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PG8011-LET.01 Revision 4

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Attention: Stuart Cooper

Subject: Geotechnical Desktop Slope Stability Assessment
Proposed Residential Development
530 Brisebois Cres. & Part of 265 Centrum Blvd.
Ottawa, Ontario

Dear Stuart,

Further to your request and authorization, Paterson Group (Paterson) prepared this letter report to provide our geotechnical desktop slope stability assessment of the existing escarpment slope south of St. Joseph Boulevard, in support of the proposed residential development at the subject site. In particular, the primary purpose of the geotechnical review is to assess the stability of the existing slope at the subject site in relation to the proposed shoreline rehabilitation works to be completed along the northeastern property boundary.

1.0 Background Information

The desktop slope stability analysis described in the present report was undertaken in response to the April 2026 Guidance letter (referred to as “Guidance letter” in this report) provided by the City of Ottawa outlining requirements for assessing the presence of clay soils susceptible to retrogressive landslides within the nearby escarpment slope. The present report was prepared to investigate the potential exemption for escarpment slopes, particularly the existing escarpment slope located along the southern side of St. Joseph Boulevard, approximately 180 m south of the proposed residential development.

In summary, the Guidance letter recommends that the following criteria be determined prior to confirming whether an escarpment slope may be deemed exempt from the minimum field and laboratory requirements outlined in the Guidance letter: *demonstrates that the escarpment slope meets the minimum factors of safety as follows:*

- ❑ ≥ 1.5 under static conditions
- ❑ ≥ 1.1 under seismic conditions
- ❑ ≥ 1.3 under post-seismic conditions

The following sections present the methodologies, assumptions, and existing data used in the analysis, along with a summary and discussion of the results of the desktop slope stability analysis completed by Paterson. The assessment was prepared based on the methodology outlined in the Guidance letter and based on consultations with the City of Ottawa Development Review and Rideau Valley Conservation Authority (RVCA) staff.

2.0 Proposed Development

Based on our review of available reports and site plan documents, it is understood that the proposed development will consist of a multi-storey community centre building and several mid- and high-rise residential buildings. It is understood that the proposed buildings will be provided with one level of underground parking. The approximate site location is shown in the attached Figure 1 – Key Plan.

3.0 Existing Geotechnical Information

3.1 Surface Conditions and Topography

Escarpment Slope – South Side of St. Joseph Boulevard

Paterson field personnel completed a walkthrough and visual assessment of the subject escarpment slope along the south side of St. Joseph Boulevard on April 28, 2026. At the time of the site visit, the escarpment slope profile was observed to generally contain dense, mature, medium-sized trees, with some fallen trees noted throughout the area. The trees were generally observed to extend vertically from the existing ground surface with no evidence of curving or bending at their bases. Such curvature is commonly associated with gradual slope movement or instability, where trees tilt as the slope slowly displaces and subsequently correct their vertical growth, resulting in a curved trunk base. Gravel pedestrian pathways were noted throughout, providing access from the roadways located at the top of escarpment slope to St. Joseph Boulevard below.

Several segmental block retaining walls were noted at the base of the escarpment slope, while a stacked armor stone retaining wall was noted further up the slope along the south side of Prestone Drive. It should be noted that the majority of the segmental block retaining wall located at the base of the escarpment slope between Vieux-Silo Street and Tenth Line Road was noted to be founded over a limestone bedrock outcrop. The limestone bedrock outcrop was observed extending eastward through and beyond the intersection of Tenth Line Road and St. Joseph Boulevard.

Paterson completed a review of the general topography of the subject escarpment slope based on available LiDAR topographic data (2015). The steepest sections of the subject escarpment slope were noted to generally extend from top of slope to bottom of slope geodetic elevation 86 m to a bottom of slope geodetic elevation 72 m. The inclination was generally noted to range between 9° and 16.5° (16% and 30%) throughout the unsupported sections of the escarpment slope.

The existing average ground surface elevation across the top of the escarpment slope was noted to be relatively flat and at-grade with the surrounding areas and streets, ranging between approximate geodetic elevations 87 to 88 m. The ground surface elevation across the bottom of the escarpment slope was noted to slope gently east to west along St. Joseph Boulevard between approximate geodetic elevations 75 to 70 m, respectively.

North of Escarpment Slope – North Side of St. Joseph Boulevard & Subject Site

The existing average ground surface elevation north of the subject escarpment slope (towards and including the subject site), were noted to downwards slope gently northward from St. Joseph Boulevard between approximate geodetic elevations 72 to 65 m. The properties to the north of the subject escarpment slope were noted to include one- and two-storey commercial buildings, multi storey residential and municipal buildings, parking lots, and landscaped areas.

The subject site parcels, 530 Brisebois Crescent and Part of 265 Centrum Boulevard, were noted to be vacant. The 530 Brisebois Crescent parcel as noted to consist of vacant grassed land with the southern half of the parcel containing dense medium sized trees, and was noted to border Highway 174 to the immediate north. The Part of 265 Centrum Boulevard parcel was noted to consist of grassed land with several medium to large sized trees sparsely placed throughout.

3.2 Escarpment Slope Subsurface Conditions

Overburden

Paterson completed a review of several borehole log reports completed historically by Paterson and by others that were previously advanced within the top side of the subject escarpment slope (south of St. Joseph Boulevard). Further, Paterson completed a review of the borehole log reports advanced by others north of the escarpment slope and within the subject site boundary. Generally, based on our review and our knowledge of the area, the subsurface soil profile typically consists of topsoil underlain by a layer of desiccated brown silty clay crust, further underlain by a layer of unweathered grey silty clay, further underlain by a glacial till deposit and underlying bedrock formation.

Bedrock

Based on available geological mapping, the bedrock below the subject escarpment slope consists of limestone of the Bobcaygeon formation with an approximate overburden drift thickness ranging between 0 to 15 m. *It should be noted that geological mapping is approximate and published data may vary from in-situ conditions.* Further, it should be noted that the slope stability analysis presented herein does not rely on the bedrock depths from the above-noted available geological mapping. Reference should be made to the slope stability section of this report for more information and clarification.

Groundwater

Groundwater levels were previously measured in piezometers and monitoring wells within the boreholes from the surrounding investigations completed at nearby properties along the high side of the subject escarpment slope. The long-term groundwater level can also be estimated based on moisture levels, consistency, and coloring of the recovered samples. Based on the existing groundwater information and our knowledge of the groundwater within the nearby properties, the long-term groundwater level is estimated to be between **3 and 5 m** below the existing ground surface. However, for slope stability analysis purposes, the long-term groundwater level has been conservatively considered to be **1.5 m** below the existing ground surface. Reference should be made to the slope stability analysis section of the present report.

4.0 Geotechnical Desktop Slope Stability Analysis

4.1 Considerations and Assumptions

Background Information

The revised slope stability analysis presented herein was completed following discussions with the RVCA, during which the technical review comments and report contents were discussed in further detail. The revised analysis considers the feedback provided by each party with respect to the relevant discussion items.

Existing Slope Profile Topography

The slope stability analysis was completed using the existing slope topography derived from available LiDAR topographic data (2015). To verify the accuracy and suitability of the LiDAR data for the assessment, Paterson completed topographic survey shots during our site visit on April 29, 2026, using a high-precision GPS unit. The field survey observations and spot check survey shots generally confirmed the accuracy of the LiDAR-derived slope profile relied upon in the analysis.

Subsurface Information

The slope stability analysis was completed using available nearby and surrounding subsurface investigation data, including historical borehole logs and in-situ shear strength testing results, to assess the anticipated stratigraphy, soil strength parameters, and bedrock profile along the analyzed slope cross-section. As intrusive field investigations were not completed at the exact analyzed location, the subsurface profile and associated soil strength parameters incorporated into the analysis were selected conservatively to provide a reasonable worst-case assessment of slope stability conditions.

Paterson completed a review of several historical borehole investigation reports from test holes previously advanced south of the high side of the subject escarpment slope. The reviewed borehole data generally demonstrated consistent subsurface conditions and soil strength characteristics throughout the local silty clay deposit, with no significant stratigraphic discontinuities identified between investigation locations. Based on this consistency, Paterson considers the available nearby subsurface information to be representative and suitable for desktop slope stability assessment purposes.

The analysis approach adopted herein incorporates conservative assumptions regarding both soil strength and bedrock geometry to account for the limitations associated with the absence of site-specific intrusive investigations at the analyzed cross-section. Reference should be made to Drawings *PG8011-1 – Test Hole Location Plan* and *PG8011-2 Extrapolated Borehole Data Cross-Section* attached to the present report for the approximate borehole locations considered in our assessment.

Subsoil Stratigraphy

Brown Silty Clay

Based on the reviewed nearby borehole data, the upper brown silty clay crust was noted to exhibit a hard to very stiff consistency, with Standard Penetration Test (SPT) N-values generally ranging from approximately 12 to 16 blows per 300 mm and undrained shear strength values ranging between approximately 100 and 240 kPa. This layer was noted to generally extend from the existing ground surface to an approximate depth of 2 m below the existing ground surface. Beneath the crust, a transitional very stiff to stiff brown silty clay layer was noted, generally characterized by SPT N-values below 10 and undrained shear strength values ranging between approximately 50 and 210 kPa. This layer was noted to extend from approximately 2 to 3 m below the existing ground surface.

Grey Silty Clay

The underlying grey silty clay deposit was noted to exhibit a stiff to firm consistency with undrained shear strength values generally ranging between approximately 25 and 97 kPa. This layer was noted to extend from approximately 3 to 5 m below the existing ground surface. Beneath this layer, a firm grey silty clay was noted, generally characterized by undrained shear strength values ranging between approximately 22 and 52 kPa. This layer was noted to extend from approximately 5 to 11 m below the existing ground surface.

Glacial Till and Bedrock

Glacial till deposits were identified within portions of the reviewed historical test hole and well record datasets and were intentionally omitted from the modeled stratigraphy to maintain a conservative approach and to avoid incorporating additional stabilizing benefit associated with the presence of higher-strength materials.

Strength Parameter Selection Background Information

The soil strength parameter selection was completed conservatively to reflect potential variability in subsurface conditions across the subject silty clay deposit. The undrained shear strength profile was developed by grouping the undrained shear strength testing results into geologically consistent layers based on the observed changes in physical characteristics and measured shear strength values. For each layer, the average undrained shear strength was determined from the available nearby field vane data.

To provide a conservative approach that reflects the observed variability within each layer, the design undrained shear strength was selected by subtracting the standard deviation from the calculated mean strength for each layer. Further, given the absence of undrained shear strength values deeper than 11 m, the undrained shear strength of the grey silty clay below 11 m was assumed to not increase with depth but rather was assigned the same value as the deepest available undrained shear strength data (i.e. the same as the firm grey silty clay layer). This approach provides a representative lower-bound estimate of the available undrained shear strength data while accounting for potential variability throughout the deposit.

The post-seismic slope stability assessment was completed using a strain-softened undrained shear strength approach to account for the potential cyclic degradation of the silty clay soils following seismic loading. The assessment methodology considers the post-cyclic degradation approach presented by Ajmera (2015)[1], while considering its applicability based on published cyclic loading studies and literature on sensitive Champlain Sea clays in eastern Ontario and Quebec, including Mitchell and King (1977)[2] and LeBoeuf et al. (2016)[3].

The Canadian Foundation Engineering Manual (CFEM) (2023) criterion regarding the potential use of remoulded shear strength was also considered. Although the subject clay exhibits high sensitivity, remoulded shear strength represents a fully de-structured soil condition associated with large strain deformation and substantial breakdown of the natural clay fabric. The available Canadian-based literature indicates that cyclic degradation of Champlain Sea clay is progressive and governed by stress level, pore pressure response, and the accumulation of cyclic strains, rather than an immediate transition to a fully remoulded condition.

Of particular relevance, LeBoeuf et al. (2016) reported that Rigaud clay (located roughly 100km east of Ottawa within the historical Champlain Sea) subjected to approximately 150 loading cycles at a cyclic deviatoric stress equal to approximately 80% of the sample’s undrained shear strength did not exhibit a significant reduction in subsequent peak undrained shear strength.

[1] Ajmera, Beena. (2015). Factors Influencing the Post-Earthquake Shear Strength.
[2] Mitchell and King. (1977). Cyclic loading of an Ottawa area Champlain Sea Clay.
[3] LeBoeuf, Denis. (1977). Cyclic Softening and Failures in Sensitive Clays and Silts.

Considering the available cyclic loading research, the limited number of significant stress cycles anticipated during a design earthquake in eastern Ontario, and the calculated seismic factor of safety exceeding 1.1 (as discussed in subsequent sections of the present report), widespread deformation and the large strains required to fully de-structure the clay deposit are not anticipated. As such, the use of fully remoulded shear strength for the post-seismic assessment is not considered representative of the anticipated in-situ response for the subject escarpment slope.

Accordingly, a post-seismic degradation ratio of δ = 0.67 was adopted and was considered to provide a conservative representation of a degraded, but not fully remoulded, undrained shear strength condition for the post-seismic slope stability assessment.

Strength Parameters

The soil strength parameters presented in Table 1, 2 and 3 were considered for the slope stability analysis under Static, Seismic, and Post-Seismic conditions, respectively.

Table 1 – Effective Stress Soil Parameters (Static Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Brown Silty Clay Crust	17	33	5
Brown Silty Clay	17	33	5
Stiff to Firm Grey Silty Clay	16	33	10
Firm Grey Silty Clay	16	33	10
Bedrock	21	-	-

Table 2 – Total Stress Soil Parameters (Seismic Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Brown Silty Clay Crust	17	0	157
Brown Silty Clay	17	0	75
Stiff to Firm Grey Silty Clay	16	0	32
Firm Grey Silty Clay	16	0	28
Bedrock	21	-	-

Table 3 – Residual Total Stress Soil Parameters (Post-Seismic Analysis)			
Soil Layer	**Unit Weight (kN/m^3)**	**Friction Angle (degrees)**	**Cohesion (kPa)**
Brown Silty Clay Crust	17	0	105
Brown Silty Clay	17	0	50
Stiff to Firm Grey Silty Clay	16	0	22
Firm Grey Silty Clay	16	0	19
Bedrock	21	-	-

Bedrock Profile

The slope stability analysis considers a bedrock surface elevation tapering from north to south between approximate elevation 66.9 m beyond the toe of slope (towards the north), and 56.6 m beyond the top of slope (towards the south). These interpolated bedrock surface elevations are based on nearby borehole rock coring data obtained from borehole BH25-08 completed by others at 265 Centrum Boulevard (located within the subject site to the north of the subject escarpment slope toe) and nearby Dynamic Cone Penetration Testing (DCPT) refusal obtained from borehole BH 5-23 previously completed to the south of the subject escarpment slope by Paterson. Nearby Ontario Well Record data was reviewed as to confirm the general bedrock surface depth to support the suitability of the DCPT refusal depth.

It should be noted that evidence of localized upward undulations in the bedrock surface is present based on visible bedrock outcrops along St. Joseph Boulevard between Vieux-Silo Road and Tenth Line Road, as well as south of the St. Joseph Boulevard and Tenth Line Road intersection along Tenth Line Road. Similar indications of shallower bedrock conditions were also identified within nearby Ontario Geological Survey (OGS) borehole 804200 located east of the analyzed escarpment near the intersection of Tenth Line Road and St. Joseph Boulevard.

Despite these observations, a relatively uniform and deeper bedrock profile was assumed within the analysis to maintain a conservative assessment and eliminate any potential benefit associated with shallower bedrock conditions. Visible bedrock outcrops and well records locations considered in the analysis are presented on Drawing PG8011-1 – Test Hole Location Plan attached to the present report.

Groundwater

The groundwater table depth incorporated into the slope stability analysis was assigned a depth limited by foundation drainage systems and hardscaping and considered as **1.5 m** below the existing ground surface, which is considered the minimum founding depth below ground surface for heated occupied structures to be founded below the local depth of frost migration.

4.2 Slope Stability Analysis

Analysis Methodology

One (1) cross-section (Section A) was studied as a worst-case scenario. The location of Section A was selected to model the slope in its unsupported state rather than relying on the potential stability increase that the various existing retaining walls along the subject escarpment slope toe would provide. The cross-section location is presented on Drawing PG8011-1 – Test Hole Location Plan, attached to the present report.

The slope stability analysis was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favoring failure.

Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and variability of the subsoil and groundwater conditions, a factor or safety greater than one is usually required to ascertain the risks of failure is acceptable. A minimum factor of safety of 1.5 is generally recommended under static conditions where the failure of the slope would endanger permanent structures. A factor of safety of 1.1 is considered to be satisfactory for stability analysis considering seismic loading.

Analysis Results

Static Loading

The results of the existing escarpment slope under static loading conditions at Section A are shown in Figure 1A attached to the present report. The overall slope stability factor of safety for the subject section was found to be greater than 1.5. As such, a stable slope allowance setback is not required for the subject escarpment slope under static conditions.

Seismic Loading

An analysis considering seismic loading was also completed as part of the slope stability analysis. A horizontal seismic loading acceleration, Kh, of 0.2g was considered for the analyzed section. The results of the existing escarpment slope under seismic loading conditions at Section A are shown in Figure 1B attached to the present report. The overall slope stability factor of safety for the subject section was found to be greater than 1.1. As such, a stable slope allowance setback is not required for the subject escarpment slope under seismic conditions.

Post-Seismic Loading

An analysis considering post-seismic loading was also completed as part of the slope stability analysis. Reduced undrained shear strength values were considered for the analyzed section, as discussed in previous sections of the present report. The results of the existing escarpment slope under post-seismic loading conditions at Section A are shown in Figure 1C attached to the present report. The overall slope stability factor of safety for the subject section was found to be greater than 1.3. As such, a stable slope allowance setback is not required for the subject escarpment slope under post-seismic conditions.

Sensitivity Analysis

A series of sensitivity analyses were completed as part of the revised slope stability assessment to evaluate the influence of uncertainty associated with the interpreted subsurface conditions, groundwater levels and adopted undrained shear strength parameters. These analyses were completed to support the conservative approach of the slope stability model, recognizing that subsurface conditions were interpolated from the available borehole data in the vicinity of the analyzed cross-section.

High-Groundwater Scenario

A high groundwater sensitivity analysis was completed with the groundwater table placed at the existing ground surface to assess the potential influence of adverse groundwater conditions that may occur during periods of significant snowmelt or precipitation. The results of the analyses completed using both groundwater conditions indicated that the calculated factors of safety remained above the minimum values required by the Guidance letter. The results of the high-groundwater scenario analysis yielded factors of safety of 2.83, 1.27, and 1.43 under static, seismic, and post-seismic loading conditions, respectively.

Undrained Shear Strength

Sensitivity analyses were also completed to assess the influence of the adopted undrained shear strength profile. As mentioned in previous sections of this report, the undrained shear strength values were developed from a statistical interpretation of the available field vane test data and were conservatively selected as the mean value less one standard deviation for each interpreted layer of the deposit. To further assess the reliability of the stability results, an additional sensitivity analysis was completed using an additional 10% reduction in the already conservatively selected undrained shear strength values for the seismic and post-seismic loading conditions. The results of the reduced undrained shear strength analysis yielded factors of safety of 1.14 and 1.32 under seismic and post-seismic conditions, respectively. Both results are greater than the minimum values required by the Guidance letter under seismic and post-seismic conditions.

The sensitivity analyses demonstrate that the conclusions of the slope stability assessment are not significantly affected by reasonable variations in the interpreted groundwater conditions or undrained shear strength parameters. The results further support that the adopted subsurface model and input parameters provide a conservative assessment of the stability of the subject escarpment slope.

Concluding Remarks

Based on our review and analysis, the subject escarpment slope was found to satisfy and exceed the minimum factors of safety of 1.5, 1.1, and 1.3 under static, seismic, and post-seismic conditions, respectively. Based on the results of the assessment, a stable slope allowance setback is not considered necessary for the subject escarpment slope. Furthermore, given the absence of an active watercourse or evidence of significant toe erosion processes at the base of the slope, neither toe erosion nor erosion access setbacks are considered warranted for the subject site.

Based on the above, Paterson considers the subject escarpment slope exempt from the minimum field investigation and laboratory testing requirements outlined within the aforementioned Guidance letter. Accordingly, Paterson finds the subject site parcels located north of the escarpment slope suitable for the proposed development from a geotechnical and slope stability perspective.

5.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. A desktop investigation is a limited investigation of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Forum Investment and Development Corporation or their agents, without review by this firm for the applicability of our recommendations to the altered use of the report.

We trust that the current submission meets your immediate requirements.

Best Regards,

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
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Attachments:

- ❑ Soil Profile and Test Data Sheets.
- ❑ Atterberg Limits Results.
- ❑ Well Records.
- ❑ Figure 1 – Key Plan.
- ❑ Figures 1A to 1C – Slope Stability Analysis.
- ❑ Drawing PG8011-1 – Test Hole Location Plan.
- ❑ Drawing PG8011-2 - Extrapolated Borehole Data Cross-Section.

Report Distribution

- ❑ Forum Investment and Development Corporation (e-mail copy)
- ❑ Paterson Group (1 copy)