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Memorandum

Date: August 27, 2021

Project #: 1701603

File #:

To: Frank Filippo (Zancor Homes (Bolton) Inc.)

From: Michael Brierley M.Sc., Dan McParland P.Geo., and Robin McKillop P.Geo.

cc: Jason Cole P.Geo.

Re: Chickadee Lane Erosion Threshold of Humber River Tributaries

1. Introduction

Palmer is pleased to provide Brookvalley Project Management Inc. (Brookvalley), on behalf of Zancor Homes Inc. (Zancor), the results of our erosion threshold assessment of two reaches (A5 and D2) of Humber River downstream of a proposed stormwater management (SWM) pond outlet that descend into the Humber River Valley and drain the northwest corner of the subject property at the intersection of Chickadee Lane and Glasgow Road, in Bolton.

1.1 Background

Initial geomorphological field reconnaissance was completed on February 5, 2019, to examine the conditions and erosional processes along a headwater gully system downstream of the proposed stormwater management (SWM) pond (**Figure 1; Palmer 2020a**). TRCA, in comments received May 15, 2020, expressed concern that reaches downstream of the proposed SWM pond may be susceptible to excessive erosion due to the proposed development of the subject property as well as recent urban development south of Emil Kolb Parkway. Accordingly, Palmer's Fluvial Processes Specialists assessed existing conditions along the entire headwater tributary drainage network (Reaches A, B, C, and D) west of the subject property on June 30, 2020, to document erosional processes and inform appropriate pond outlet locations (Palmer, 2020a).

Following the existing conditions assessment (Palmer, 2020a), an options assessment for the pond outlet was completed (Palmer, 2020b). The options assessment identified that Option 2 would be the most appropriate outlet location from a geomorphological perspective (**Figure 1; Palmer 2020a**). Option 2 would result in the proposed SWM pond[1] discharging into Reach A5. Reach A5 is transitional in its genesis and

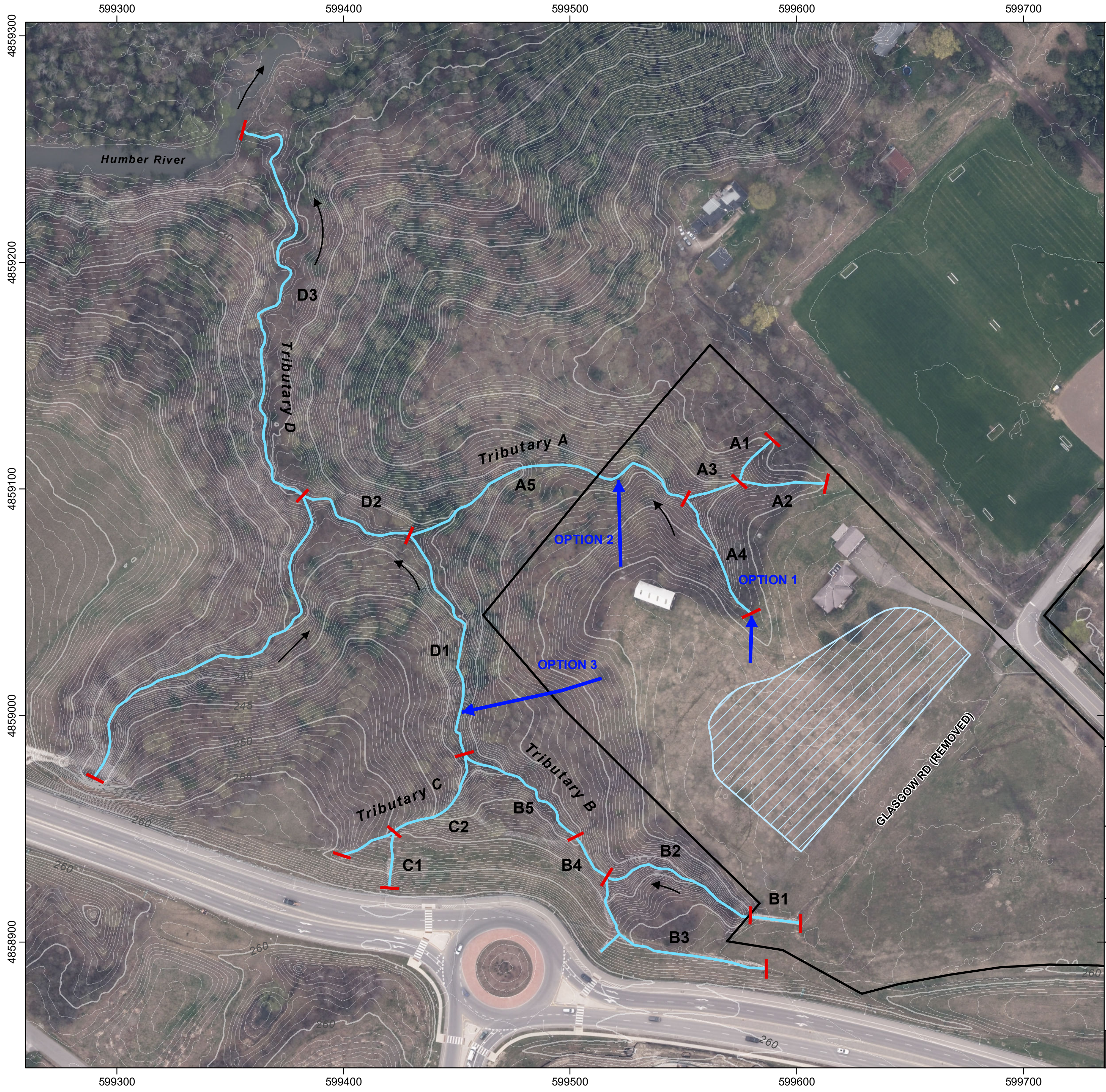
[1] *Following correspondence from TRCA on 15 May 2020, the proposed SWM pond will need to be relocated outside of the delineated Long-Term Stable Top of Slope (LTSTOS) and associated allowances, which represents the limit of the Significant Valleyland as a KNHF under the Greenbelt Plan 15 m development buffer established based on habitat delineation.*

characteristics, exhibiting more influence from fluvial characteristics. Between the proposed SWM pond and the Option 2 outlet, the valley wall has a gentler gradient relative to slopes 50 m to the east and west along and reduced mature vegetation cover along the proposed alignment.

To inform release rates from the proposed SWM Pond, Palmer's Fluvial Processes Specialists completed erosion threshold analyses in both Reach A5 and Reach D2 (**Figure 1; Palmer 2020a**). Reach D2, which is immediately downstream of Reach A5, was assessed because it is rapidly responding to an altered flow regime due to urban development south of Emil Kolb Parkway and, thus, very sensitive to changes in flow regime. Reach A5 and Reach D2 are both downstream of Option 1 outlet. Reach D2 is downstream of the Option 3 outlet.

2. Physical Setting

In the vicinity of the subject property, Humber River has incised through thick deposits of clay- to silt-textured till at least partly derived from erosion of glaciolacustrine deposits. Borehole logs from drilling completed within the subject property generally confirm that a veneer of topsoil and earth fill overlie silty clay till and compact to very dense sandy silt till at greater depths (Soil Engineers Ltd., 2018). Borehole 2 (BH2), which is located closest to the proposed SWM pond and the edge of the valley, corroborates field observation that the walls of the gully features that descend into the Humber River valley comprise silty clay till, with traces of gravel, sand seams, cobbles and boulders (Soil Engineers Ltd., 2018). The till helps maintain morphological form in the steep headwater tributaries and supplies sediment to downstream reaches.



LEGEND:

- Property Boundary
- SWM Pond
- Channel Centreline
- Reach Break
- Flow Direction
- Proposed SWM Pond Drainage Outlet Option
- Contour (5 m)
- Contour (50 cm)

Imagery (2019) provided by Peel Region.

0 20 40 60 80
metres

PROJECT NO.	1701603	REVISION:	1-2
DATE:	Aug 27, 2021	SCALE:	1:2300
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	MB	PROJECTION:	UTM zone 17

CLIENT: Brook Valley Homes

PREPARED BY: Palmer

PROJECT: Chickadee Lane

TITLE:

Study Area and Proposed Drainage Routes

Figure 1

Document Path: G:\Shared drives\Projects 2017\17016 - Brook Valley Homes\1701603 - Chickadee Lane Ecology and Hydrogeology\Mapping\mxd\2021\1701603_Figure1-1_Proposed Drainage Routes.mxd

3. Methods

The erosion threshold assessment was completed in accordance with TRCA's detailed procedural documents (2008). Field data collection occurred on December 9, 2020, by Palmer's Fluvial Process Specialists. Site-specific data collection included four bankfull cross-sections along each reach (locations shown in **Figure 1**); a local longitudinal bed survey (rod and level); substrate characteristics, including grain size distribution estimates based on modified Wolman (1954) pebble counts at each cross-section along Reach D2 and a single representative sample for Reach A5; and description of bank structure and composition. Fine-grained bed material was characterized by grain size range class (e.g. silt, fine sand) by visual examination and hand texturing, with confirmatory reference to nearby borehole logs and associated grain size analysis records. Bankfull dimensions were based on field indicators defining the principal limit of scour, including abrupt changes in bank vegetation, material, and steepness (Harrelson et al., 1994), which is assumed to correspond to the 'channel-forming' discharge. Irregular and unstable morphology complicates the identification of bankfull indicators along Reach D2 (Palmer, 2020a).

Although cohesive till substrate was locally observed along both reaches, channel morphology of Reach A5 and Reach D2 is largely controlled by cohesionless alluvial material present along the bed and banks. Furthermore, in Reach A5 the range of bed grain sizes is broad and channel morphology is controlled by both silts and sands present along channel periphery and interstitial spaces of coarser-grained materials as well as coarse gravels and cobbles unevenly distributed along the bed. In Reach D2, the gravel bed material is more consistent along the reach. For observed coarse-grained material (gravels and cobbles) in Reach D2 and Reach A5, erosion threshold and critical discharge analyses were completed based on a Shields (1936) approach as outlined by Church (2006), as it is a semi-empirical approach (as opposed to completely empirical). The median grain size (D_{50}) was used for the erosion threshold calculations. Erosion thresholds were compared to hydraulic conditions at bankfull flows (established from the field survey) to better understand the propensity for entrainment.

To determine the erosion threshold for the fine-grained material (silt and sand) in Reach A5 a representative silt grain size (0.05 mm) was compared to entrainment thresholds established by Hjulström (1935). The Hjulström (1935) approach better represents the entrainment of fine-grained material relative to Shields (1936). Silts were more readily observed than sand during hand texturing at Reach A5 and more susceptible to erosion compared to cohesive tills documented in borehole logs (Soil Engineers Ltd., 2018). Cohesive material is bound together by electrochemical forces in such a way that resists entrainment. As such, cohesive material entrainment is not a function of particle size (Knighton, 1998). Therefore, the establishment of an erosion threshold based on the silt fraction is considered a conservative approach.

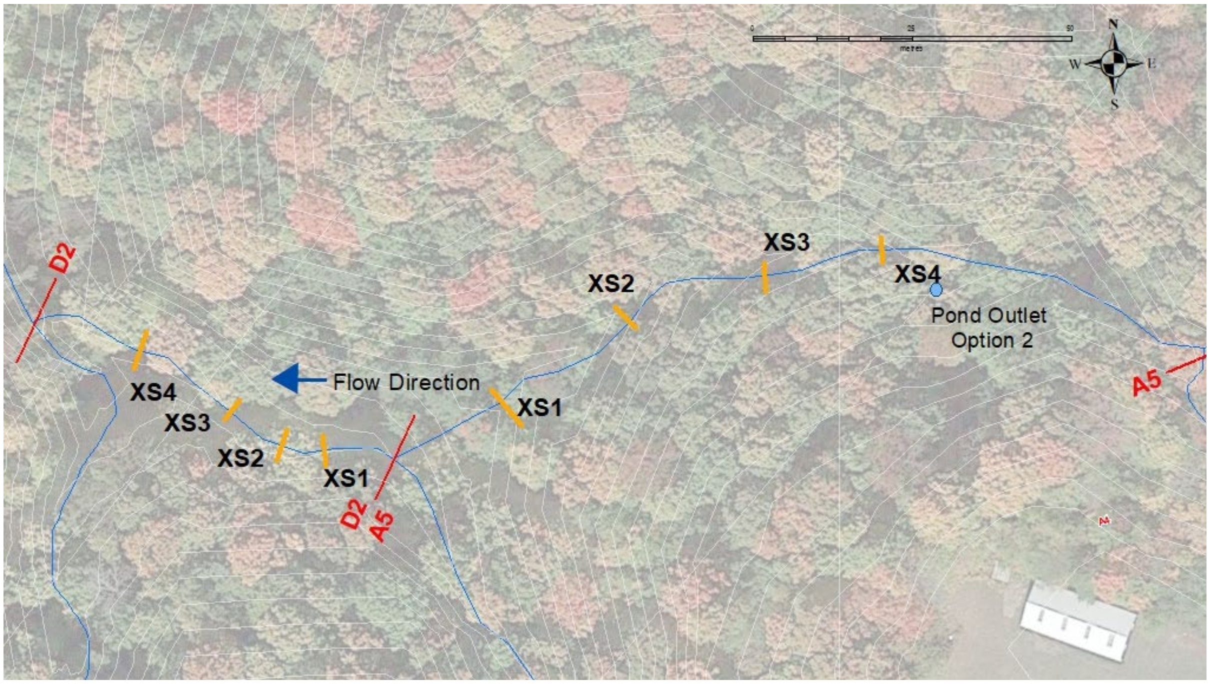


Figure 2. Reach breaks, preferred stormwater management discharge location (Option 2), and surveyed cross-section locations.

4. Description of Channel Morphology of Reach A5 and Reach D2

The planned SWM pond is proposed to discharge into the Humber River Valley (**Figure 1**). Three outlet alternatives were identified during a field investigation on May 26, 2020 (**Figure 1**). Two of the outlet alternatives are proposed to discharge into Tributary A catchment, located at the northeast corner of the subject property. The third alternative is proposed to discharge into Tributary D, located west of the property boundary.

4.1 Reach A5

Reach A5 exhibits little sign of active erosion along sidewalls and no mass movement failures. The channel has a sinuous planform; however, it is not a function of lateral erosion but forced by valley topography. The gully has a moderate-high gradient (9.54%). The bed and bank material consist of sand and silts as well as localized till exposure, overlain by cobbles and boulders (**Photo 1**). Sand and small gravels are temporarily deposited upstream of boulder clusters and woody debris. Woody debris and exposed tree roots impart structure and roughness along the bed (**Photo 2**). High organic matter (i.e. fallen leaves) increase erosion resistance of the bed and valley substrate. Coarsening of the bed material moderates bed erosion.

Photo 1. Upstream view of cobbly substrate along the bed near the downstream extent of Reach A5.

Photo 2. Upstream view of wood debris and organic matter accumulation along the bed which adds additional roughness.

4.2 Reach D2

Immediately downstream of Reach A2, Reach D2 is morphologically sensitive and is adjusting to unnaturally deep and fast flows resulting from watershed urbanization west of Emil Kolb Parkway (**Photo 3**). Reach D2 is a sinuous channel confined on both sides by terraces (1.5 – 2.0 m high) and prominent valley walls with no accessible floodplain. The channel has incised through alluvial floodplain into underlying till. Increased peak flows have also begun to widen and deepen the channel, creating a new corridor with a low discontinuous floodplain. The new corridor has a width and depth of 5 m and 1.5 m. The averaged bankfull width and depth are 3 m and 0.4 m, respectively. The bankfull depth is well below the physical top of bank following rapid bed degradation. The average bed gradient along the reach is approximately 4.15%. Bed morphological units (e.g. pools, riffles) are poorly defined due to active degradation. Bed materials are dominated by gravels and cobbles and locally overlain by sand (**Photo 4**). Till is exposed locally along the bed, mostly along the thalweg, and extensively along the lower banks.

Photo 3. Downstream view of channel incision that has lowered the bed 1.5 to 2.0 m below the floodplain.

Photo 4. Downstream view of gravel and cobble bed material locally overlain by sand.

5. Erosion Thresholds

5.1.1 Reach A5 – Coarse-grained Material

Using the Shields (1936) approach[2], a critical shear stress of 116 N/m^2 was established for the D_{50} (120 mm) of the gravel and cobbly to boulder alluvium lag along the bed of Reach A5. This critical shear stress is exceeded at a discharge of 0.21 m^3/s, which corresponds to approximately 41% of the bankfull flow[3] (0.51 m^3/s), demonstrating that the coarse grain bed material is mobilized during flows below the physical tops of bank. However, bed structure (steps, knickpoints, roots, etc.), cohesive till material and woody debris provide stability along the reach bottom, moderating erosive potential and therefore transport potential of cobble and boulder substrate.

5.1.2 Reach A5 – Fine-grained Material

Using the Hjulström (1935) approach, a critical velocity of 0.53 m/s was established for silt (0.05 mm). This critical velocity is exceeded at a discharge of 0.058 m^3/s, which corresponds to approximately 11% of the bankfull flow (0.51 m^3/s). Thus, the fine-grained material along the channel periphery and in the interstitial spaces of the coarser-grained sediments will be more readily eroded in Reach A5 than the coarse-grained material.

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[2] *Critical Shields (1936) parameter assumed to be 0.06 (Church, 2006).*

[3] *To estimate bankfull hydraulics, a Manning's 'n' of 0.075 was chosen for Reach A5 due to the large relative roughness and accumulation of organic debris. This value was corroborated by measured Manning's 'n' values presented in Hick and Mason (1991) for is a watercourse that had a similar gradient and discharge to Reach A5.*

5.1.3 Reach D2

Using the Shields (1936) approach[4], a critical shear stress of 25 N/m^2 was established for the D_{50} (34 mm) of the bed material in Reach D2. This critical shear stress is exceeded at a discharge of 0.18 m^3/s, which corresponds to approximately 8% of the bankfull flow[5] (2.29 m^3/s), demonstrating that bed material is mobilized during flows well below bankfull conditions. Furthermore, average shear stresses at bankfull conditions can entrain the D_{95} (105 mm), indicating bankfull flow can lead to reach-scale morphological restructuring in Reach D2. The erosion threshold of Reach D2 (0.18 m^3/s) is less than the erosion threshold of the coarse-grained fraction in Reach A5 (0.21 m^3/s) but considerably higher than the erosion threshold of the fine-grained fraction of Reach A5 (0.058 m^3/s).

6. Summary and Recommendations

Palmer completed an erosion threshold assessment along two headwater tributaries (A5 and D2) downstream of a proposed SWM pond outlet. An erosion threshold of 0.058 m^3/s was established for the observed fine-grained sediments in A5. The established erosion threshold will not exacerbate ongoing instability in Reach D2. The established erosion threshold (0.058 m^3/s) exceeds the 25 mm 4-hour Chicago storm event discharge (0.011 m^3/s). Therefore, the 25 mm storm discharge from the SWM Pond is only 17% of the established erosion threshold.

7. Certification

This memorandum was prepared and reviewed by the undersigned:

Prepared By:

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Reviewed By:

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Fluvial Processes Specialist

Approved By:

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Principal, Fluvial Geomorphologist

[4] *Critical Shields (1936) parameter assumed to be 0.045 (Church, 2006).*
[5] *To estimate bankfull hydraulics, a Manning's 'n' of 0.04 was chosen for Reach D2.*

References

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