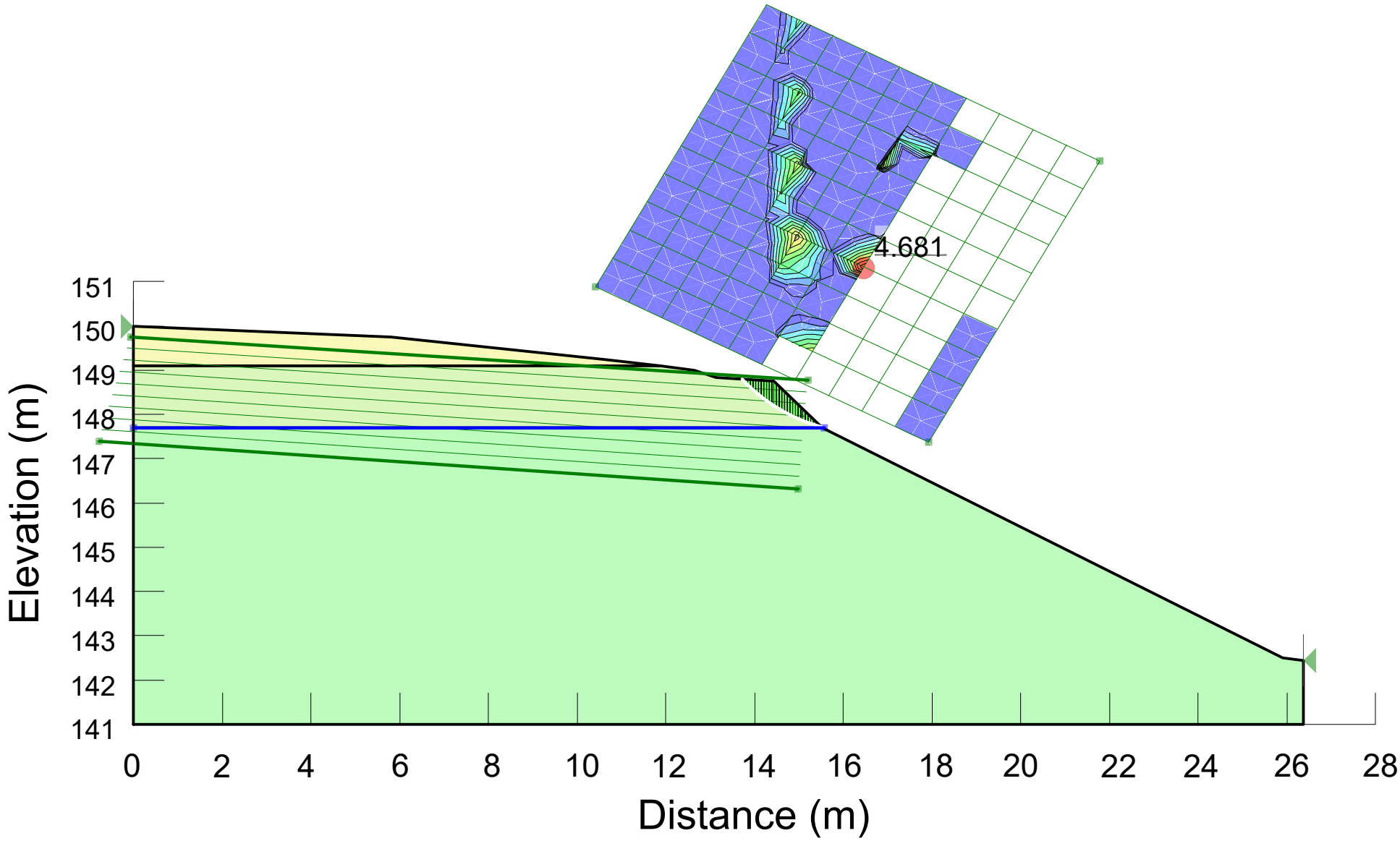
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION F-F' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	17



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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION G-G' MODELING ANALYSIS
UPDATED SLOPE STABILITY ASSESSMENT
1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
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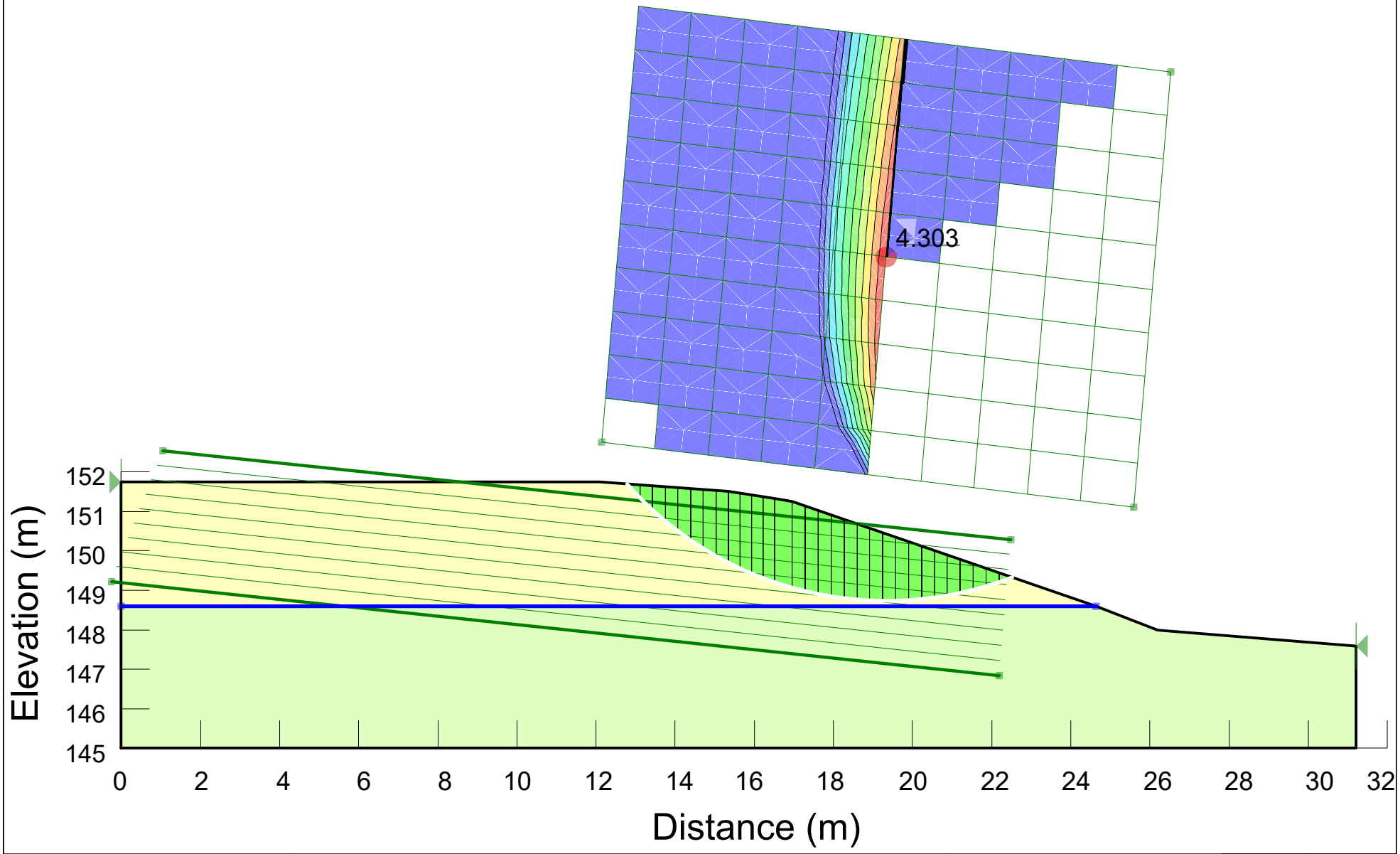

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12-5500 Tomken Rd.
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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	CLAYEY SILT TILL/SILTY CLAY TILL	Mohr-Coulomb	20	10	28	0	1
	SHALE	Mohr-Coulomb	23	600	30	0	1

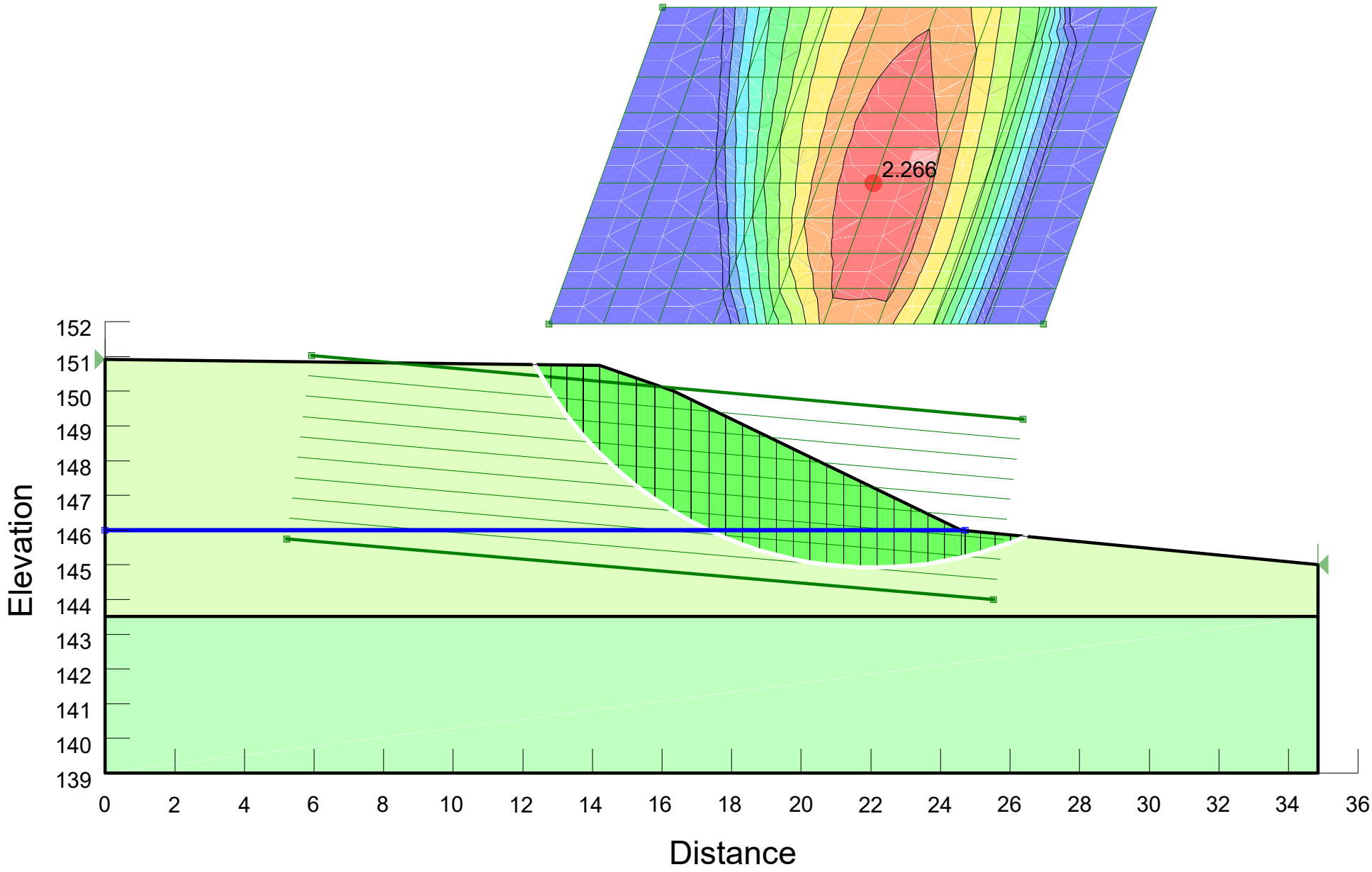
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION H-H' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	19



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12-5500 Tomken Rd.
Misissauga, ON L4W 2Z4
Canada

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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	CLAYEY SILT TILL/SILTY CLAY TILL	Mohr-Coulomb	20	10	28	0	1
	SHALE	Mohr-Coulomb	23	600	30	0	1

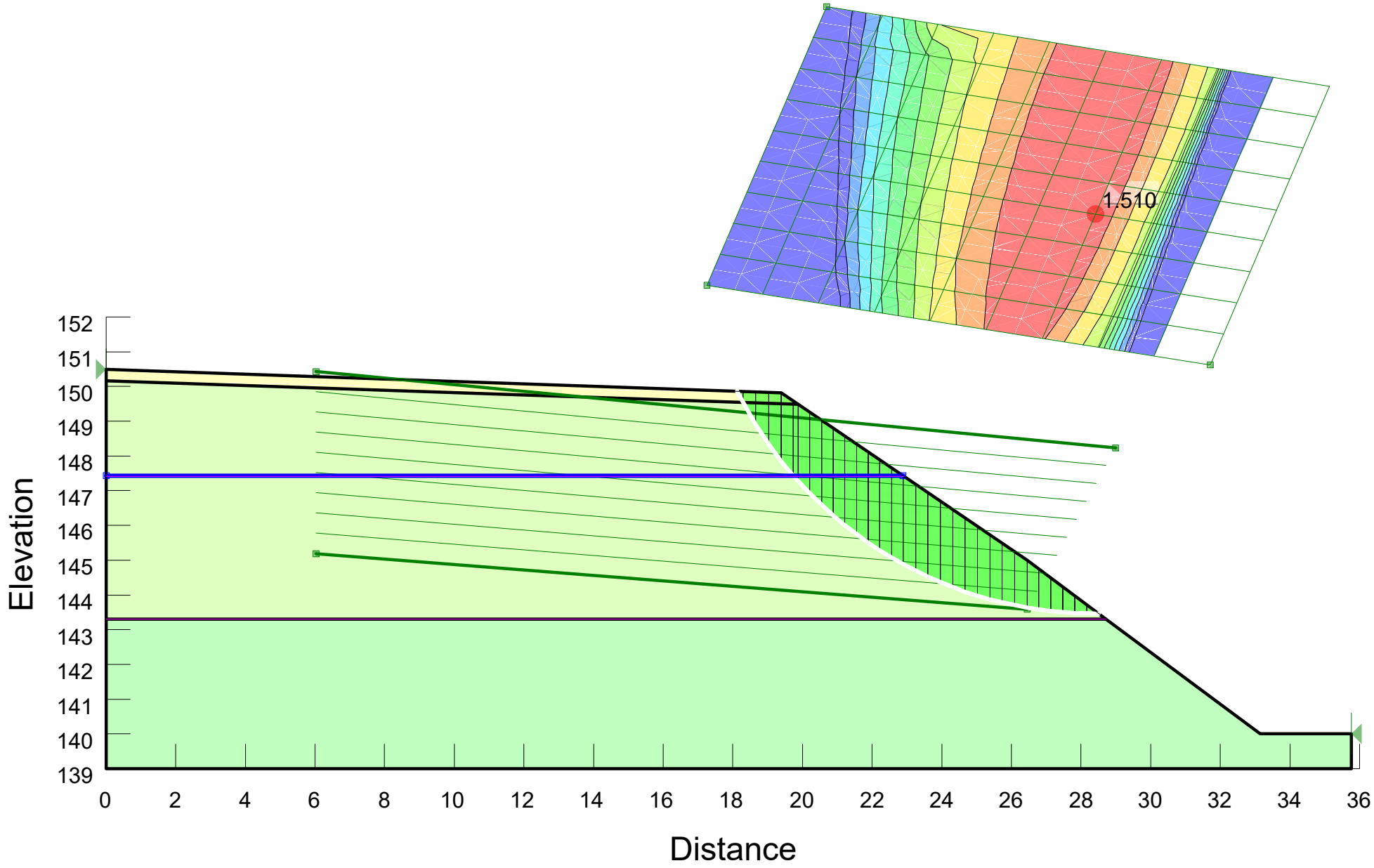
TITLE AND LOCATION

GEOLOGICAL CROSS SECTION I-I' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	20



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12-5500 Tomken Rd.
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LEGEND

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	Clayey Silt Till	Mohr-Coulomb	20	10	28	1
	Fill	Mohr-Coulomb	18.5	0	26	1
	Shale	Mohr-Coulomb	23	600	30	1

TITLE AND LOCATION

GEOLOGICAL CROSS SECTION J-J' MODELING ANALYSIS

UPDATED SLOPE STABILITY ASSESSMENT

1260 AND 1280 DUNDAS STREET WEST, OAKVILLE, ONTARIO

PROJECT NO.	DWN.
BIGC-GEO-185E	S.M.
SCALE	CK.
AS NOTED	O.L.
DATE	FIG NO.
NOVEMBER 2021	21

Appendix A: GEO Morphix Ltd. Report

Erosion Hazard and Mitigation Assessment
Sixteen Mile Creek Tributaries

Delmanor West Oak Development
Oakville, Ontario

Prepared for:
Delmanor West Oak Inc.
4800 Dufferin St
Toronto, ON M3H 5S

November 26, 2021
PN21077

GEO MORPHIX
Geomorphology
Earth Science
Observations

Report Prepared by:	GEO Morphix Ltd. 36 Main Street North PO Box 205 Campbellville, ON L0P 1B0
Report Title:	Erosion Hazard and Mitigation Assessment Sixteen Mile Creek Tributaries Delmanor West Oak Development Oakville, Ontario
Project Number:	PN21077
Status:	Final
Version:	1.0
Prepared by:	Suzanne St. Onge, M.Sc., John Tweedie, M.Sc., Dena Van de Coevering, B.A.Sc.
Approved by:	Paul Villard, Ph.D., P.Geo., CAN-CISEC, EP, CERP
Approval Date:	November 26, 2021

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Appendices

1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained to complete an erosion hazard and mitigation assessment within the property located at 1280 Dundas Street West in Oakville in support of a zoning by-law amendment (ZBA) application. The property, hereafter referred to as the subject lands, is bounded by Dundas Street West and Fourth Line to the north, Fourth Line and the main branch of Sixteen Mile Creek to the east, an existing development to the west, and the St Volodymyr Ukrainian Cemetery to the south (**Appendix A**).

Glenayr Creek, a tributary to the main branch of Sixteen Mile Creek, flows along the southern limit of the subject lands. A relatively small unnamed tributary of Sixteen Mile Creek is centrally located in the subject lands, and discharges to Glenayr Creek downstream of Fourth Line. In addition, a remnant pond feature is located on the tablelands immediately south of Fourth Line. Drainage from this pond is connected to the central ravine via a 0.4 m diameter pipe. As noted in the Environmental Impact Study (EIS) prepared by SLR Consulting (2020), a CCTV investigation of the pipe revealed that it is blocked or has collapsed in more than one location. As such, the remnant pond currently does not contribute flows to the central ravine but may have historically.

The subject lands are approximately 4.6 ha in area, with the proposed development consisting of a seniors' living facility and associated amenities. The proposed stormwater management strategy includes an underground storage facility and a storm sewer outlet that will discharge to the central ravine. Conservation Halton provided comments on the first ZBA submission, noting concerns regarding potential increased erosion within the central ravine due to stormwater discharge. In addition, the determination of a toe erosion allowance was requested by Conservation Halton for the ravine system, which includes Glenayr Creek and the unnamed tributary.

The following activities were completed by GEO Morphix to address comments from Conservation Halton and the Town of Oakville regarding delineation of the erosion hazard and erosion mitigation for the proposed storm sewer outlet:

- Review topographic and geologic maps and previously completed reporting
- Complete a historical assessment using aerial photographs to identify changes to the tributaries due to land use and past channel modifications
- Delineate watercourse reaches through a desktop exercise
- Conduct rapid field reconnaissance to document reach-scale observations of channel substrate, flow behaviour, geomorphological units, and locations of any valley wall contacts and areas of active erosion
- Define the erosion hazard to establish, in part, development limits within the subject lands
- Complete a detailed geomorphological field assessment, the primary objective of which is to determine the critical flow or erosion threshold
- Determine an erosion threshold for use in the proposed stormwater management strategy using an in-house model that predicts the discharge at which the dominant channel material will become entrained
- Completed an erosion exceedance assessment using hydrological modelling provided by R.V. Andreson Associates Ltd to evaluate the potential impacts of the development on the receiving watercourse

2 Background Review

2.1 Site History

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics and potentially how past changes may affect channel planform in the future. Historical aerial photographs from 1934 (1:20,000), 1954 (1:15,840), 1965 (1:20,000), 1974 (1:25,000), 1978 (1:10,000), and 1985 (1:40,000) from the Ministry of Natural Resources and National Air Photo Library were reviewed to understand site history and inform the erosion hazard assessment. Recent satellite imagery from Google Earth Pro was also reviewed. Copies of this imagery are provided in **Appendix B** for reference.

In 1934, the subject lands and upstream drainage area were actively cultivated. Minor drainage features were visible on the landscape, draining in a northwest to southeast orientation across Dundas Street West, with an overland flow route to the central ravine apparent within the property. A rural residence and associated outbuildings were present on the site, and the Dundas Street bridge crossing Sixteen Mile Creek had been constructed. A narrow buffer of woody riparian vegetation was present along the central and southern ravines but appeared to have been selectively cleared to facilitate agriculture.

In 1954, land use surrounding the property remained predominantly agricultural. Woody vegetation establishment within the riparian zone of the central ravine channel and southern ravines was evident, and tree plantings were visible on the property. The existing pond at the northern extent of the property had been constructed by this time, as well as an additional driveway access from Dundas Street. Outflows from the pond travelled through a narrow forested buffer towards the central ravine channel, though it is not certain whether these flows traveled over land or through a culvert. However, the existing crossing immediately south of the pond is visible in the 1954 image. The inflow source for the constructed pond is not discernable from the available aerial photograph.

The Dundas Street Bridge over Sixteen Mile Creek had expanded from two lanes to four lanes between 1954 and 1965. The driveway access off of Dundas Street was also relocated further west, likely to accommodate the bridge widening. By 1974, a farm road crossing at the downstream extent of the central ravine was visible. This crossing may have been established as early as 1954 but was not explicitly visible in the aerial imagery until 1974. By 1978, construction was underway to widen Dundas Street West from two lanes to four lanes on either side of Sixteen Mile Creek.

Despite the expansion of linear infrastructure, overall land use changes within and around the property were relatively limited between 1954 and 1985. During this period, vegetation in the channel riparian zone continued to establish and was not significantly modified. Vegetation within and around the pond feature became increasingly established as well. Notably, the 1974 image suggests that the drainage feature in the field north of Dundas Street West that may have historically fed the central ravine was directed to a roadside ditch on the north side of Dundas Street West and drained east to Sixteen Mile Creek.

In 2004, one of the rural residential buildings within the subject lands was removed. The vegetation buffer spanning from the pond to the central ravine was reduced, which was presumably associated with the building removal process. It is clear during this time that the pond outflows were directed through an underground culvert to the central ravine channel. In 2016, the remaining rural residential building was removed while the vegetation communities remained relatively unchanged.

Overall, the subject lands have not experienced significant land use changes throughout the period of available record. Vegetation communities were established in the riparian zones of the central and southern ravines and would remain relatively unchanged to present day. The most significant changes were associated with Dundas Street West construction. The drainage features that may have fed the central ravine channel historically appear to have been cut off at Dundas Street West. Thus, it is evident that the drainage area of the central ravine channel has been reduced from its natural extent.

2.2 Surficial Geology

Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity. Understanding local surficial geology is important for delineating the erosion hazard and determining appropriate erosion thresholds, as the stability of the channel banks and bed is dependent on the composition of soils, sediment, and underlying parent materials (MNR, 2002).

The subject lands are located within the South Slope physiographic region. This region is situated on the southern slope of the Oak Ridges Moraine and is characterized by a subdued morainic topography overlying till plains with localized sand and gravel deposits. Drainage is typically controlled by and oriented in the direction of the predominant regional south-facing slope, with exposed red shales of the Queenston Formation being common on valley walls (Chapman and Putnam, 1984). The surficial geology of the subject lands is characterized by both clay to silt-textured till derived from glaciolacustrine deposits or shale (OGS, 2010).

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are divided as such because they are expected to have similar inputs and outputs in terms of sediments and discharge. They are also expected to react similarly throughout to flow events and other stressors. They are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity.

Reaches are delineated based on changes in the following:

- Channel planform
- Channel gradient

- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Certain types of channel modifications by humans

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field.

A single reach was delineated along the relatively small ravine that is central to the subject lands and is labelled as **GCT-1** in **Appendix A**. Reaches of Glenayr Creek adjacent to and upstream of the subject lands were previously delineated in support of a future development north of Dundas Street West. These reaches have been carried forward and included in this report for consistency. **Reach GC-3** extends approximately 280 m upstream from the confluence with **Reach GCT-1**.

3.2 General Reach Observations

Rapid and detailed field assessments were completed along **Reach GCT-1** on August 26, 2021. Observations along **Reach GC-3** were collected on November 2, 2020 and have also been included as conditions along this reach were used to inform toe erosion allowance recommendations. Photographs from the field assessments are provided in **Appendix C**, rapid field observations are provided in **Appendix D**, and the detailed assessment summary is provided in **Appendix E** for reference. A summary of the general observations characterizing the delineated reaches is presented in **Table 1**.

Table 1. Reach characteristics summary

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Notes
GCT-1	3.08	0.24	Cobble, clay, and silt	Clay and silt	Mature trees, herbaceous species in understory	Confined system with valley wall contact, no bedrock exposed in reach, herbaceous vegetation present on channel bed
GC-3	5.29	0.45	Shale cobbles and gravel	Clay, soil, and shale cobbles	Mature trees	Confined system with moderate-high gradient, parent material exposed in banks

Reach GCT-1 is an ephemeral channel contained within the relatively small ravine central to the subject lands. Two small, corrugated pipes are present at the upstream extent of the reach that formerly drained the small pond at the north end of the subject lands. The reach was dry during the time of assessment and likely remains dry outside of major storm events. Mature trees characterize the riparian zone, which extends to the top of the valley walls. Herbaceous vegetation on the channel bed exists throughout approximately 30% of the reach. Bed substrate ranges from

silt and clay to small cobbles, with higher proportions of finer sediment being found at the downstream extent of the reach, where backwatering-induced deposition is evident. Banks are comprised of a silty-clay loam with trace amounts of shale particles. Valley wall contact in the ravine was nearly constant, but evidence of ongoing bank erosion was not excessive, likely due to the ephemeral flow regime and blocked outlet from the upstream pond.

Reach GC-3 is a meandering mixed load channel conveying flows within a confined valley. The channel is entrenched, with poor access to its floodplain and a relatively high gradient. The channel's bed and banks are predominantly composed of shale parent material, with clay rich soils also present on the banks. The channel has an average bankfull width of 5.29 m, and an average bankfull depth of 0.45 m.

3.3 Rapid Assessments

Rapid assessments were completed to identify dominant geomorphic processes, document stream health, and to identify any areas of concern regarding erosion or instability. Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

Reaches were also classified according to a modified Downs (1995) Channel Evolution Model. The Downs Model describes successional stages of a channel because of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system. The results of these assessments are summarized below.

The River Styles Framework (Brierley and Fryirs, 2005) provides a geomorphic approach to examining river character, behaviour, condition and recovery potential through the identification of the Geomorphic Process Zone. Geomorphic attributes are assessed, larger scale interactions between zones are analyzed, and historical data are studies in order to understand the historical evolution and future trajectories of those reaches. This ultimately provides a physical template for river management. A modified classification approach was applied to the study reaches. A summary of the reach classifications and rapid assessment scores is provided in **Table 2**.

For **Reach GCT-1**, the RGA score was 0.28, indicating that the channel was in transition/stress. The dominant geomorphic process shaping the channel in this reach was determined to be widening, largely due to the erosion of the banks. Aggradation was also noted as dominant, but this process was largely confined to the lower-gradient portion of the reach at the downstream extent. The RSAT was not applicable to **Reach GCT-1**, as it was completely dry during the time

of assessment. Under the Downs (1995) model, the dominant channel evolution mechanism was determined to be lateral migration. **GCT-1** was classified as a mixed-load dominated meandering channel under the River Styles Framework (Brierley and Fryirs, 2005).

Table 2: Summary of reach classification and rapid assessment results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs Channel Evolution Model (1995)	River Styles Framework †
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)		
GCT-1	0.28	In transition/ Stress	Aggradation, widening	N/A (Channel dry)			m - Lateral migration	Mixed-load meandering
GC-3	0.38	In transition/ Stress	Widening	23	Fair	Channel stability	U - Undercutting	Mixed load meandering

† Brierley and Fryirs, (2005)

3.4 Detailed Geomorphological Assessment

The detailed geomorphological assessment, used to inform the erosion threshold analysis, was completed on **Reach GCT-1** on August 26th, 2021. Activities completed for the detailed assessment included the following:

- Longitudinal survey of the channel centre line
- Eight detailed cross-section surveys of the watercourse
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Bed material sampling at each cross-section following a modified Wolman (1954) pebble count or substrate sample, as appropriate

The resulting measured channel parameters are outlined in **Table 3** in **Section 4.2**, and a summary of the detailed assessment results is provided in **Appendix E**.

4 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material. As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans.

Erosion thresholds were determined from detailed field observations of **Reach GCT-1**. The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate.

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on

a modified Shield's curve. A velocity approach could also be applied, such as that described by Komar (1987). For cohesive materials, empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1998), could be applied.

4.1 Methods

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, *U* is calculated at various depths for a representative cross section until the average velocity in the cross section slightly exceeds the critical velocity of the bed material. The velocity is determined using a Manning's approach, where the Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using Limerinos' (1970) approach. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2} \qquad \text{[Eq. 1]}$$

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness coefficient. The Limerinos (1970) approach was adopted for determining the Manning's roughness coefficient.

For the bank materials, following Chow (1959) in a simplified cross section, 75% of the bed shear stress acts on the channel banks. In a similar approach, the depth of flow is increased until the shear stress acting on the banks exceeds the resisting shear strength of the bank materials.

4.2 Results

For **Reach GCT-1,** the bed and bank materials were both characterized, and a corresponding permissible velocity for each was obtained from literature. From this, the critical discharge was computed within several representative cross-sections, where the minimum resulting value was selected as the erosion threshold.

The bed materials within **Reach GCT-1** range from silty-clay to cobbles, with a D_{50} below 2 mm. Consequently, limitations exist with the methodologies outlined by Miller et al. (1977) and Komar (1987) for the D_{50}, as the cohesive properties of this finer material are not properly accounted for. The D_{84} material provides a more accurate representation of the dominant, non-cohesive material within the channel and is more suitable for use with the aforementioned methodologies. Further, the composition of the bed material (silt to cobbles) may better suit the methodology outlined by Komar (1987), which accounts for the particle shielding effects that modify critical shear stress and velocity in poorly-sorted sediment environments.

Under Miller et al. (1977), the D_{84} results in a critical shear of 40.94 N/m. The critical shear stress approach to defining the bed material erosion threshold was considered but was ultimately rejected as an appropriate method due to high channel roughness and highly variable grain size.

Under Komar (1987), the D_{84} of 56 mm results in a critical velocity of 1.26 m/s. This was compared to other stated critical velocities within literature. Julien (1998), for non-colloidal graded loam to cobbles, states a critical velocity of 1.14 m/s. To remain conservative, the 1.14 m/s velocity was adopted. The critical velocity from Julien (1998) accounts for the full range of materials present within the bed of **GCT-1**.

The channel banks within **Reach GCT-1** are comprised of a fairly compact silty-clay loam. The material has cohesive properties and is somewhat stabilized by the large root systems present within the banks. For the bank material, a critical velocity of 0.61 m/s for silt loam (Julien, 1998) was adopted as the erosion threshold criteria. As the bank shear stresses are a function of the bed shear stresses, this approach was similarly rejected due to the aforementioned reasons.

Summarized results of the erosion threshold analysis are provided in **Table 3**. The resulting critical discharge required to entrain the bed materials was 0.402 m^3/s. The critical discharge required to entrain the bank materials was 0.117 m^3/s. Thus, the bank material was the limiting factor, and the erosion threshold was defined accordingly by the computed critical discharge of 0.117 m^3/s. The bank-limited erosion threshold is consistent with the findings of the RGA, which identified channel widening (erosion of the banks) as the dominant geomorphic process shaping the channel within **Reach GCT-1**.

The apparent shear stresses acting on bed appear large but are typically overstated in the modelling process. The effective (actual) shear stress applied to bed materials is dissipated by the high roughness from the coarse bed material itself, as well as the encroached vegetation, large woody debris, and meandering planform of the channel. The Miller et al. (1977) shear stress computations do not directly account for high roughness or high quantities of flow impeding structures. Since the velocity computation methods are a partial function of channel roughness, this approach was deemed more suitable and was adopted for the threshold computations.

Table 3: Bankfull conditions and erosion threshold calculation parameters for Reach GCT-1

Channel parameter	Reach GCT-1
Bankfull Conditions	
Average bankfull width (m)	3.08
Average bankfull depth (m)	0.36
Channel gradient (%)	5.94
D_{50} (mm)	<2
D_{84} (mm)	56
Manning's n roughness coefficient	0.050
Bankfull discharge (m^3/s)	1.23
Bankfull velocity (m/s)	1.64
Channel Bed Erosion Threshold	
Bed Material	Silty-clay loam to cobbles, D_{84} = 56 mm
Apparent shear stress acting on bed (N/m^2)	52.45
Critical velocity at the bed (m/s) *	1.26
Critical discharge (m^3/s)	0.403
Channel Banks Erosion Threshold	
Bank Material	Non-colloidal silt loam
Apparent shear stress acting on banks (N/m^2)	28.12
Critical velocity at the banks (m/s)**	0.61

Channel parameter	Reach GCT-1
Critical discharge (m^3/s)	0.117
Limiting Critical discharge (m^3/s)	**0.117**

* Criteria of Julien (1998) for non-colloidal graded loam to cobbles
** Criteria of Julien (1998) for non-colloidal silt loam

Using a drainage area of 4.281 ha provided by R.V. Anderson Associates Ltd., a unitary threshold of 0.0274 $m^3/s/ha$ was computed. This value is significantly higher than other established erosion thresholds in the Town of Oakville and is likely a result of the small existing drainage area. As evidenced by the historical aerial photograph analysis, **Reach GCT-1** originally likely had a drainage area that extended into the agricultural fields north of Dundas Street. Connectivity to the northern extent of the drainage area past Dundas Street was removed, likely due to the road widening and pond construction activities adjacent to and within the site. It is therefore expected that the true drainage area for **Reach GCT-1**, which had historically formed and sized the channel, was significantly larger than the existing drainage area. Thus, the true unitary erosion threshold would be much lower than the stated value of 0.0274 $m^3/s/ha$.

For comparison, a critical discharge erosion threshold of 0.55 m^3/s was established by GEO Morphix (2020) for Glenayr Creek **Reach GC-3** in support of a separate development. The 120.2 ha drainage area for **Reach GC-3**, obtained from the Ontario Flow Assessment Tool (OFAT), extended beyond Dundas Street, resulting in a unitary erosion threshold of 0.0046 $m^3/s/ha$. Despite having comparably similar bankfull dimensions, the drainage area obtained for **GC-3** is orders of magnitude larger than that of **GCT-1**. This discrepancy provides further evidence that the existing drainage area for **GCT-1** is undersized relative to its bankfull dimensions, and that the true unitary erosion threshold is smaller than 0.0274 $m^3/s/ha$.

5 Post- to Pre-Development Erosion Exceedance Assessment

Using the results of the erosion threshold analysis and hydrological modelling, provided by R.V. Anderson Associates Limited (2021) for post- and pre-development conditions, additional analyses regarding the impacts of SWM controls on potential erosion within the receiving watercourse was completed with our own in-house model, based on four indices:

1) Cumulative time of exceedance
2) Number of exceedance events
3) Cumulative effective discharge
4) Cumulative effective work index (i.e. cumulative effective stream power)

These indices have been applied elsewhere in Conservation Halton's jurisdiction, as well as the jurisdictions of the Toronto and Region Conservation Authority and Credit Valley Conservation. They, as a product, provide an evaluation of the number of events, period of transport, and magnitude. We note that the most relevant indicator is the cumulative effective stream power.

Time of exceedance and number of exceedances can be simply calculated from the discharge record. For more relevant indicators, hydraulic information is required. Our model applies the discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each

time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross section and channel roughness. This provides analysis that is site appropriate and specific.

The post- and pre-development hydrological modelling reflects changes to the hydrological regime resulting from SWM measures being implemented within the catchment. Flow data was provided by R.V. Anderson Associates Limited (2021) in 10-minute increments for synthetic 25 mm, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Chicago storm events. The hydrological modeling was analyzed to calculate the aforementioned erosion indices to identify changes in the erosive potential within **GCT-1** following development.

5.1 Methods

To calculate work terms, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, *U*, is calculated for each panel using the Manning's approach. This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i, such that:

$$Q_{T=} \sum Q_i \qquad \text{[Eq. 2]}$$

Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 3]}$$

where, w_i and d_i are width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{\max}}$ based on:

$$\tau_{o_{\max}} = d_{\max} \rho g S_{\text{bed}} \qquad \text{[Eq. 4]}$$

where, $d_{\max}$ is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\max}} . U_{\text{avg}} . \Delta t \qquad \text{[Eq. 5]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr}.U.\Delta t, \omega < 0 = 0 \quad \text{[Eq. 6]}$$

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{\text{ex}} = \sum \Delta t \ \text{ for } (Q_T > Q_{\text{threshold}}) \quad \text{[Eq. 7]}$$

where, $Q_{\text{threshold}}$ is the discharge at the erosion threshold.

5.2 Results

The full series of post- to pre-development hydrographs are included in **Appendix E**, and include the erosion threshold based on discharge, for reference. **Table 4** provides the results of the assessment based on the hydrographs provided by R.V. Anderson Associates Limited (2021).

Table 4: Post- to pre-development erosion exceedance analysis results for Reach GCT-1

Simulation		CED (m^3/s)	ω_{eff} (N/m^2)	t_{ex} (hrs)
25 mm	**(PRE)**	0.00	0.00	0.00
	(POST)	0.00	0.00	0.00
	Change (%)	**0%**	**0%**	**0%**
2-Year	**(PRE)**	0.00	0.00	0.00
	(POST)	0.00	0.00	0.00
	Change (%)	**0%**	**0%**	**0%**
5-Year	**(PRE)**	0.07	1.82	0.50
	(POST)	0.04	0.07	0.33
	Change (%)	**-44.13%**	**-96.09%**	**-33.33%**
10-Year	**(PRE)**	0.09	5.23	0.50
	(POST)	0.13	4.19	0.83
	Change (%)	**35.24%**	**-19.94%**	**66.67%**
25-Year	**(PRE)**	0.15	10.52	0.67
	(POST)	0.24	13.20	1.33
	Change (%)	**66.63%**	**25.50%**	**100.00%**
50-Year	**(PRE)**	0.17	14.63	0.67
	(POST)	0.30	19.21	1.50
	Change (%)	**76.14%**	**31.27%**	**125.00%**

Simulation		CED (m^3/s)	ω_{eff} (N/m^2)	t_{ex} (hrs)
100-Year	(PRE)	0.22	19.54	0.83
	(POST)	0.40	25.81	2.00
	Change (%)	**82.39%**	**32.11%**	**140.00%**

It is noted that the cumulative effective discharge (CED) and cumulative effective work index (ω_{eff}) are considered the most relevant erosion indices, as they reflect both the severity and duration of an exceedance event. Further, storms of moderate magnitudes and of relatively frequent recurrence typically exert the most influence on a given channel's geomorphic regime. Results from the 25 mm event and, to a lesser extent, the 2-year event are therefore the most relevant storm simulations in the context of evaluating erosion potential following hydrological regime changes.

For the 25 mm and 2-year storms, no exceedance events were predicted, as flows entering the reach did not exceed the threshold discharge under the post- and pre-development hydrological conditions. For the 5-year event, the CED is predicted to decrease by 44.13% in the post-development hydrological conditions relative to the existing conditions. The ω_{eff} is predicted to decrease by 96.09% and the cumulative exceedance duration (t_{ex}) by 33.33%. For the 10-year event, increases of 32.24% and 66.67% are predicted for the CED and t_{ex}, respectively, while the ω_{eff} is predicted to decrease 19.94%. For the larger, less-frequent storms, the CED is predicted to increase by 66.63-82.39%, he ω_{eff} is by 25.50-32.11%, and the t_{ex} by 100-140%.

The lack of exceedance events for the 25 mm and 2-year event is likely attributable to the historical reduction of the catchment area, leading to an oversized channel relative to the modelled flows. Since no exceedance events were predicted for either the post- or pre-development conditions, the channel is expected to retain its existing limited geomorphic function and dynamics during 25-mm and 2-year events. Further, the decrease in erosion potential predicted for the 5-year event is expected to offset the moderate increases predicted for the larger, less frequent storms. Thus, the modelling results indicate that exacerbated rates of erosion resulting from development will not occur within Reach **GCT-1**.

6 Erosion Hazard Assessment

The location and extent of erosion hazards associated with a given creek system are typically delineated in support of activities where infrastructure is proposed within or adjacent to a watercourse (e.g., new/replacement crossing structures and various types of land development). The extent of the hazard informs, in part, constraints to a proposed activity. When defining the erosion hazard for a creek system, TRCA (2004) and MNR (2002) protocols treat unconfined and confined systems differently. Confined systems are those where the watercourse is contained within a defined valley, where contact between the watercourse and a valley wall is possible. Partially confined systems are those where meander bends are adjacent to only one valley wall and the watercourse is therefore restricted in migration and floodplain occupation on one side of the valley system.

In contrast, unconfined systems are those with poorly defined valleys or slopes that are well-outside where the channel could realistically migrate. Unconfined systems are generally found within glaciated plains with flat or gently rolling topography. In this setting, a meander belt width assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future.

Reaches GCT-1 and **GC-3** are confined systems. In confined systems where the channel is less than 15 m from the toe of the valley slope, the erosion hazard can be delineated using a toe erosion allowance, stable slope allowance, and an erosion access allowance. Following MNR (2002) guidelines, the toe erosion allowance can be determined by 1) calculating the average annual recession rate based on a minimum of 25 years of record, 2) applying a 15 m toe erosion allowance measured inland horizontally and perpendicular to the toe of the watercourse slope, 3) identifying a toe erosion allowance based on soil types and hydraulic processes, or 4) use of a study that applies accepted geotechnical and engineering principles based on a minimum of 25 years of record.

In this case, channel migration rates could not be measured due to the presence of trees along the ravine corridors (i.e., planform not clearly visible). Table 3 in the MNR (2002) guidelines provides recommendations for an appropriate toe erosion allowance based on evidence of erosion, channel bank composition and bankfull channel width. With regard to **Reach GCT-1**, there was limited evidence of active erosion due to the blocked culvert between the remnant pond and the ravine. Should stormwater outlet to the central ravine is it anticipated that the channel will be activated on a regular basis. A toe erosion allowance of 5 m is recommended due to the presence of clay/silt in the channel banks. A toe erosion allowance of 2 m is recommended for **Reach GC-3.** This is due to the presence of shale bedrock in the channel banks, which will act to limit erosion at the channel toe. The recommended toe erosion allowances should be considered in conjunction with the geotechnical study prepared under separate cover by B.I.G. Consulting Inc.

7 Summary and Recommendations

GEO Morphix was retained to complete an erosion hazard and mitigation assessment for the proposed Delmanor West Oak development at 1280 Dundas St. West, Oakville, Ontario. Our assessment included a review of previously completed reports and secondary source information, an examination of site history, determination of the erosion threshold based on the detailed geomorphological assessment completed in August 2021 and toe erosion allowance recommendations in support of the erosion hazard assessment and slope stability assessment being undertaken by others.

The site history assessment was completed using a series of historical images ranging from 1934 to 2016. Land use change within and upstream of the subject lands has been relatively limited throughout the period of available record. No significant changes in channel planform were noted for **Reach GCT-1**, but a large reduction in its natural drainage area was evident. The drainage features which naturally fed **Reach GCT-1** were cut off at Dundas Street. In addition, it is understood that the pipe that formerly directed discharge from the remnant pond to the central ravine is currently blocked in multiple locations.

The purpose of the erosion threshold analysis was to provide an appropriate critical discharge (the theoretical discharge at which the bed or bank materials will become entrained) to support the sizing and release rate planning procedures associated with the proposed underground SWM storage facility. To complete this, rapid and detailed assessments were conducted within the receiving watercourse (**Reach GCT-1**). An erosion threshold was determined from the field assessment data and was expressed as a critical discharge of 0.117 m^3/s. Maintaining a post-development flow regime that exceeds this threshold discharge at similar frequencies and magnitudes to the existing conditions will help preserve the function and stability of the receiving watercourse. Due to the historical differences in drainage area, the unitary erosion threshold of 0.0274 $m^3/s/ha$ is considered large and should not be used for SWM planning purposes outside of the subject lands.

A post- to pre-development comparison of erosion indices was completed using the hydrological modelling provided by R.V. Anderson Associates Limited (2021) and the erosion threshold determined for **Reach GCT-1**. While the applicability of this approach was limited by the historical truncation of the drainage area, the results indicated that no exacerbated rates of erosion are expected within **Reach GCT-1** as a consequence of the development. The channel within **GCT-1** is expected to maintain its current geomorphological regime in the post-development condition. Thus, no additional modifications to the proposed SWM plan are recommended.

An erosion hazard assessment was completed for Reaches **GCT-1** and **GC-3**, adjacent to the proposed development. As these reaches are treed ravines that are confined, the erosion hazard can be delineated following MNR (2002) guidelines. A 5 m toe erosion allowance is recommended for **Reach GCT-1** as it has banks composed of clay/silt. A 2 m toe erosion allowance is recommended for **Reach GC-1** as exposed shale was observed in the channel banks, which will act to limit erosion at the bank toe. These recommendations should be considered in conjunction with the geotechnical study prepared under separate cover by B.I.G. Consulting Inc.

We trust this report meets your requirements. Should you have any questions please contact the undersigned.

Respectfully submitted,

Paul Villard Ph.D., P.Geo., CAN-CISEC
Director, Principal Geomorphologist

Suzanne St. Onge, M.Sc.
Senior Environmental Scientist

John Tweedie, M.Sc.
Environmental Scientist

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Appendix A
Reach Delineation

Legend

- GC-2 Reach Breaks and Label
- Watercourse
- Piped
- Detailed Assessment Extent
- Contour (0.25 m)
- Pond
- Study Area

Delmanor West Oak Inc.

Study Area and Reach Delineation

Oakville, Ontario

N

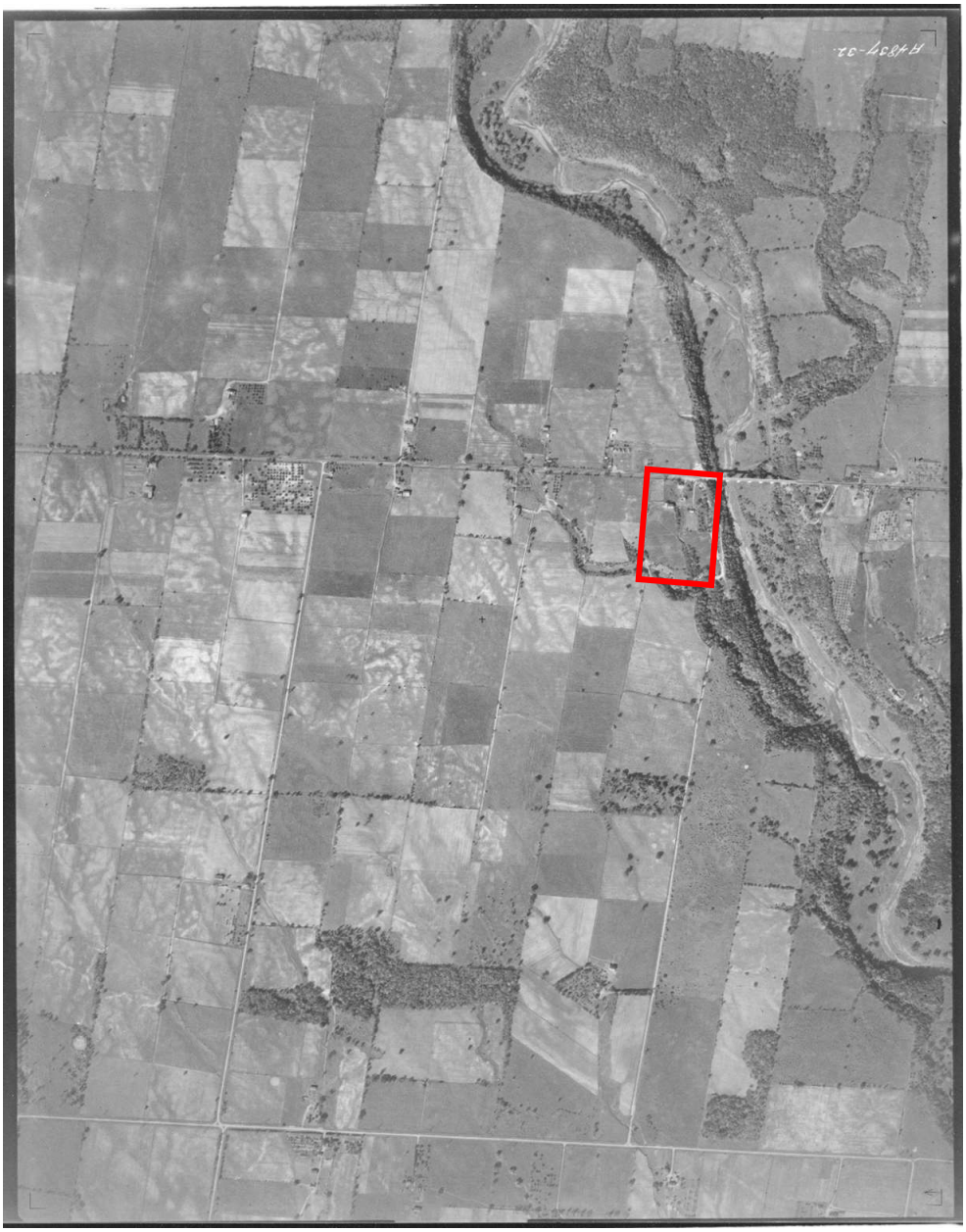
0 20 40

Metres

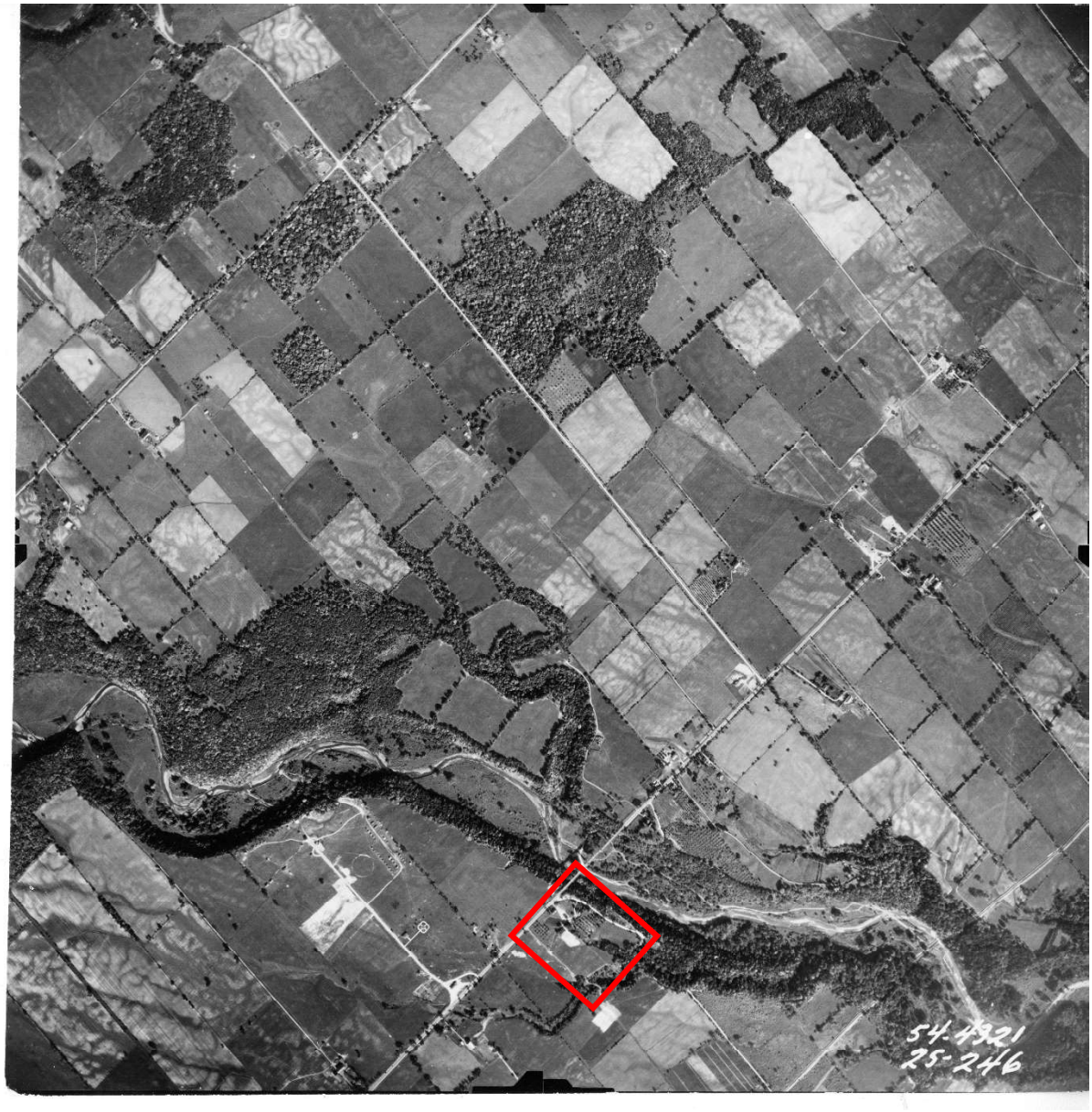
GEO MORPHIX™

Imagery: Town of Oakville, 2017.
Watercourse: Town of Oakville, 2020/GEO Morphix Ltd., 2021.
Culvert, Reach Break, Detailed Assessment, Pond: GEO Morphix Ltd., 2021.
Contour: JD Barnes, 2020.
Study Area: GEO Morphix Ltd., 2021.
Print Date: September 2021. PN21077. Drawn By: M.O., J.T., S.S.

Appendix B
Historical Aerial Imagery



Location: 1280 Dundas St W, Oakville, ON
Year: 1934
Scale: 1:20:000
Source: Ministry of Natural Resources



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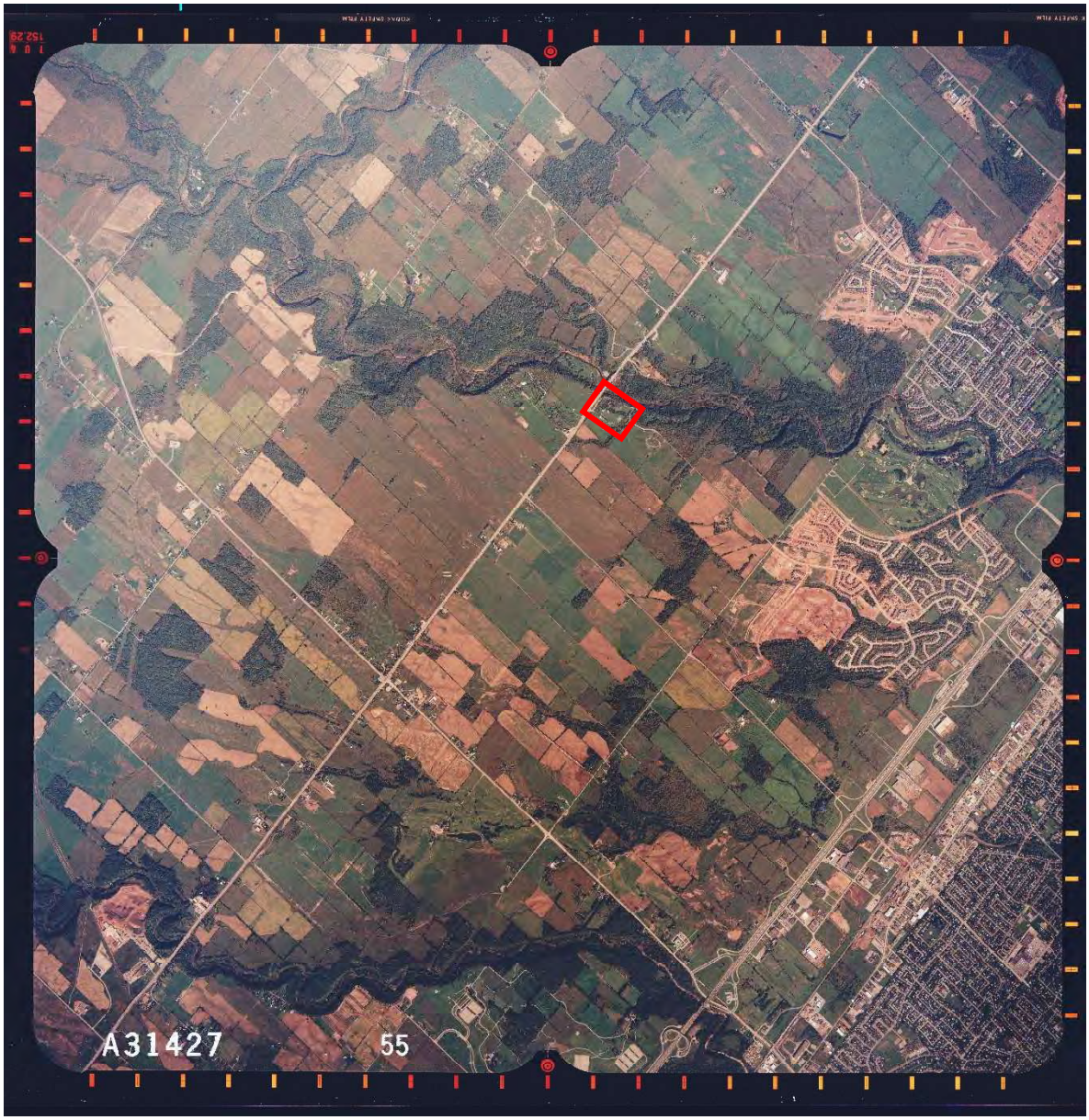
Year: 1954
Scale: 1:15,840
Source: Ministry of Natural Resources

Location: 1280 Dundas St W, Oakville, ON
Year: 1954
Scale: 1:15,840
Source: Ministry of Natural Resources

Location: 1280 Dundas St W, Oakville, ON
Year: 1965
Scale: 1:20,000
Source: National Air Photo Library

Location: 1280 Dundas St W, Oakville, ON
Year: 1974
Scale: 1:25,000
Source: National Air Photo Library

Location: 1280 Dundas St W, Oakville, ON
Year: 1978
Scale: 1:10,000
Source: Ministry of Natural Resources



Location: 1280 Dundas St W, Oakville, ON
Year: 1985
Scale: 1:40,000
Source: National Air Photo Library

Appendix C
Photo Record

Photo 1
Reach GCT-1 – Tributary of Sixteen Mile Creek

Upstream view towards the upstream extent of the ravine feature. The two culverts, left to right, were approximately 0.40 m and 0.30 m in diameter.

Photo 2
Reach GCT-1 – Tributary of Sixteen Mile Creek

Photograph taken in the upper section of the reach looking downstream where the channel gained definition.

Photo 3
Reach GCT-1 – Tributary of Sixteen Mile Creek

The riparian buffer zone was 4 to 10 channel widths. Riparian vegetation was comprised of a mix of mature tree species. Leaning/fallen trees, indicated by the red circle were observed approximately every 50 meters in the channel.

Photo 4
Reach GCT-1 – Tributary of Sixteen Mile Creek

Photograph taken looking downstream. The reach consisted of riffles and bed materials consisted primarily of cobble embedded by clay and silt. No shale bedrock was exposed in the channel bed or banks.

Photo 5
Reach GCT-1 – Tributary of Sixteen Mile Creek

Downstream view of the watercourse. The reach was dry at the time of assessment. Average bankfull width and depth were 3.08 m and 0.24 m, respectively.

Photo 6
Reach GCT-1 – Tributary of Sixteen Mile Creek

Photo taken at the downstream extent of reach, facing downstream. The culvert connected to Reach GC2 and was approximately 0.5 m in diameter.

Photo 7
Reach GC-3 – Tributary of Sixteen Mile Creek

Flows exited the culvert south of Glenayr Gate into a stone treatment. No scour was noted downstream of the outlet.

Photo 8
Reach GC-3 – Tributary of Sixteen Mile Creek

Reach **GC-3** was characterized as a narrow, confined, forested valley with a high gradient.

Photo 9
Reach GC-3 – Tributary of Sixteen Mile Creek

Several instances of valley wall contact and erosion were noted in **Reach GC-3**.

Photo 10
Reach GC-3 – Tributary of Sixteen Mile Creek

Exposed parent-material, Queenston shale, was frequently observed along the channel banks.

Photo 11
Reach GC-3 – Tributary of Sixteen Mile Creek

Mature tree roots were commonly exposed on the banks. Substrate was coarse and consisted of platy pebbles and cobbles derived from the shale material.

Photo 12
Reach GC-3 – Tributary of Sixteen Mile Creek

The meandering planform was constricted by the narrow valley corridor. Valley wall slopes were steep but well vegetated with mature trees. Grasses were largely absent.

Appendix D
Field Observations

Reach Characteristics Key

Table 1 Land Use
1. Forest
2. Pasture
3. Agricultural
4. Industrial
5. Park
6. Institutional
7. Residential
8. Golf Course
9. Commercial

Table 2 Valley Type
1. Unconfined
2. Confined
3. Partially Confined

Table 3 Channel Type

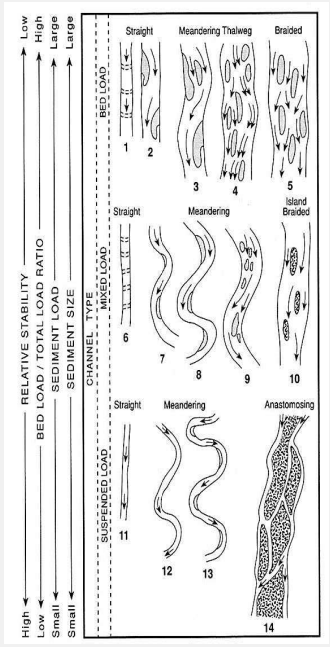


Table 4 Channel Zone
1. Headwater zone
2. Transfer zone
3. Deposition zone

Table 5 Flow Type
1. Perennial
2. Intermittent
3. Ephemeral

Table 6 Dominant Vegetation Type
1. Trees
2. Shrubs
3. Grasses
4. Herbaceous

Table 7 Extent of Encroachment into Channel
1. None
2. Minimal
3. Moderate
4. Heavy
5. Extreme

Table 8 Type of Aquatic Vegetation
1. Rooted Emergent
2. Rooted Submergent
3. Rooted Floating
4. Free Floating Roots
5. Floating Algae
6. Attached Algae

Table 9 Type of Sinuosity
1. Sinuous
2. Irregular Meanders
3. Regular Meanders
4. Tortuous Meanders
5. Confined pattern (within valley)

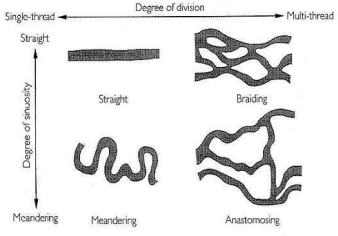


Table 10 Degree of Sinuosity
1. Straight (1 – 1.05)
2. Low sinuosity (1.06–1.30)
3. Meandering (1.31 - 3.0)

Table 11 Gradient
1. Low
2. Moderate
3. High

Table 12 Number of Channels
1. Single
2. Up to 3 (Wandering)
3. >3 (Braided)
4. >3 (Anastamosing or Anabranching)
5. Discontinuous or Absent

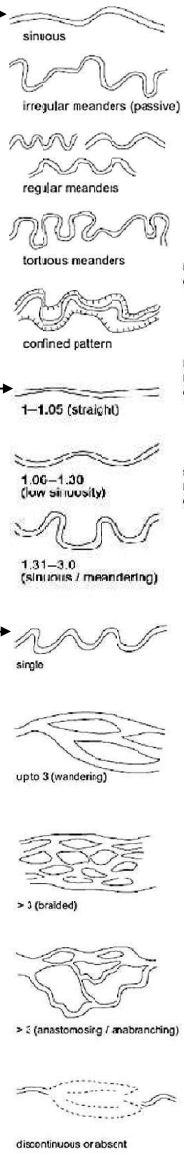
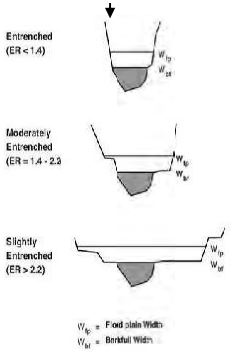


Table 13 Entrenchment
1. Low (>2.2)
2. Moderate (1.4 – 2.2)
3. High (<1.4)



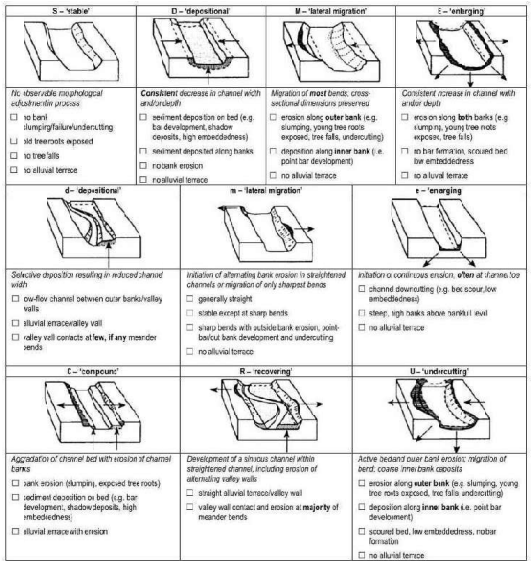


Table 14 Type of Bank Failure
1. Fluvial Entrainment (Hydraulic action)
2. Undercutting (Hydraulic action)
3. Slab Failure (Mass failure)
4. Parallel slide (Mass failure)
5. Fall/Sloughing (Mass failure)
6. Rotational slip and slump (Mass failure)

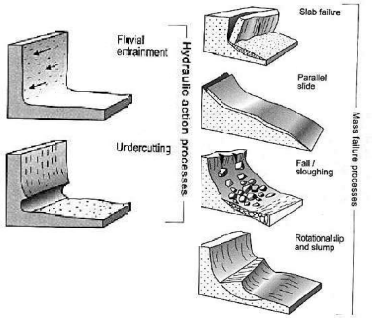


Table 15 Downs's Model of Channel Classification
S – Stable
D or d – Depositional
M or m – Lateral Migration
E or e – Enlarging
C – Compound
R – Recovering
U – Undercutting

Table 16 Odours
1. None
2. Fishy
3. Petroleum
4. Sewage
5. Chemical
6. Other

Table 17 Turbidity
1. Clear
2. Slightly turbid
3. Turbid
4. Opaque
5. Stained
6. Other

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: PN21077

Date:	08-26-2021	**Stream/Reach:**	GCT1 (Ravine Feature)
Weather:	Sunny, 38°C	**Location:**	Oakville
Field Staff:	JT + DV	**Watershed/Subwatershed:**	16MC
UTM (Upstream)	4812314.48, 601045.40	**UTM (Downstream)**	4812277.31, 601181.74

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☐ Groundwater | Evidence: N/A

Riparian Vegetation

Dominant Type: (Table 6): 1
Species: _____

Coverage:
- ☐ None
- ☐ Fragmented
- ☒ Continuous

Channel widths
- ☐ 1-4
- ☒ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☐ Established (5-30)
- ☒ Mature (>30)

Encroachment: (Table 7): 3

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 30

Woody Debris
- ☐ Present in Cutbank
- ☒ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☒ Moderate
- ☐ High

WDJ/50m: 4

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): N/A

Channel Characteristics

Sinuosity (Type) (Table 9): 2
Sinuosity (Degree) (Table 10): 3
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 3
Type of Bank Failure (Table 14): 1
Downs's Classification (Table 15): R

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☒	☐	☐	☒	☐	☐	☐
Pool Substrate (N/A)	☐	☐	☐	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	2.33	3.27	2.98	**Wetted Width (m)**	N/A	N/A	N/A
Bankfull Depth (m)	0.22	0.19	0.24	**Wetted Depth (m)**	N/A	N/A	N/A

Riffle/Pool Spacing (m): N/A | **% Riffles:** 80 | **% Pools:** N/A | **Meander Amplitude:** N/A

Pool Depth (m): N/A | **Riffle Length (m):** 15 | **Undercuts (m):** N/A

Velocity (m/s) (Wiffle ball / ADV / Estimated): N/A | N/A | N/A

Bank Angle
- ☐ 0 – 30
- ☒ 30 – 60
- ☒ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☒ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Comments: Channel predominantly made of riffles

Notes: Channel dry at time of assessment, confined valley, no shale exposed, vegetation present on bed of channel.

Completed by: DV | Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment **Project Code:** PN21077

Date:	2021-08-26	**Stream/Reach:**	Ravine Feature
Weather:	Sunny, 38°C	**Location:**	Oakville
Field Staff:	JT + DV	**Watershed/Subwatershed:**	16 MC

Process	Geomorphic Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		X	3/7
	2	Coarse materials in riffles embedded	X		
	3	Siltation in pools	X		
	4	Medial bars		X	
	5	Accretion on point bars		X	
	6	Poor longitudinal sorting of bed materials	X		
	7	Deposition in the overbank zone		X	
		Sum of indices =			0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		0/7
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)		X	
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets		X	
	6	Cut face on bar forms		X	
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		3/7
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		X	
	6	Outflanked gabion baskets / concrete walls / etc.		X	
	7	Length of basal scour >50% through subject reach	N/A		
	8	Exposed length of previously buried pipe / cable / etc.	N/A		
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation	N/A		
		Sum of indices =			0.43
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	2/7
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form	X		
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		X	
	7	Bar forms poorly formed / reworked / removed	X		
		Sum of indices =			0.29

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.28

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☒ 0.21 - 0.40	☐ 0.41

Completed by: DV Checked by: _____

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code/Phase: PN300048

Date:	2020-11-03	**Stream/Reach:**	GC-3
Weather:	SUNNY 4°C	**Location:**	OAKVILLE
Field staff:	BB JY	**Watershed/Subwatershed:**	16 MC
UTM (Upstream)		**UTM (Downstream)**	

CEMETERY OS HALF

Land Use (Table 1): 7 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 9 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: _____

Riparian Vegetation

Dominant Type: (Table 6): 1
Species: _____

Coverage:
- ☐ None
- ☐ Fragmented
- ☑ Continuous

Channel widths:
- ☑ 1-4
- ☐ 4-10
- ☐ > 10

Age Class (yrs) :
- ☐ Immature (<5)
- ☐ Established (5-30)
- ☑ Mature (>30)

Encroachment: (Table 7): 3

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): <5

Woody Debris
- ☑ Present in Cutbank
- ☑ Present in Channel
- ☐ Not Present

Density of WD:
- ☐ Low
- ☐ Moderate
- ☑ High

WDJ/50m: 5

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9): 2-3
Sinuosity (Degree) (Table 10): 5
Gradient (Table 11): 2
Number of Channels (Table 12): 1
Entrenchment (Table 13): 1
Type of Bank Failure (Table 14): 2
Downs's Classification (Table 15): U

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☑	☑	☑	☐	☐	☐
Pool Substrate	☑	☑	☐	☐	☐	☐	☐
Bank Material	☑	☐	☐	☐	☐	☑	☑

	1	2	3		1	2	3
Bankfull Width (m)	3.60	0.69	4.30	**Wetted Width (m)**	1.88	0.60	0.64
Bankfull Depth (m)	0.50	0.25	0.40	**Wetted Depth (m)**	0.10	0.05	0.03

Riffle/Pool Spacing (m): \ | **% Riffles:** 40 | **% Pools:** 30 | **Meander Amplitude:** \

Pool Depth (m): 0.26 | **Riffle Length (m):** ~4.5 | **Undercuts (m):** 0.45 | **Comments:** _____

Velocity (m/s): 0 | 0 | 0 | **Wiffle ball / ADV / (Estimated)**

STANDING WATER

Bank Angle
- ☐ 0 – 30
- ☑ 30 – 60
- ☑ 60 – 90
- ☑ Undercut

Bank Erosion
- ☐ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☑ 60 – 100%

Notes:

BF 4 MEASUREMENT
→ BF W: 4.68 m
D: 0.50 m
W W: 2.53 m
D: 0.03 m
V = 0 m/s

Completed by: BB Checked by: _____

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: PN30048

Date:	2020-11-03	**Stream/Reach:**	GC-3
Weather:	SUNNY 4°C	**Location:**	OAKVILLE
Field Staff:	BB JV	**Watershed/Subwatershed:**	16 MC

Process	Geomorphic Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		✓	1/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	1	6	0.14
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	✓		2/8
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knick point migration		✓	
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock	✓		
		Sum of indices =	2	6	0.25
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		5/7
	2	Occurrence of large organic debris	✓		
	3	Exposed tree roots	✓		
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle	✓		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.	N/A		
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation	N/A		
		Sum of indices =	5	2	0.71
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		3/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form	✓		
	7	Bar forms poorly formed / reworked / removed	✓		
		Sum of indices =	3	4	0.43

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.38

Condition	In Regime	In Transition/Stress	In Adjustment
SI score =	☐ 0.00 - 0.20	☑ 0.21 - 0.40	☐ 0.41

Completed by: BB Checked by: _____

Rapid Stream Assessment Technique

Project Code: PN30048

Date:	2020-11-03	**Stream/Reach:**	GC-3
Weather:	SUNNY 4°C	**Location:**	OAKVILLE
Field Staff:	BB JV	**Watershed/Subwatershed:**	16 MC

Evaluation Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ **0** ☐ **1** ☐ **2**	☑ **3** ☐ **4** ☐ **5**	☐ **6** ☐ **7** ☐ **8**	☐ **9** ☐ **10** ☐ **11**
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ **0** ☐ **1** ☐ **2**	☐ **3** ☐ **4**	☐ **5** ☑ **6**	☐ **7** ☐ **8**

Date:	2020-11-03	Reach:	GC-3	Project Code:	PN20048

Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C N/A	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☑ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☑ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 23	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: BD Checked by: _____

Appendix E
Detailed Assessment Summary

Detailed Geomorphological Assessment Summary

Reach GCT1

Project Number:	PN21077	**Date:**	2021-08-26
Client:	Delmanor West Oak Inc.	**Length Surveyed (m):**	105.8
Location:	Oakville, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	4.281	**Dominant Riparian Vegetation Type:**	Trees, herbaceous
Geology/Soils:	Clay to silt till, shale	**Extent of Riparian Cover:**	Continuos
Surrounding Land Use:	Residential	**Width of Riparian Cover:**	4-10 channel widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature
Dominant Instream Vegetation Type:	Herbaceous	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	30	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.00	**Calculated Bankfull Discharge (m^3/s):**	1.23
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.64
Modelled 2-year Velocity (m/s):	Not modelled		

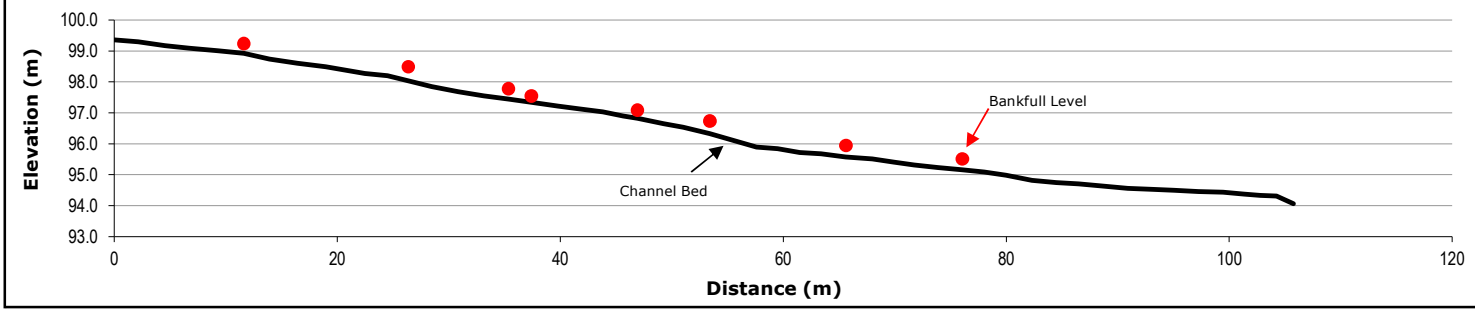
Profile Characteristics

Bankfull Gradient (%):	5.94
Channel Bed Gradient (%):	5.26
Riffle Gradient (%):	n/a
Riffle Length (m):	n/a
Riffle-Pool Spacing (m):	n/a

Planform Characteristics

Sinuosity:	1.32
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.25	1.10	0.64
Bank Angle (deg):	0.6	90	58
Root Depth (m):	0.10	30.00	2.91
Root Density (%):	5	25	12
Bank Undercut (m):	0.05	0.06	0.06

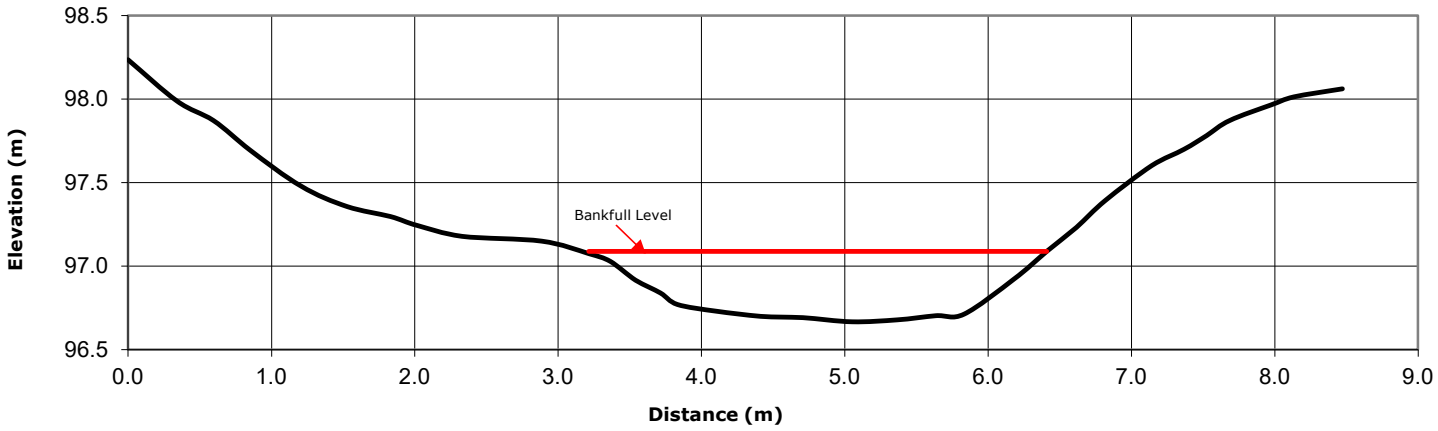
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Silty-clay loam, trace shale	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	2.33	3.50	3.08
Average Bankfull Depth (m):	0.19	0.32	0.24
Bankfull Width/Depth (m/m):	10	17	13
Wetted Width (m):	0.00	0.00	0.00
Average Water Depth (m):	0.00	0.00	0.00
Wetted Width/Depth (m/m):	n/a	n/a	n/a
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.00	0.00	0.00
Manning's *n*:		0.058	

Photograph at cross section 5 (looking upstream)

Representative Cross-Section #5



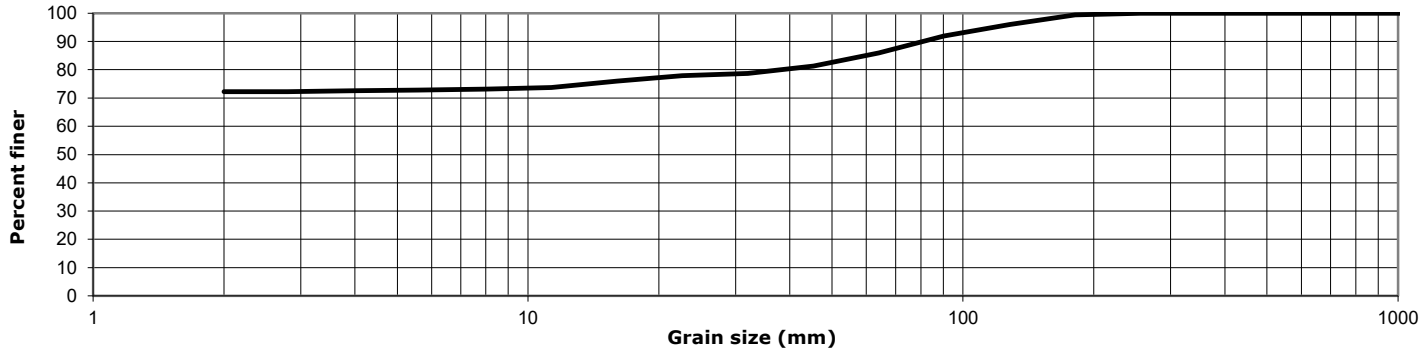
Substrate Characteristics

Particle Size (mm)

D_{10} :	2.0
D_{50} :	2.0
D_{84} :	56.2

Subpavement:	Shale
Particle shape:	Sub-rounded, platy
Embeddedness (%):	20-60%
Particle range (riffle):	Silt to cobbles
Particle Range (pool):	Silt to gravel

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	142.34
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	1.26	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	233.63		

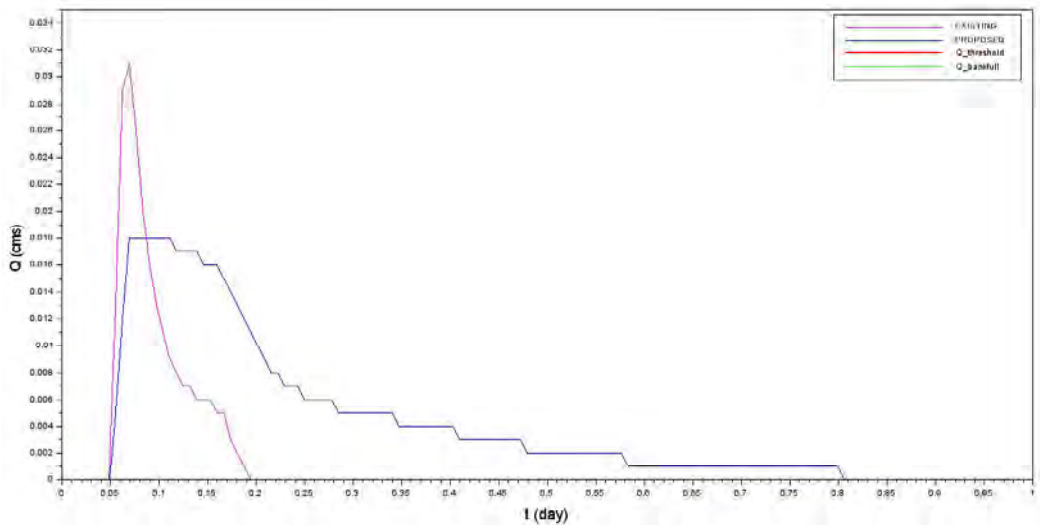
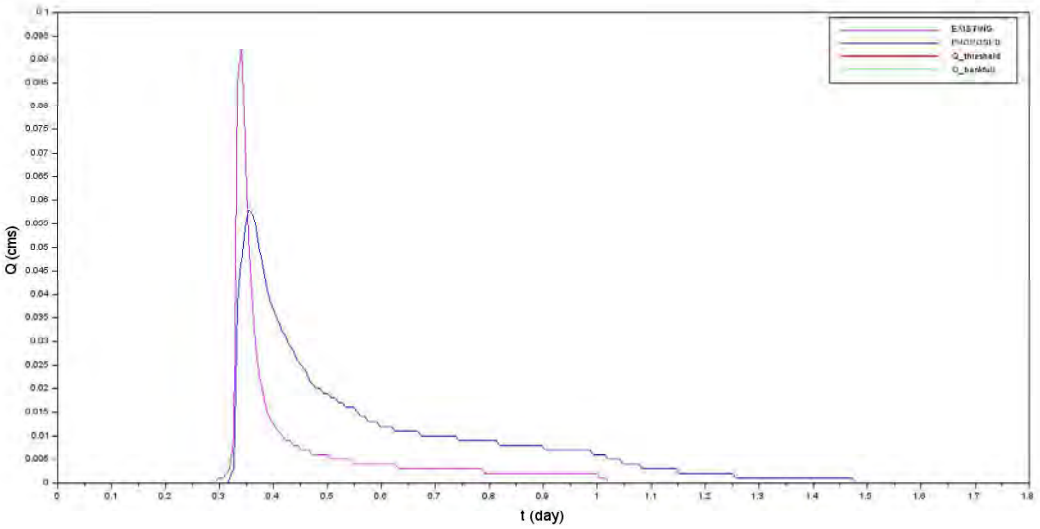
General Field Observations

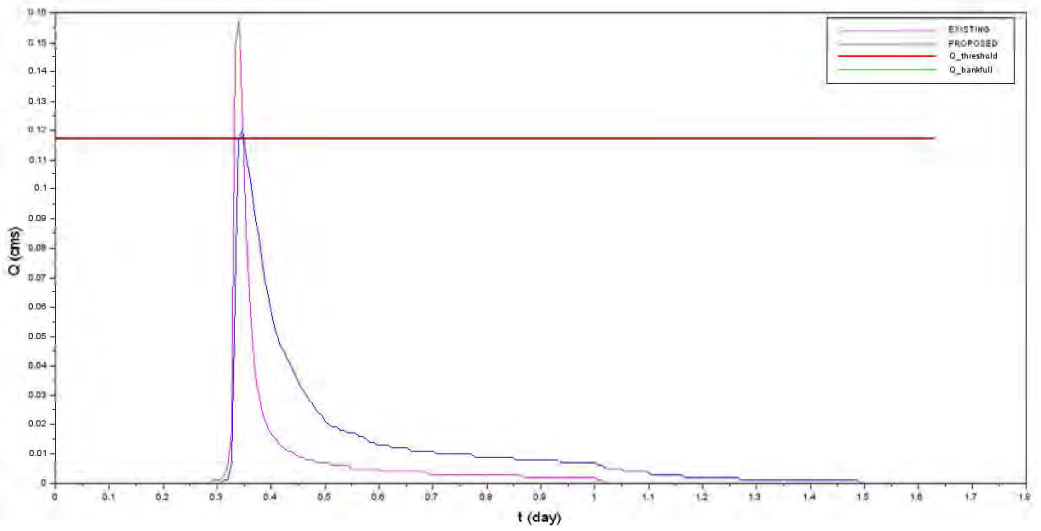
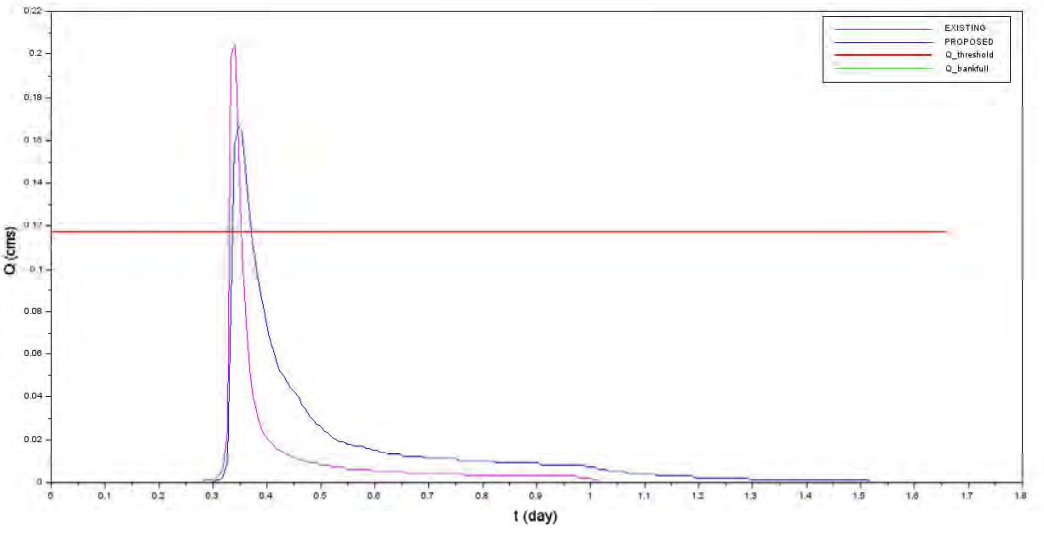
Channel Description

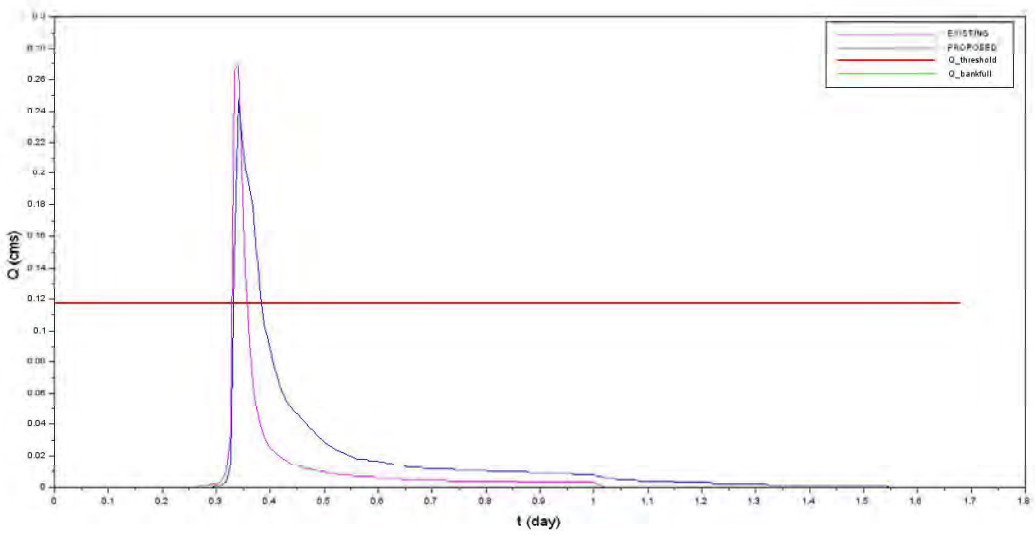
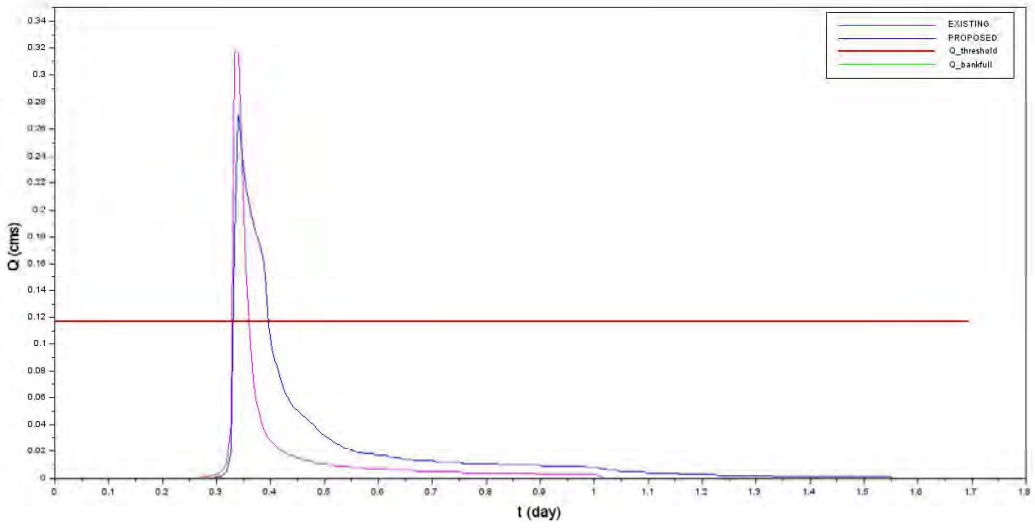
Reach GCT1 flows through the ravine central to the subject property. The channel follows a meandering planform, confined within the valley and making contact with the valley walls in several locations. Evidence of active erosion was minimal, with undercutting up to only 0.06 m noted at two cross-sections. The channel was dry during the time of assessment. The riparian zone is confined to the valley extent, and is characterized by mature trees. Approximately 30% of the channel bed was encroached by herbaceous and grassy vegetation. Average bankfull width and depth were 3.08 and 0.24 m, respectively. Bed substrate ranges from silt to platy cobbles, while the bank material is characterized as a silty-clay loam throughout.

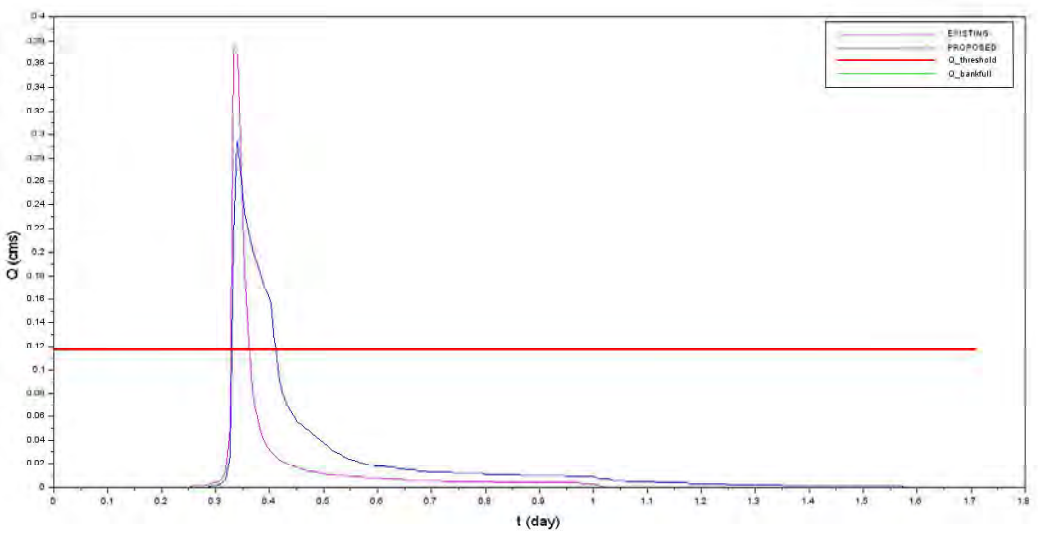
Cross Section 6 - Facing Upstream

Appendix F
Hydrographs

GCT-1 25 mm event	
GCT-1 2-year event	

GCT-1 5-year event	
GCT-1 10-year event	

GCT-1 25-year event	
GCT-1 50-year event	

GCT-1 100-year event	

Appendix B: Record of Boreholes

NOTES TO RECORD OF BOREHOLES

DRILLING METHOD		SAMPLE TYPE		LABORATORT DATA	
SSA	Solid Stem Auger	SS	Split Spoon	W	Water Content
HSA	Hollow Stem Auger	AS	Auger Flight Sample	W_p	Plastic Limit
WB	Wash Boring	TW	Thin Wall Open	W_l	Liquid Limit
RM	Rotary Mud Drilling	TP	Thin Wall Piston	γ	Natural Unit Weight (kN/m^3)
		WS	Washed Sample	C_u	Undrained Shear Strength (kPa)
		VT	Vane Test	PP	Pocket Penetrometer
		GS	Grab Sample	UC	Unconfined Compression
		RC	Rock Core	UU	Unconsolidated Undrained
		PH	Sample Advanced Hydraulically	CU	Consolidated Undrained
		PM	Sample Advanced Manually	CD	Consolidated Drained
		CC	Continuous Core	TOV	Total Organic Vapors

STANDARD PENETRATION TEST (SPT 'N'): The number of blows required to advance a standard 51 mm outer diameter split spoon sampler to penetrate 0.3 m distance into the undisturbed ground in a borehole driven by means of a 63.5 kg hammer falling freely from a distance of 0.76m.

DYNAMIC CONE PENETRATION TEST (DCPT): The number of blows required to advance a 51 mm diameter – 60 degree cone fitted to the end of the drill rods to penetrate 0.3 m distance into the undisturbed ground driven by 475 Joules driving energy per blow.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR RELATIVE DENSITY

CONSISTENCY: Cohesive soils are described on the basis of their undrained shear strength (Cu) or 'N' values as follows:

N (blows/0.3m)	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	>30
Consistency	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD
Cu (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200

RELATIVE DENSITY: Cohesionless soils are described on the basis of their relative density as indicated by 'N' values as follows:

N (blows/0.3m)	0 - 4	4 - 10	10 - 30	30 - 50	>50
Relative Density	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH

RECOVERY: Sum of the lengths of all recovered rock core pieces divided by the total length of the core run (expressed as a percent).

ROCK QUALITY DESIGNATION (RQD): Sum of the lengths of intact rock core pieces, 100 mm or more in lengths, divided by the total length of the core run (expressed as a percent). Classifications of a rock based on the RQD value are as follows:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
Quality	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50 Millimeters	50 - 300 Millimeters	0.3 – 1.0 Metres	1.0 – 3.0 Metres	> 3.0 Metres
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

RECORD OF BOREHOLE No. BH/MW201

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	96 mm Mud Rotary/ HQ Core	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	16 Sep 21	Date Completed: 21 Sep 21	Revision No.: 0, 4/11/21

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS
	Geodetic Ground Surface Elevation: 151.71 m							Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	★ Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading △ parts per million (ppm) 100 200 300 400; ▲ Lower Explosive Limit (LEL) W_P W W_L Plastic Liquid 20 40 60 80		
	TOPSOIL: 50 mm with grass cover 151.66										
	FILL: clayey silt / silty clay, reddish brown, damp 151.06 0.6	SS	1	79	8			○	○ 14		
	CLAYEY SILT TO SILTY CLAY TILL: reddish brown, dry to damp	SS	2	92	16	1	151	○	○ 10		
	shale fragments below 1.20 m	SS	3	54	60	2	150	○	○ 11		
	trace gravel, damp, stiff below 2.29 m	SS	4	84	11	3	149	○	○ 11		
		SS	5	100	47	4	148	○	○ 12		
	some oxidised fissures below 4.57 m	SS	6	100	36	5	147	○	○ 12		
	grey, moist below 6.10 m	SS	7	100	21	6	146	○	○ 12		
	144.09	SS	8	50	50/10	7	145	○ 50/10	○ 7		
	TILL/SHALE COMPLEX: reddish brown, dry to damp 144.06 7.7					8	144				
	SHALE BEDROCK: highly weathered, reddish brown to pale grey, dry	RC	1	97	71	9	143				
	ROCK CORE BEGINS					10	142				
	Fair Quality	RC	2	97	57	11	141				
	clay seam from 9.45 to 9.75 m										
	Fair Quality										
	highly weathered clay seam from 10.56 to 10.75 m	RC	3	99	95	12	140				
	Excellent Quality										
	Excellent Quality	RC	4	100	95	13	139				
	Excellent Quality	RC	5	99	92	14	138				
	highly fractured zones from 15.56 to 15.64 m and 15.7 to 15.78 m	RC	6	99	93	15	137				
	Excellent Quality					16	136				
	Excellent Quality	RC	7	99	93	17	135				
	132.96					18	134				
	End of Borehole 18.75 m 18.8						133				

Notes:
1. Borehole open completion of drilling.
2. Groundwater level reading not measured upon completion of drilling due to introduced drilling water.
3. Groundwater level reading 2.25 m on September 30, 2021.

B.I.G. Consulting Inc.
12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

▽ Groundwater depth on completion of drilling: Drilling Water m.

▼ Groundwater depth observed on 30/09/2021 at a depth of: 2.25 m.

■ Cave in depth recorded on completion of drilling: Open m.

RECORD OF BOREHOLE No. BH/MW202

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	96 mm Mud Rotary/ HQ Core	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	21 Sep 21	Date Completed: 22 Sep 21	Revision No.: 0, 4/11/21

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (○ SPT ● DCPT); MTO Vane* (△ Intact ▲ Remould); Nilcon Vane* (◇ Intact ◆ Remould); * Undrained Shear Strength (kPa) 20 40 60 80	LAB TESTING: ★ Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading △ parts per million (ppm) 100 200 300 400; ▲ Lower Explosive Limit (LEL); W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS
	Geodetic Ground Surface Elevation: 151.18 m										
	TOPSOIL: 85 mm with grass cover 151.09	SS	1	16	16	0	151	○ 16	○ 16		
	CLAYEY SILT TO SILTY CLAY TILL: with some shale fragments, trace gravels, trace organic rootlets at top, brown to mottled brown, damp to dry, hard	SS	2	41	38	1	150	○	○ 17		
		SS	3	33	80/28	2	149	○ 80/28	○ 11		
		SS	4	70	41	3	148	○	○ 12		
		SS	5	100	57	4	147	○	○ 13		
	damp to moist below 4.57 m	SS	6	67	59	5	146	○	○ 15		
	144.63	SS	7	1020	52/5	6	145	○ 52/5	○ 12		
	TILL/SHALE COMPLEX: reddish brown, damp to dry 6.6					7	144				
	143.52										
	SHALE BEDROCK: highly weathered, reddish brown to pale grey, moist 7.7	SS	8	8	50	8	143	○			
	ROCK CORE BEGINS at 8.99 m	RC	1	91	10	9	142	○			
	Very Poor Quality very soft clay zones zones from 9.14 to 9.39 m	RC	2	100	68	10	141	○			
	Fair Quality					11	140				
	Fair Quality	RC	3	100	84	12	139	○			
	Excellent Quality	RC	4	100	93	13	138	○			
	Excellent Quality	RC	5	100	92	14	137	○			
	Excellent Quality	RC	6	100	100	15	136	○			
	Excellent Quality	RC	7	100	100	16	135	○			
	Poor Quality 131.37	RC	8	99	44	17	134				
	End of Borehole 19.81 m 19.8					18	133	○			
						19	132	○			

Notes:
1. Borehole open completion of drilling.
2.Groundwater level reading not measured upon completion of drilling due to introduced drilling water.
3.Groundwater level reading 5.19m on September 30, 2021.

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12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

▽ Groundwater depth on completion of drilling: Drilling Water m.

▼ Groundwater depth observed on 30/09/2021 at a depth of: 5.19 m.

■ Cave in depth recorded on completion of drilling: Open m.

Scale: 1 : 121

RECORD OF BOREHOLE No. BH/MW203

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	150 mm Solid Stem Augering	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	17 Sep 21	Date Completed: 17 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 150.81 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT ○ / DCPT ●); MTO Vane* (Intact △ / Remould ▲); Nilcon Vane* (Intact ◇ / Remould ◆); * Undrained Shear Strength (kPa) 20 40 60 80	LAB TESTING: ★ Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading △ parts per million (ppm) 100 200 300 400; ▲ Lower Explosive Limit (LEL) W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS
	TOPSOIL: 80mm with grass cover 150.73 0.1										
	FILL: silty clay to clayey silt, possibly reworked, mottled brown, damp	SS	1	33	6				16		
	149.29	SS	2	95	14	1	150		13		
	CLAYEY SILT TO SILTY CLAY TILL: trace gravel, some sandy fissures, greyish brown, dry to damp, hard 1.5	SS	3	95	30	2	149		13		
	147.46	SS	4	95	39	3	148		13		
	TILL/SHALE COMPLEX: highly weathered, reddish brown, dry 3.4	SS	5	67	70	4	147		11		
	146.54										
	SHALE BEDROCK: highly weathered, reddish brown, dry 4.3	SS	6	100	50/5	5	146	50/5			
	144.66	SS	7	100	50/5	6	145				
	End of Borehole 6.15m 6.2										

Notes:
1. Borehole open upon completion of drilling.
2. Groundwater level reading at 3.66 m bgl upon completion of drilling
3.Groundwater level reading 3.97 m bgl on September 30, 2021.

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12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

▽ Groundwater depth on completion of drilling: Dry m.

▼ Groundwater depth observed on 30/09/2021 at a depth of: 3.97 m.

Cave in depth recorded on completion of drilling: Open m.

RECORD OF BOREHOLE No. BH/MW204

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	150 mm Solid Stem Augering	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	20 Sep 21	Date Completed: 20 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 150.76 m

DESCRIPTION	Elevation	Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%
TOPSOIL: 120 mm with grass cover	150.64	0.1	SS	1	59	11
FILL: silty clay to clayey silt, possibly reworked, mottled brown, damp	150.00	0.8	SS	2	100	49
CLAYEY SILT TO SILTY CLAY TILL: trace gravel, reddish brown, hard	149.24	1.5	SS	3	73	78
TILL/SHALE COMPLEX: highly weathered, reddish brown, dry	148.47	2.3	SS	4	100	50/5
SHALE BEDROCK: highly weathered, reddish brown, damp			SS	5	60	50/5
			SS	6	60	50/5
First water strike	144.61	6.2	SS	7	100	50/3
moist to wet below 6.1m						
End of Borehole 6.12m						

Notes:
1. Borehole open upon completion of drilling.
2. Groundwater level reading at 3.66 m bgl upon completion of drilling
3.Groundwater level reading 2.14 bgl on September 30, 2021.

FIELD TESTING: Penetration Testing — SPT, DCPT; MTO Vane* Intact, Remould; Nilcon Vane* Intact, Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading, parts per million (ppm) 100 200 300 400; Lower Explosive Limit (LEL) W_P W W_L; Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS

B.I.G. Consulting Inc.
12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

Groundwater depth on completion of drilling: 3.66 m.

Cave in depth recorded on completion of drilling: Open m.

Groundwater depth observed on 30/09/2021 at a depth of: 2.14 m.

RECORD OF BOREHOLE No. BH/MW205

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	150 mm Solid Stem Augers	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	20 Sep 21	Date Completed: 20 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 150.79 m

DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT ○ / DCPT ●)	LAB TESTING: Soil Vapour Reading (ppm)	COMMENTS
TOPSOIL: 100 mm with grass cover (150.69)									
FILL: silty clay to clayey silt, trace gravel, trace organic rootlets, possibly reworked, brown, damp (150.03)	SS	1	75	12	0	150		20	
CLAYEY SILT TO SILTY CLAY TILL: trace sand and gravel, mottled brown, damp (149.42)	SS	2	100	43	1		50	11	
TILL/SHALE COMPLEX: highly weathered, reddish brown, dry (149.27)	SS	3	16	50/10	2	149	10	7	
SHALE BEDROCK: highly weathered, reddish brown, dry to damp	SS	4	8	50/8	3	148	50 / 8		
	SS	5	8	50/5	4	147	50 / 5		
First water strike	SS	6	5	50/5	5	146	50 / 5		
moist to wet below 4.57m									
(144.64)	SS	7	60	50/5	6	145	50 / 5		
End of Borehole 6.15m (6.2)									

Notes:
1. Borehole open to 5.94 m upon completion of drilling.
2. Groundwater level reading at 5.57 m bgl upon completion of drilling
3.Groundwater level reading 1.96 m bgl on September 30, 2021.

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12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

▽ Groundwater depth on completion of drilling: 4.57 m.

▼ Groundwater depth observed on 30/09/2021 at a depth of: 1.96 m.

■ Cave in depth recorded on completion of drilling: 5.94 m.

RECORD OF BOREHOLE No. BH/MW206

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	100 mm Solid Stem Augering	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	17 Sep 21	Date Completed: 17 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 150.85 m

DESCRIPTION	Elevation	Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%
TOPSOIL: 150 mm with grass cover	150.70	0.2	SS	1	25	9
FILL: silty clay to clayey silt, possibly reworked, brown, damp	149.63	1.2	SS	2	100	11
CLAYEY SILT TO SILTY CLAY TILL: trace gravel, some sandy and oxideised fissures, brown, damp, hard	149.13 / 148.15	1.7	SS	3	89	50/13
TILL/SHALE COMPLEX: highly weathered, reddish brown, dry			SS	4	100	50/5
SHALE BEDROCK: highly weathered, reddish brown, dry			SS	5	100	50/5
			SS	6	100	50/5
First water strike	144.70	6.2	SS	7	100	50/5
moist to wet below 6.1m						
End of Borehole 6.15m						

Notes:
1. Borehole open to 5.94 m upon completion of drilling.
2. Groundwater level reading at 5.64 m bgl upon completion of drilling
3.Groundwater level reading 2.30 m bgl on September 30, 2021.

FIELD TESTING: Penetration Testing (SPT / DCPT); MTO Vane* (Intact / Remould); Nilcon Vane* (Intact / Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading, parts per million (ppm) 100 200 300 400; Lower Explosive Limit (LEL) W_P W W_L; Plastic / Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS

B.I.G. Consulting Inc.
12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

Groundwater depth on completion of drilling: 5.64 m.

Cave in depth recorded on completion of drilling: 5.94 m.

Groundwater depth observed on 30/09/2021 at a depth of: 2.3 m.

RECORD OF BOREHOLE No. BH/MW207

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	150 mm Solid Stem Augering	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	17 Sep 21	Date Completed: 17 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 151.27 m

DESCRIPTION	Depth (m)	Elevation (m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%
TOPSOIL: 100 mm with grass cover	0.1	151.17	SS	1	70	9
FILL: silty clay to clayey silt, possibly reworked, brown, damp	0.8	150.51	SS	2	59	45
CLAYEY SILT TO SILTY CLAY TILL: trace gravel, some sandy and oxideised fissures, pale brown, dry to damp, hard			SS	3	100	37
	2.29	148.98	SS	4	50	50/10
TILL/SHALE COMPLEX: highly weathered, reddish brown, dry	2.6	148.68	SS	5	100	50/5
SHALE BEDROCK: highly weathered, reddish brown, dry			SS	6	100	50/5
First water strike		145.12	SS	7	100	50/5
moist to wet below 5.49m	6.2					
End of Borehole 6.15m						

Notes:
1. Borehole open to 5.94 m upon completion of drilling.
2. Groundwater level reading at 5.33 m bgl upon completion of drilling
3.Groundwater level reading 2.40 m bgl on September 30, 2021.

FIELD TESTING: Penetration Testing (SPT, DCPT); MTO Vane* (Intact, Remould); Nilcon Vane* (Intact, Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading, parts per million (ppm) 100 200 300 400; Lower Explosive Limit (LEL) W_P W W_L; Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS

B.I.G. Consulting Inc.
12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

Groundwater depth on completion of drilling: 5.33 m.

Cave in depth recorded on completion of drilling: 5.94 m.

Groundwater depth observed on 30/09/2021 at a depth of: 2.4 m.

RECORD OF BOREHOLE No. BH/MW208

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	100 mm Solid Stem Augering	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	17 Sep 21	Date Completed: 17 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 151.77 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Undrained Shear Strength (kPa) 20 40 60 80	LAB TESTING: Soil Vapour Reading (ppm) 100 200 300 400	LAB TESTING: Rinse pH Values 2 4 6 8 10 12	LAB TESTING: Lower Explosive Limit (LEL) Plastic 20 40 60 80 Liquid	INSTRUMENTATION INSTALLATION	COMMENTS
	TOPSOIL: 180 mm with grass cover 151.59	SS	1	67	8	0	151						
	FILL: silty clay to clayey silt, possibly reworked, pale brown, damp 151.01 0.8	SS	2	95	30	1							
	CLAYEY SILT TO SILTY CLAY TILL: trace gravel, some shale fragments, reddish brown, dry to damp, hard	SS	3	70	67	2	150						
	Pale grey below 1.52 m 149.48												
	TILL/SHALE COMPLEX: highly weathered, reddish brown, dry 149.33 2.4	SS	4	100	50/8								
	SHALE BEDROCK: highly weathered, reddish brown, dry	SS	5	100	50/5	3	149						
		SS	6	100	50/5	4	148						
	First water strike 145.62 6.2	SS	7	100	50/3	5	147						
	moist to wet below 6.1m **End of Borehole 6.12m**					6	146						

Notes:
1. Borehole open to 5.94 m upon completion of drilling.
2. Dry upon completion of drilling
3.Groundwater level reading 5.54 m bgl on September 30, 2021.

FIELD TESTING: Penetration Testing — SPT ○ DCPT ●; MTO Vane* Intact △ Remould ▲; Nilcon Vane* Intact ◇ Remould ◆

LAB TESTING: Soil Vapour Reading △ parts per million (ppm); Rinse pH Values ★; Lower Explosive Limit (LEL) ▲; W_P W W_L

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Mississauga, ON L4W 2Z4
Canada
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F: 416-551-2633

Groundwater depth on completion of drilling: Dry m.

Cave in depth recorded on completion of drilling: 5.94 m.

Groundwater depth observed on 30/09/2021 at a depth of: 5.54 m.

RECORD OF BOREHOLE No. BH/MW209

Project Number:	BIGC-GEO-185E	Drilling Location:	See Borehole Location Plan	Logged by:	MV
Project Client:	Delmanor West Oak Inc.	Drilling Method:	96 mm Mud Rotary/ HQ Core	Compiled by:	MV
Project Name:	Geotechnical and Hydrogeological Assessment Update	Drilling Machine:	Track Mounted Drill	Reviewed by:	OL
Project Location:	1280 Dundas Street, Oakville	Date Started:	22 Sep 21	Date Completed: 23 Sep 21	Revision No.: 0, 4/11/21

Geodetic Ground Surface Elevation: 150.93 m

Depth (m)	Elevation (m)	Description	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value/RQD%
0	150.93	**TOPSOIL:** 85 mm with grass cover	SS	1	79	14
	150.77	**POSSIBLE FILL:** trace gravel, trace rootlets, mottled brown, damp				
	150.17	**CLAYEY SILT TO SILTY CLAY TILL:** with some shale fragments, trace gravels, trace organic rootlets at top, brown to mottled brown, damp to dry, hard	SS	2	75	8
1	150		SS	3	84	18
2	149		SS	4	100	27
3	148		SS	5	95	38
	147.42	**TILL/SHALE COMPLEX:** reddish brown, damp to dry				
4	147		SS	6	63	50/8
5	146					
6	145		SS	7	60	50/5
7	144					
	143.31	**SHALE BEDROCK:** highly weathered, reddish brown to pale grey, moist	SS	8	100	50/3
8	143					
9	142					
		ROCK CORE BEGINS at 9.30 m	RC	1	98	46
10	141	Poor Quality very soft clay zones zones from 9.53 - 9.75 m	RC	2	91	59
11	140	Fair Quality very soft clay zones zones from 9.91 - 10.21 m				
12	139	Excellent Quality	RC	3	107	86
13	138	Excellent Quality	RC	4	97	87
14	137					
15	136	Excellent Quality	RC	5	101	91
16	135	Excellent Quality	RC	6	101	97
17	134					
18	133	Good Quality	RC	7	86	86
19	132	Good Quality	RC	8	100	88
20	131					
	130.66	**End of Borehole 20.27 m**				
	20.3					

Notes:
1. Borehole open completion of drilling.
2. Groundwater level reading not measured upon completion of drilling due to introduced drilling water.
3. Groundwater level reading 3.50 m bgl on September 30, 2021.

FIELD TESTING: Penetration Testing (SPT, DCPT); MTO Vane* (Intact, Remould); Nilcon Vane* (Intact, Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Rinse pH Values 2 4 6 8 10 12; Soil Vapour Reading parts per million (ppm) 100 200 300 400; Lower Explosive Limit (LEL); W_P W W_L; Plastic Liquid; 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS

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12-5500 Tomken Rd.
Mississauga, ON L4W 2Z4
Canada
T: 416-214-4880
F: 416-551-2633

Groundwater depth on completion of drilling: Drilling Water m.

Groundwater depth observed on 30/09/2021 at a depth of: 3.50 m.

Cave in depth recorded on completion of drilling: Open m.

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RECORD OF BOREHOLE No BH1

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY A.B.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.22 - 2018.05.22 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.8											
150.7 / 0.1	**TOPSOIL:** 100 mm										
	FILL: clayey silt, trace gravel and organics, mottled reddish brown, moist		1	SS1	10				○		
	- trace rootlets at 0.8 m		2	SS2	4		150		○		
			3	SS3	8		149		○		
148.5	- 75 mm black organic layer at 2.0 m										
2.3	**CLAYEY SILT TILL:** trace gravel, reddish brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		4	SS4	37		148		○		
147.8											
3.1	**CLAYEY SILT TILL:** trace gravel, red shale inclusion, reddish brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		5	SS5	57				○		
			6	SS6	55		147		○		
	- grey and very stiff below 4.6 m (Pocket Penetrometer: 200 kPa)		7	SS7	23		146		○		
145.2	Till/Shale Complex below 5.5 m		8	SS8	100				○		
5.6	**SHALE:** weathered, red, damp						145				
144.7											
6.1	**Borehole terminated at 6.2 m**		9	SS9	100				○		
	Notes: 1. Open to 6.2 m bgs upon completion of drilling 2. Water at 4.1 m bgs upon completion of drilling										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW2

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY A.B./F.C.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.22 - 2018.05.23 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
151.8											
151.7 / 0.1	**TOPSOIL:** 100 mm										
151.0 / 0.8	**FILL:** clayey silt, trace gravel, some rootlets, topsoil inclusions above 0.3 m, reddish brown, moist - 150 mm topsoil inclusion at 0.15m		1	SS1	6		151	○	○		
	CLAYEY SILT TILL: trace gravel, mottled, reddish brown, moist, very stiff, (Pocket Penetrometer: > 225 kPa) - red shale inclusions and hard below 1.5 m		2	SS2	18				○		
			3	SS3	33		150		○		
			4	SS4	41		149		○		
			5	SS5	43				○		
147.2						▽	148				
4.6	**CLAYEY SILT TILL:** trace gravel, red shale inclusion, grey, moist, hard, (Pocket Penetrometer: > 225 kPa)		6	SS6	31		147		○		
			7	SS7	29		146		○		
144.4			8	SS8	36		145		○		
7.4	**SHALE:** weathered, red, damp		9	SS9	100		144		○		
			10	SS10	100		143		○		
141.1							142				
10.7	-----Run #1: 10.7 to 11.2 m RQD=81% Recovery=84% - red shale, interbedded grey shale - fractive along horizontal plane - minimal vertical cracking		1	CORE			141		○		
140.6 / 11.2	-----Run #2: 11.2 to 12.6 m RQD=92% Recovery=100% - red shale, interbedded grey shale - minimal vertical fractures		2	CORE			140				
139.1 / 12.6	**Borehole terminated at 12.6 m** Notes: 1. Open to 12.6 m upon completion of drilling 2. Water at 3.2 m upon completion of drilling 3. Water level at 3.0 m bgs on June 13, 2018 4. Water level at 4.2 m bgs on December 2, 2019.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW3

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY A.B.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.22 - 2018.05.22 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
151.1							151
150.9 / 0.2	**TOPSOIL:** 150 mm						
	FILL: clayey silt, trace gravel, rootlets, asphalt fragments, brown, moist		1	SS1	11		
149.9			2	SS2	7		150
1.2	**CLAYEY SILT TILL:** trace gravel, mottled, brown, moist, firm to very stiff, (Pocket Penetrometer: 225 kPa) - mottled, red shale inclusions and very stiff to hard below 1.5 m		3	SS3	27		
			4	SS4	33		149
148.1							
3.1	**CLAYEY SILT TILL:** trace gravel, mottled, red shale inclusion, orange-brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		5	SS5	65	▽	148
	- oxidized red and grey at 4.6		6	SS6	60		147
144.8	- Till/Shale Complex below 6.1 m						146
6.3	**SHALE:** weathered, red, damp		7	SS7	100		145
			8	SS8	100		144
142.0							143
9.1 / 141.5	-----Run #1: 9.1 to 9.6 m RQD=22% Recovery=77% - weathered red shale - some mottling - vertical and horizontal fractures		1	CORE			142
9.6	-----Run #2: 11.2 to 12.6 m RQD=92% Recovery=100% - red shale, interbedded grey shale - minimal vertical fractures		2	CORE			141
140.0							140
11.2	**Borehole terminated at 11.2 m** Notes: 1. Open to 11.2 m bgs upon completion of drilling 2. Water at 2.5 m bgs upon completion of drilling 3. Water level at 2.7 m bgs on June 13, 2018. 4. Water level at 3.495 m bgs on December 2, 2019.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (20 40 60)

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW4

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY F.C.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.23 - 2018.05.23 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
151.3							
151.2 / 0.1	**TOPSOIL:** 125 mm		1	SS1	10		151
	FILL: clayey silt, trace gravel, brown, moist						
	- mottled, inclusions of black organics, orange-brown at 0.8 m		2	SS2	6		
149.8 / 1.5	**CLAYEY SILT TILL:** trace gravel, mottled, reddish brown, moist, very stiff to hard, (Pocket Penetrometer: > 225 kPa)		3	SS3	24		150
			4	SS4	43		149
			5	SS5	51	▽	148
146.8 / 4.6	**CLAYEY SILT TILL:** trace gravel, red shale inclusion, oxidized fissures, brown/reddish brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		6	SS6	49		147
	- grey and very stiff to hard at 6.1 m. (Pocket Penetrometer: > 225 kPa)		7	SS7	25		146
143.7 / 7.6	**SHALE:** weathered, red, damp		8	SS8	100		145
	Borehole terminated at 7.6 m						144

Notes:
1. Water at 3.0 m bgs upon completion of drilling
2. Open to 7.6 m bgs upon completion of drilling
3. Water level at 2.6 m bgs on June 13, 2018.
4. Water level at 3.295 m bgs on December 2, 2019.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH5

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY F.C.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.23 - 2018.05.23 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
151.2							151				
151.0 / 0.1	**TOPSOIL:** 125 mm **FILL:** clayey silt, trace gravel, top soil inclusion, brown, moist		1	SS1	3				○		
150.2 / 0.9	- 125 mm granular fill at 0.8 m **CLAYEY SILT TILL:** trace gravel, reddish brown, moist, very stiff to hard, (Pocket Penetrometer: > 225 kPa)		2	SS2	26		150		○		
			3	SS3	44				○		
148.9 / 2.3	**CLAYEY SILT TILL:** trace gravel, red shale inclusion, reddish brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		4	SS4	54		149		○		
			5	SS5	54		148		○		
			6	SS6	42		147		○		
	- grey and very stiff below 6.1 m (Pocket Penetrometer 175 kPa)		7	SS7	18		146		○		
143.5 / 7.6	**SHALE:** weathered, red, damp		8	SS8	100		145		○		
143.3 / 7.9	**Borehole terminated at 7.9 m** Notes: 1. Open to 7.9 m bgs upon completion of drilling 2. Water not measured upon completion of drilling						144				

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW6

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY F.C.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.24 - 2018.05.24 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
151.3											
~~150.9~~ 0.1	**TOPSOIL:** 125 mm										
	POSSIBLE FILL: clayey silt, trace gravel, rootlets, organic stains, reddish brown, moist		1	SS1	6		151				
150.6 0.8	**CLAYEY SILT TILL:** trace gravel, shale inclusion, reddish brown, moist, very stiff to hard (Pocket Penetrometer: > 225 kPa)		2	SS2	28						
			3	SS3	26	▽	150				
	- hard below 2.3 m		4	SS4	31		149				
			5	SS5	43		148				
146.7 4.6	**CLAYEY SILT TILL:** trace gravel, red shale inclusions, brown, moist, very stiff to hard, (Pocket Penetrometer: > 225 kPa) - grey below 5.0 m		6	SS6	29		147				
			7	SS7	15		146				
143.7							145				
~~143.6~~ 7.7	**SHALE:** weathered, red, damp		8	SS8	100		144				
143.2	-----Run #1: 7.7 to 8.1 m RQD=40% Recovery=78% - weathered red shale, interbedded grey shale - one vertical fracture		1	CORE							
8.1	-----Run #2: 8.1 to 9.6 m RQD=94% Recovery=98% - red shale, interbedded grey shale - minimal vertical fractures - some horizontal fractures along planes - some interbedded clayey silt at 9.1 m		2	CORE			143				
141.7 9.6	**Borehole terminated at 9.6 m**						142				

Notes:
1. Open to 9.6 m bgs upon completion of drilling
2. Water at 1.09 m bgs upon completion of drilling
3. Water level at 2.8 m bgs on June 13, 2018.
4. Water level at 2.01 m bgs on December 2, 2019.

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW7

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1280 Dundas Street West, Oakville, ON | ORIGINATED BY F.C.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.D.

PROJ. NAME Geo/HG/PII Investigations | DATE 2018.05.24 - 2018.05.24 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.9											
~~150.8~~ 0.1	**TOPSOIL:** 100 mm										
	POSSIBLE FILL: clayey silt, reworked and distributed, trace rootlets and organic staining, brown, moist		1	SS1	3	▽			○		
150.1 0.8	**CLAYEY SILT TILL:** trace gravel, shale inclusions, reddish brown, moist, stiff to very stiff, (Pocket Penetrometer: > 225 kPa)		2	SS2	26		150		○		
	- very stiff below 1.5 m		3	SS3	44		149		○		
	- hard below 2.3 m		4	SS4	54		148		○		
			5	SS5	54		147		○		
146.3 4.6	**CLAYEY SILT TILL:** red shale inclusions, reddish brown, moist, hard, (Pocket Penetrometer: > 225 kPa)		6	SS6	42		146		○		
144.8							145				
~~144.7~~ 6.1	**SHALE:** weathered, red, damp		7	SS7	18				○		
6.2	**Borehole terminated at 6.2 m**										

Notes:
1. Open to 6.2 m bgs upon completion of drilling
2. Water not measured completion of drilling
3. Water level at 2.0 m bgs on June 13, 2018.
4. Water level at 0.63 m bgs on December 2, 2019.

+ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No BH/MW103

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1260 Dundas Street West, Oakville, ON | ORIGINATED BY F.G.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.C.

PROJ. NAME Geo/HG/PII Investigations | DATE 2019.11.13 - 2019.11.13 | CHECKED BY F.C.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
151.6											
~~151.6~~ 0.0	**TOPSOIL:** 125 mm										
0.1	**CLAYEY SILT TILL/SILTY CLAY TILL:** disturbed upper 300 mm, brown, moist, very stiff to hard		1	SS1	6		151		○		
			2	SS2	19						
			3	SS3	36		150		○		
	- reddish brown, shale inclusions below 2.29 m		4	SS4	46		149		○		
148.6											
3.0	**SHALE:** weathered, red, damp		5	SS5	100				○		
148.1											
3.5	**Borehole terminated at 3.5 m** Notes: 1. Open to 3.5 m bgs upon completion of drilling. 2. Dry upon completion of drilling. 3. Water level was at 3.32 m bgs November 25, 2019. 4. Water level was as 3.09 m bgs on December 2, 2019.										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

B.I.G. Consulting Inc
12-5500 Tomken Road
Mississauga, ON L4W 2Z4
www.bigconsultinginc.com

RECORD OF BOREHOLE No BH104

1 OF 1 **METRIC**

PROJ. NO. BIGC-ENV-185C | LOCATION 1260 Dundas Street West, Oakville, ON | ORIGINATED BY F.G.

DATUM Geodetic | BOREHOLE TYPE Continuous flight solid stem auger, split spoon samples and augered core samples | COMPILED BY F.C.

PROJ. NAME Geo/HG/PII Investigations | DATE 2019.11.13 - 2019.11.13 | CHECKED BY F.C.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.6											
150.5	**TOPSOIL:** 50 mm										
0.1	**FILL:** clayey silt to silty clay, trace organic staining, brown, moist		1	SS1	7						Metals & Inorganics, Pesticides, Herbicides Analysis PAHs Analysis
			2	SS2	8		150				
149.1											
1.5	**CLAYEY SILT TILL/SILTY CLAY TILL:** reddish brown, moist, stiff to hard (Pocket Penetrometer: > 225 kPa)		3	SS3	26		149				
			4	SS4	59		148				
147.7	-weathered shale inclusion below 2.7 m										
2.9	**SHALE:** highly weathered, red, damp		5	SS5	100		147				
146.9											
3.7	**Borehole terminated at 3.7 m**										

Notes:
1. Open to 3.7 m bgs upon completion of drilling.
2. Dry upon completion of drilling.

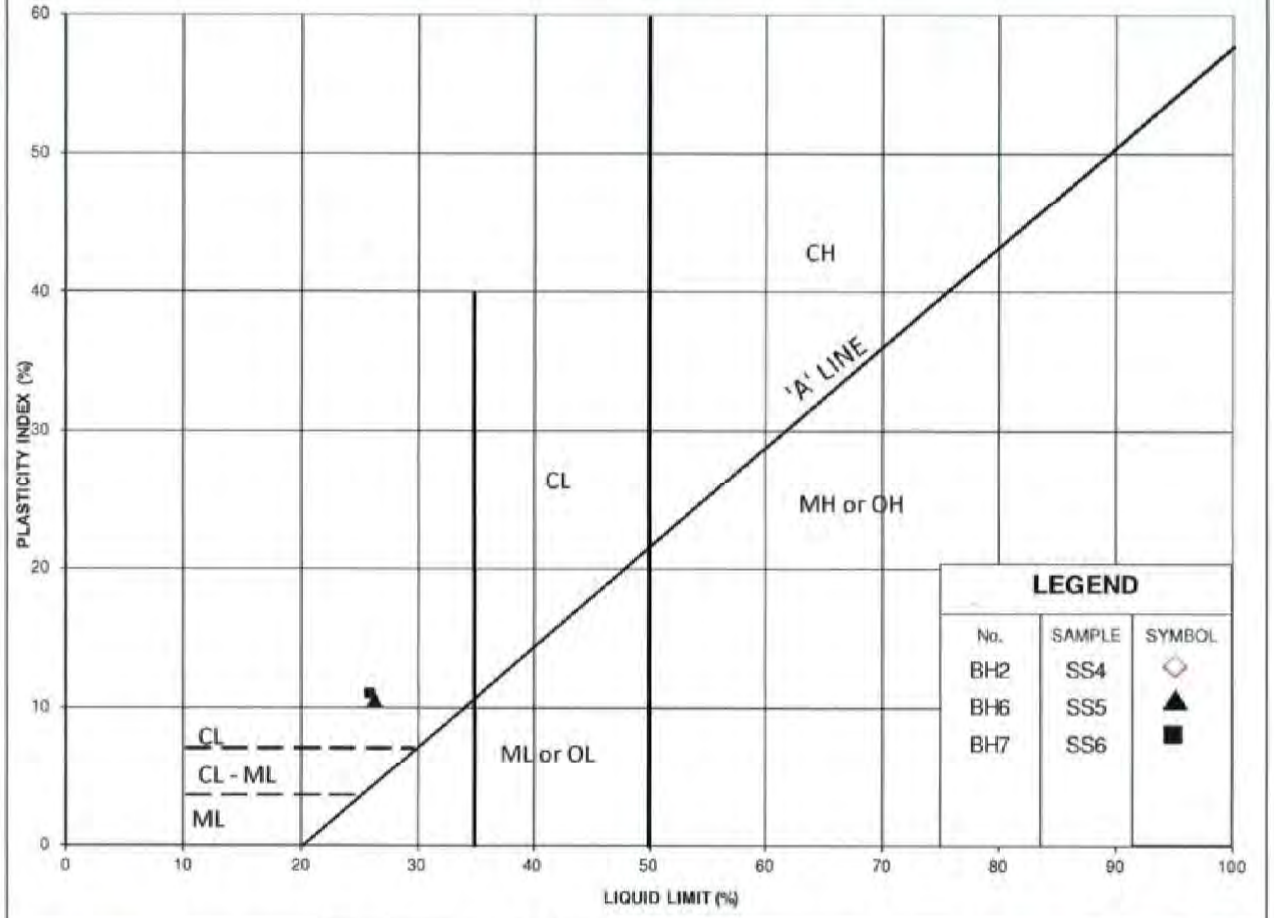
$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Appendix C: Geotechnical Laboratory Test Results

B.I.G. Consulting Inc.

1280 Dundas Street West, Oakville



B.I.G. CONSULTING INC.

PLASTICITY CHART

Clayey Silt Till

FIGURE: 1

PROJECT NO:BIGC-GEO-1858

DATE: 18/06/2018

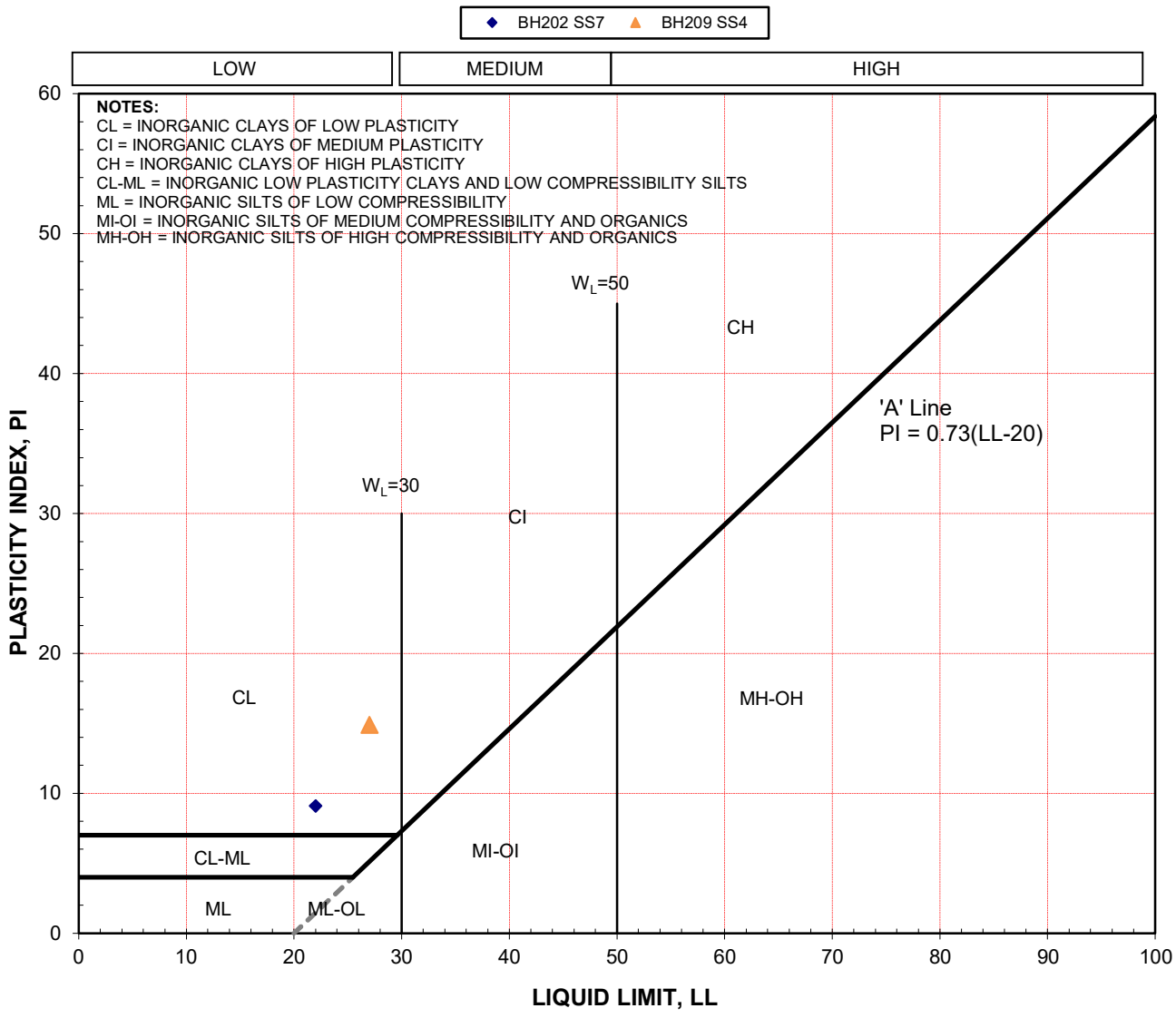
B.I.G CONSULTING INC.

PLASTICITY CHART

Job # :	BIGC-GEO-185E	**Lab #** :	40-2021
Project Client:	Delmanor West Oak Inc.	**Technician** :	SM
Project :	Geotechnical Investigation	**Supervisor** :	SS
Location :	1260 & 1280 Dundas Street West, Oakville, ON	**Date** :	10/19/2021

TEST RESULTS

Specimen #	Sample #	Depth (m)	LL%	PL%	PI	Fines%	W%	Classification	Remarks
BH202	SS7	6.1	22	13	9			CL	Silty CLAY TILL
BH209	SS4	2.3	27	15	12			CL	Silty CLAY TILL



Appendix D: MNRF Table 8.1 - Slope Stability Rating Charts

B.I.G. Consulting Inc.

SLOPE STABILITY RATING CHART

B.I.G. Consulting Inc.
12-5500 Tomken Road
Mississauga, Ontario, L4W 2Z4
Tel: (416) 214-4880
Fax: (416) 551-2633
www.bigconsultinginc.com

Site Location: Sixteen Mile Creek Valley – 1260 & -1280 Dundas Street West, Oakville

Project No.: BIGC-GEO-185E

Property Owner: Delmanor West Oak Inc.

Inspected By: Oswin Li, P.Eng. **Weather Conditions**: Sunny **Inspection Date:** August 26, 2021

			Rating Value
1.	**SLOPE INCLINATION**		
	degrees	**horiz. : vert.**	
a)	18 or less	3 : 1 or flatter	0
b)	18 – 26	2 : 1 to more than 3 : 1	6
c)	**More than 26**	**Steeper than 2 : 1**	**16**
2.	**SOIL STRATIGRAPHY**		
a)	Shale, Limestone, Granite (Bedrock)		0
b)	Sand, Gravel		6
c)	**Glacial Till**		**9**
d)	Clay Silt		12
e)	Fill		16
f)	Leda Clay		27
3.	**SEEPAGE FROM SLOPE FACE**		
a)	**None or Near bottom only**		**0**
b)	Near mid-slope only		6
c)	Near crest only or, From several levels		12
4.	**SLOPE HEIGHT**		
a)	2 m or less		0
b)	2.1 to 5 m		2
c)	5.1 to 10 m		4
d)	**More than 10 m**		**8**
5.	**VEGETATION COVER ON SLOPE FACE**		
a)	**Well vegetated: Heavy shrubs or forested with mature trees**		**0**
b)	Light vegetation: Mostly grass, weeds, occasional trees, shurbs		4
c)	No vegetation: Bare		8
6.	**TABLE LAND DRAINAGE**		
a)	Table land flat, no apparent drainage of slope		0
b)	**Minor drainage over slope, no active erosion**		**2**
c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**		
a)	15 metres or more from slope toe		0
b)	**Less than 15 metres from slope toe**		**6**
8.	**PREVIOUS LANDSLIDE ACTIVITY**		
a)	**No**		**0**
b)	Yes		6
	SLOPE INSTABILITY RATING	**RATING VALUES TOTAL**	**INVESTIGATION REQUIREMENTS**	**TOTAL**
				41
1.	Low potential	<24	Site inspection only, confirmation, report letter.	
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.	
3.	Moderate potential	>35	Boreholes, piezometers, lab tests, surveying, detailed report.	

NOTES: a) Choose only one from each category; compare total rating value with above requirements.
b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in details and, protection provided if require.

SLOPE STABILITY RATING CHART

B.I.G. Consulting Inc.
12-5500 Tomken Road
Mississauga, Ontario, L4W 2Z4
Tel: (416) 214-4880
Fax: (416) 551-2633
www.bigconsultinginc.com

Site Location: West Valley System – 1260-1280 Dundas Street West, Oakville **Project No.:** BIGC-GEO-185E

Property Owner: Delmanor West Oak Inc.

Inspected By: Oswin Li, P.Eng. **Weather Conditions**: Sunny **Inspection Date:** August 26, 2021

			Rating Value
1.	**SLOPE INCLINATION**		
	degrees	**horiz. : vert.**	
a)	18 or less	3 : 1 or flatter	0
b)	18 – 26	2 : 1 to more than 3 : 1	6
c)	**More than 26**	**Steeper than 2 : 1**	**16**
2.	**SOIL STRATIGRAPHY**		
a)	Shale, Limestone, Granite (Bedrock)		0
b)	Sand, Gravel		6
c)	**Glacial Till**		**9**
d)	Clay Silt		12
e)	Fill		16
f)	Leda Clay		27
3.	**SEEPAGE FROM SLOPE FACE**		
a)	**None or Near bottom only**		**0**
b)	Near mid-slope only		6
c)	Near crest only or, From several levels		12
4.	**SLOPE HEIGHT**		
a)	2 m or less		0
b)	2.1 to 5 m		2
c)	5.1 to 10 m		4
d)	**More than 10 m**		**8**
5.	**VEGETATION COVER ON SLOP FACE**		
a)	**Well vegetated: Heavy shrubs or forested with mature trees**		**0**
b)	Light vegetation: Mostly grass, weeds, occasional trees, shurbs		4
c)	No vegetation: Bare		8
6.	**TABLE LAND DRAINAGE**		
a)	Table land flat, no apparent drainage of slope		0
b)	**Minor drainage over slope, no active erosion**		**2**
c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**		
a)	15 metres or more from slope toe		0
b)	**Less than 15 metres from slope toe**		**6**
8.	**PREVIOUS LANDSLIDE ACTIVITY**		
a)	**No**		**0**
b)	Yes		6

SLOPE INSTABILITY RATING	**RATING VALUES TOTAL**	**INVESTIGATION REQUIREMENTS**	**TOTAL**
			41

1.	Low potential	<24	Site inspection only, confirmation, report letter.
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.
3.	Moderate potential	>35	Boreholes, piezometers, lab tests, surveying, detailed report.

NOTES: a) Choose only one from each category; compare total rating value with above requirements.
b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in details and, protection provided if require.

Appendix E: Site Photographs

West Slope – Looking south, Cross Section C

West Slope – Looking North, Gabion Retaining Wall

West Slope – Looking West, drainage flowing east toward Sixteen Mile Creek, Cross Section E

West Slope – Looking South, Cross Section E

West Slope – Looking South, Cross Section D

West Slope – Looking South, Cross Section D

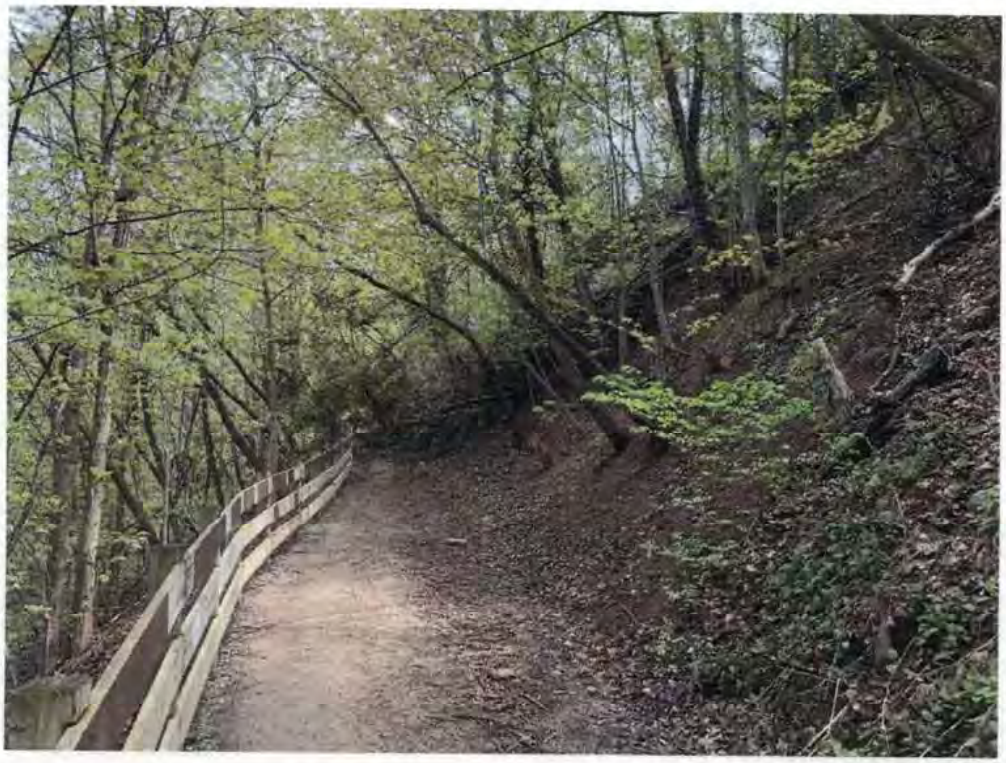
Sixteen Mile Creek Slope – Looking South, Cross Section C

Sixteen Mile Creek Slope – Looking Northwest, Cross Section C

Sixteen Mile Creek Slope – Trail dividing the slope, looking Southeast

Sixteen Mile Creek Slope – Looking Northwest, slope overburden erosion, Cross Section B

Sixteen Mile Creek Slope – Looking Southwest, slope overburden erosion impeding path, Cross Section B



Sixteen Mile Creek Slope – Trail dividing the slope impeded by upper slope overburden erosion, looking South, Cross Section B

Sixteen Mile Creek Slope – Slope overburden erosion, looking East

Sixteen Mile Creek Slope – Slope overburden erosion, looking West

Sixteen Mile Creek Slope – Toe of slope, looking West

Sixteen Mile Creek Slope – Toe of slope, looking southwest, Cross Section C

Sixteen Mile Creek Slope – Erosion of overburden on top of Queenston Shale, looking southwest, Cross Section A


BH2
RUNS #1-2
May 19, 2018
Box #1
1280 Dundas St. W, Oakville
BIGC-GEO-18SB
Depth: 35ft —
Run #1: 35ft - 36ft 7"
Run #2: 36ft 7" —
RUN 2 - 4ft - 10"


BH 2
RUNS #1-2
May 19, 2018
Box #1
1280 Dundas St. W. Oakville
BIGC-GEO-18SB
Depth: 35ft —
Run #1: 35ft - 36ft 7"
Run #2: 36ft 7" —
RUN2 - 4ft - 10"


BIGC-GEO-185B
May 24, 2018
BH6 Core 1280 DUNDAS STW. OAKVILLE
RUNS 1-2 → Depth → 25ft - 31ft - 6"
Run 1 → 25ft - 26ft 5"
Box #1
Run 2 → 26ft 5" - 31ft 6"


BIGC-GEO-185B
May 24, 2018
BH6 Core 1280 DUNDAS STW. OAKVILLE
RUNS 1-2 → Depth → 25ft - 31ft - 6"
Run 1 → 25ft - 26ft 5"
Box #1
Run 2 → 26ft 5" - 31ft 6"


BIGC GEO-18SA
May 22, 2018
BH3
RUN 1-2
Box #1
RUN 2
RUN 1

BH201 Rock Core Run 1 & Run 2 (26.5’ to 36.5’) / RQD 71% to 57% Fair Quality

BH209 Rock Core Run 1 & Run 2 (30.5’ to 37.5’) / RQD 46% to 59% Poor to Fair Quality

BH209 Rock Core Run 5 & Run 6 (47.5’ to 57.5’) / RQD 91% to 97% Excellent Quality

BH209 Rock Core Run 7 & Run 8 (57.5’ to 66.6’) / RQD 86% to 88% Good Quality