Mosquito Creek Tributary 3 Geomorphological Assessment

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1 Introduction

A site at 4101 Limebank Road, Ottawa ("subject lands") is proposed to be developed from agricultural land into commercial use. The subject lands occupy 15.12 ha, of which 13.4 ha will be developed. The remaining 1.8 ha is proposed for development as a semi-rural access road by the City of Ottawa. Stormwater servicing will be achieved through a proposed stormwater management (SWM) Pond situated within the southwestern corner of the subject lands. We note that an existing SWM Pond (Pond 3) located south of the subject lands is proposed for expansion and will service lands external to the proposed 4101 Limebank Road development. The proposed SWM Pond will outlet into **Tributary 3** of Mosquito Creek, which itself flows into Rideau River approximately 3 km to the west. The subject lands lie within the Primary Bird Hazard Zone of Ottawa International Airport (YOW). As such, any stormwater ponds within this zone must be fully drained following storm events to minimise wildfowl hazards within YOW airspace. Robinson Consultants Inc. (RCI) are designing the upgrades a proposed SWM Pond to receive stormwater runoff from the site; the pond will be designed to drain within 48 hours of rainfall events to minimise congregation of wildfowl near the Ottawa International Airport, while limiting geomorphic impacts in the downstream watercourse.

GEO Morphix Ltd (GEO Morphix) have been retained by Groupe Montoni to complete a fluvial geomorphological assessment for **Tributary 3**. The objectives of the assessment were to document and characterize existing conditions within the watercourse, quantify the erosion thresholds for boundary materials, and assess the potential for stormwater discharges to alter erosion rates with the subject tributary. The results of analysis will assist with determining detention and release rates that minimise erosion within **Tributary 3** and Mosquito Creek while also enabling the SWM Pond to drain within 48 hours. GEO Morphix has extensive knowledge and experience working within the Mosquito Creek watershed, including **Tributary 3**, having authored the Master Drainage Plan (MDP) for the ongoing developments in the area (GEO Morphix, 2021), and several subsequent reports.

The following activities were completed as part of the fluvial geomorphological assessment:

- Review of available background reports and mapping (i.e., watershed/subwatershed reporting, geology, topography, etc.) related to channel form and function and controlling factors related to fluvial geomorphology
- Terrain analysis and historical assessment using aerial photograph records and LiDAR-derived DEM data to identify changes to the system due to land use and past channel modifications within the primary and extended study areas
- Review previous reach delineation along the receiving watercourses through a desktop exercise, and revise if necessary
- Conduct a rapid geomorphological field assessment to verify the findings of the background review and desktop assessment, confirm that no significant changes have occurred in the watercourse since the previous field assessment and identify the most erosion-sensitive reach along the receiving watercourse
- Review of previous detailed geomorphological field assessment along the most erosion-sensitive reach to support and inform erosion threshold modelling and erosion exceedance analysis
- Conduct a drainage area analysis of delineated reaches using LiDAR-derived DEM data to quantify the proportional contribution of the subject lands on downstream reaches
- Review and revise erosion threshold assessment for the most erosion-sensitive reach to determine the limiting erosion threshold value based on the proportional area of the subject lands to the watershed
- Conduct an event-based analysis of pre- and post-development erosion potential for the most erosion-sensitive reach under a range of synthetic storms to inform and evaluate stormwater mitigation measures and SWM pond design.

2 Study Area

The subject lands cover an area of 15.12 ha, of which 13.4 ha will be developed, with the remaining 1.8 ha reserved for the future realignment of Leitrim Road (RCI, 2026). At the confluence of **Tributary 3** and Mosquito Creek, the entire subject lands comprise around 3% of the drainage area of **Tributary 3** and 0.5% of the combined drainage area of Mosquito Creek and Tributary 3. As a result, the potential for measurable downstream impact of stormwater from the development of the subject land is limited to **Tributary 3**, with negligible potential impact in the mainstem of Mosquito Creek. As a result, the assessment provided here will focus on **Tributary 3** alone.

2.1 Reach Delineation

A reach is a length of channel that has a relatively consistent set of controlling conditions and resulting morphological characteristics, such that it can be treated as an individual unit of analysis. The upstream and downstream limits of a reach are defined as locations where there is a significant change in controlling conditions, transitions which typically manifest as a change in reach morphological characteristics. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method 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 typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Valley confinement
- Physiography
- Land cover (land use or vegetation)
- Tributary confluences
- Soil type and surficial geology
- Historical channel modifications

Reach delineation followed a scientifically defensible methodology proposed by Montgomery and Buffington (1997), the Toronto and Region Conservation Authority (TRCA, 2004) and others. Several watercourse reaches were delineated within the subject lands based on a desktop assessment of available data (e.g., MNRF stream layer, surficial geology, historical and recent aerial photographs, topographic data.

Three distinct tributaries (**T3A**, **T3B**, and **T3C)** meet and flow into Mosquito Creek **Tributary 3** (**T3)** before flowing into the mainstem of Mosquito Creek. There were seven distinct reaches within the network of tributaries: **T3**, **T3A**, **T3B**, **T3B1-R1**, **T3B1-R2**, **T3C-R1 and T3C-R2**. This delineation follows previous reporting (GEO Morphix, 2021), and there is no evidence which would require changing the previously established reaches.

See **Appendix A** for mapping of the delineated reaches.

2.2 Desktop Assessment

Stream morphodynamics are largely governed by the flow regime and the availability and type of sediments (e.g., surficial geology) within the stream corridor. Secondary variables that affect the channel include the surrounding topography, land use and riparian vegetation. These 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.

2.2.1 Physiography and surficial geology

The study area lies within the Clay Plains physiographic area (Unit 12), comprising fine glaciomarine silt and clay sediments (surficial geology unit 10a; Chapman and Putnam, 2007; OGS 2010). Site and

hillshade maps of the area are provided in **Appendix A**. Clayey sediments produce relatively stable cohesive banks which can lead to relatively deep, narrow channels.

2.2.2 Terrain Analysis

Stream channels are inherently dynamic features of the landscape, and a detailed review of channel and valley geomorphology using spatial datasets is useful to gain insight into how a given fluvial system has adjusted and is likely to adjust over time within the wider landscape, due to gradients, sediment supply and confinement and channel boundary materials. In particular, high-resolution bare-earth digital elevation models derived from airborne LiDAR surveys allow for detailed, landscape-scale mapping and analysis of geomorphic features.

A LiDAR-derived bare-earth digital elevation model was obtained from a publicly available dataset maintained by the Ontario Ministry of Natural Resources and Forestry (MNRF; 2023). The bare-earth elevation raster was used to generate a hillshade model to aid in interpreting and analyzing geomorphic features.

The areas surrounding the subject lands are low relief, consistent with the mapped clay plain physiographic region. Smaller watercourses and headwater drainage features largely flow over the surface of the clay plain, forming unconfined reaches. Larger watercourses incise into the surface of the clay plain, forming confined meandering reaches within narrow valleys; reach **T3** lies around 8 m below the upper surface of the clay plain. The meanders appear to be actively migrating within reach **T3**, with cutoff meanders observed, particularly near the confluence with Mosquito Creek. Previous erosion hazard assessments concluded that the meander belt was confined within the valley (GEO Morphix, 2021).

Valley walls slope at between approximately 15° and 25°; meander cut banks frequently impinge on the valley walls, forming steep slopes exceeding 45°. These over-steepened valley walls create an elevated risk of mass movements, and the clayey surficial geology of the study area is prone to rotational slumps and translational slides (Gautier *et al*., 2025). An 8 m toe erosion allowance has been applied to Mosquito Creek and its tributaries to account for the potential of these mass movements (Paterson Group, 2019; GEO Morphix, 2021).

2.2.3 Historical Changes

Historical aerial photographs were reviewed as part of the MDP (GEO Morphix, 2021) to determine changes to the channel and surrounding land use/cover. This study will also examine the visible changes in the watercourse since 2020. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. The 1945 photos were retrieved from NAPL; the 1976, 1991, and 2005 aerials were provided by the City of Ottawa; and the 2018 and 2025 images were retrieved from Google Earth Pro.

A summary of the historical changes to the watercourses is provided in **Table 1** and available air photographs are presented in **Appendix B**.

Broadly, the land use/land cover of the study area can be characterised as agricultural, with minor changes to human development up to 2005. Between 2005 and 2025, urban development accelerates, principally the widening of Limebank Road with associated alterations to **Tributary 3**, and the initiation of commercial development around the intersection of Limebank Road and Spratt Road. Reach **T3C-R1** was realigned and stabilised prior to 2012, with no visible change in channel course since.

Table 1. Historical assessment of the Mosquito Creek Tributary 3.

Year	Description of changes
1945	Land use is predominantly agricultural, grass and herbaceous riparian vegetation.
1976	No observable changes in riparian buffer or planform since 1945
1991	No major changes noted in land use. Growth and increased connectivity of trees within riparian buffer in T3 and T3A.
2005	The establishment of the Riverside South community has little effect at this time due to development occurring south and west of Mosquito Creek. The construction of Spratt Road entailed the re-alignment of a non-assessed reach entering T3A immediately north of Spratt Road, and the construction of a culvert for the passage of a non-assessed reach south of Spratt Road. Continued growth, and increased connectivity of trees within riparian buffer within T3 and T3A to form continuous tree cover. Expansion of trees into T3C-R1 to form continuous cover. Growth of sparse trees alongside other reaches.
2018	Widening of Limebank entails the construction of new watercourse crossings at T3B. Reaches T3C-R1 and T3C-R2 are realigned into an artificial meandering planform. Farm buildings alongside reach T3C-R2, east of Limebank Road, are demolished. A small agricultural field west of Limebank Road is converted into Pond 3. New channel design project alters the planform of T3A-R1 from an irregular meandering pattern to a regular meandering pattern. Construction of a commercial plaza at the south-east corner of Limebank and Spratt entailed the construction of a passage for a non-assessed reach immediately upstream of T3A. Construction of stormwater pond alongside T3C-R2 Continued growth and connectivity of trees within riparian zone of all reaches of Tributary 3.
2025	Initial land clearance and road construction of development on west side of Limebank Road (Gastop Street, Mosquito Drive) alongside Tributary 3. Significant increase in tree connectivity in T3C-R1; continued tree growth in other reaches.

2.2.4 Drainage Area Analysis

The potential influence of stormwater runoff from the subject lands on downstream channel erosion processes generally decreases as the contributing drainage area of the receiving watercourse increases. In this context, runoff from the proposed site accounts for a progressively smaller portion of the streamflow at downstream locations. Broadly, reaches where the proposed development contributes less than 10% of the total contributing drainage area are generally considered beyond the downstream limit of potential influence from changes in land use associated with the proposed development. The assessment therefore focused on the reaches receiving a more significant relative runoff contribution from the subject lands.

Drainage areas were defined for all reaches of **Tributary 3** from the proposed SWM pond outfall to the confluence with Mosquito Creek. The areas were determined through LiDAR-based analysis utilising Whitebox Watershed Analysis tools in QGIS through a standard workflow. The results were compared to existing mapping of drainage divides and watercourses (RVCA; City of Ottawa) and adjusted, as necessary, to the agency delineated drainage divides; RCI (2026) provided the drainage area for reach **T3C-R2** based on their hydrologic modelling, which aligned well with the drainage area delineated by GEO Morphix.

The drainage areas for each reach and the proportional contribution of the subject lands are presented in **Table 2**.

Table 2. Drainage area analysis for Mosquito Creek Tributary 3

Reach	Location	Drainage Area (ha)	Subject land contribution (%)
Subject Lands	4101 Limebank Road	13.4[a]	100
T3C-R2	Limebank Road crossing	86.1[b]	17.56
T3C-R1	Upstream of reach T3	93.8	16.12
T3	Combined flow of T3C-R1 and T3B	458.7	3.30
T3	Upstream of Mosquito Creek	466.2	3.24
Mosquito Creek	Immediately downstream of T3	3014.1	0.50

a. Area proposed for development, excluding the lands reserved for the future realigned Leitrim Road (RCI, 2026)
b. Provided by RCI (2026)

The drainage area analysis reveals that the proportional impact of the subject lands is greatest in reaches **T3C-R1** and **T3C-R2**, contributing 16.1 and 17.6% of the drainage area, respectively. The subject land contribution to reach **T3** drops significantly to 3.3% downstream of the confluence with reach **T3B**. As a result, stormwater from the subject lands will likely have minimal impact on reach **T3**. The drainage area contribution drops to 0.5% within the mainstem of Mosquito Creek, indicating that controlled drainage from the subject lands will have no detectable effect downstream of **Tributary 3**.

3 Field Assessments

Field-based reconnaissance-level assessments were undertaken in the three reaches downstream of the proposed development (**T3C-R2**; **T3C-R1**; **T3**) in August 2017 (GEO Morphix, 2018; 2021). Repeat field assessments were undertaken in November 2025 to determine whether significant change had occurred in these reaches since 2017 and whether previously determined conditions were still representative of the watercourse, and to assess the applicability of the earlier findings to the current conditions within **Tributary 3**, including the determination of an appropriate erosion threshold.

Reconnaissance-level assessments were completed to identify dominant geomorphic processes and channel forms, document stream health, and identify any areas of concern regarding channel erosion or channel instability. The assessment approach integrates several complementary methods for geomorphic assessment which are detailed below.

3.1 Methodology

The geomorphic field assessments applied a modified version of the Brierley and Fryirs (2005) River Styles Framework, which is a set of procedures used to describe channel forms and processes and assess channel response and potential future behaviour. These procedures are integrated into our geomorphic field assessment protocol. The Framework draws on established geomorphic models, such as Thorne (1999), Schumm (1985), and Downs (1995), to identify active fluvial processes, relative stability, dominant sediment transport mechanisms, and the energy in a system to do geomorphic work (e.g., mobilize sediment, erode bed/banks, reshape the channel). It also indicates the type and degree of sinuosity, system gradient, confinement, and the number of channels present in equilibrium conditions. Collectively, this information provides insight into the geomorphic structure, function, systematic adjustments, and the evolutionary trajectory of a river system, which, in turn, is used to inform river management applications (Brierley and Fryirs, 2005).

Our geomorphic field assessment protocol also incorporates the Downs (1995) model. The model uses physical indicators of systematic adjustment including channel, bank and bar morphology to classify and

forecast the type of channel instability. In doing so, the nature of fluvial and hillslope processes that are working to change the system are inferred. Channel instability is classified as varying degrees of stable, depositional, migrating laterally, enlarging, and experiencing various types of erosion (Downs, 1995; Simon and Downs, 1995).

Information gathered as part of the River Styles Framework and the Downs model of channel evolution is reviewed in tandem with rapid geomorphic assessment techniques to fully characterize a given fluvial system. Applied techniques include the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Tool (RSAT), which are described below.

The Rapid Geomorphic Assessment (RGA) technique evaluates systematic adjustments characterized as degradation, aggradation, widening, and planimetric form adjustment at the reach scale (MOE, 2003; VANR, 2007). The RGA method relies on the absence or presence of these indicators to evaluate the systematic adjustments in the reach associated with natural causes or human activities. Systematic adjustments typically result in changes to the floodplain, channel or valley characteristics. The end result of the RGA is to produce a score, or stability index, which evaluates the degree to which a reach has departed from the equilibrium condition. A reach with a score of less than 0.20 is classified as 'in regime', indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that the reach is 'in transition' or 'stress' and is experiencing a change to process and form outside the natural range of geomorphic variability. A score of greater than 0.41 indicates that the reach is in adjustment, likely exhibiting continued adjustment to the point of either returning to equilibrium or moving toward a new equilibrium (MOE, 2003; VANR, 2007).

In addition, the Rapid Stream Assessment Tool (RSAT) was applied, which evaluates stream health, based on an inclusion of biological indicators (Galli, 1996). This technique relies on a scale ranging from 'poor' to 'excellent' for observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions, to provide a qualitative assessment of stream health. The evaluation produces values that indicate whether the channel is in poor (score <13), fair (score 13-24), good (score 25-34), or excellent (score >34) condition (Galli, 1996).

3.1.1 Reach Descriptions

Reach **T3** was located after the confluence of reaches **T3B** and **T3C-R1** and flowed downstream to Mosquito Creek (**Appendix A**) and was situated in confined valley setting. Riparian vegetation consisted of mature deciduous trees. Bed materials consisted of clay, sand, gravel and cobble in the riffles, and clay, silt and sand in the pools. Average bankfull width and depth were 4.3 m and 0.74 m, respectively. The reach showed significant evidence of ongoing geomorphic change, with bank failures and steep valley wall contacts.

Reach **T3C-R1** consisted of a designed channel in which coarse substrates and a clear riffle pool formation was present, unlike the other reaches within the subwatershed. Average bankfull width within the channel was 2.3 m, and average bankfull depth was 0.36 m. The channel occupied a partially confined forested valley and showed little evidence of ongoing geomorphic change.

Reach **T3C-R2** consisted of an intermittent swale occupying a confined valley conveying flows westward towards Limebank Road. The feature was well vegetated by purple loosestrife and other hydrophilic vegetation and had poor channel development. The feature was delineated from the surrounding landscape using the extent of aquatic vegetation and was an average of 3.3 m wide and 0.4 m deep. Minimal evidence of ongoing geomorphic change was observed at the time of the field assessment.

3.1.2 Results and Discussion

The reconnaissance-level assessment in reach **T3** recorded processes broadly consistent with a confined meandering channel undergoing bank erosion and meander migration. Reach **T3** was assigned an RGA score of 0.48 in 2017, and 0.51 in 2025 (both "in adjustment"), with RSAT scores of 23 and 24 (Fair) respectively. The primary mode of adjustment was widening, in the form of bank and bed scour, bank fractures, fallen trees and exposed roots; the RSAT score was similarly limited by channel stability. The channel system was assessed as 'Depositional' under the Downs (1995) Channel Evolution Model in both

surveys. The River Styles framework (Brierley and Fryirs, 2005) varied slightly from "meandering, mixed load" in 2017 to "meandering, bedload" in 2025; this appears to result from minor differences in interpretation between investigators, rather than systematic changes to the regime in reach **T3**. These results indicate that reach **T3** is prone to geomorphic alteration through bank erosion, without major change in this state between 2017 and 2025. Based on this consistency, we determine that previous detailed assessments, and the previously determined erosion threshold, are still representative of conditions within reach **T3**.

Reach **T3C-R1** was consistently stable in both reconnaissance-level assessments, reflecting the extensive realignment and engineering control. The RGA score for **T3C-R1** decreased from 0.09 to 0.07 (in regime; evidence of degradation) between 2017 and 2025, with the RSAT score increasing from 33 to 34 (Good; limited by riparian habitat). The Downs (1995) Channel Evolution model was Stable in both surveys. As above, minor differences in the River Style Framework (Brierley and Fryirs, 2005) between "meandering, mixed load" and "meandering, bedload" are accounted for by investigator interpretation. Broadly, reach **T3C-R1** appears to be stable after the completed realignment, and is undergoing no observable geomorphological change. There is no evidence of major changes in the channel conditions between 2017 and 2025.

Reach **T3C-R2** largely occupies an enlarged agricultural channel and was consistently stable between both surveys. The RGA score for **T3C-R2** remained at 0.08 (in regime; evidence of planimetric form adjustment). The RSAT score in 2017 was not assessed due to a dry channel at the time of the survey, while the 2025 RSAT score was 26 (Good, limited by the physical instream habitat). The channel was assessed under the Downs (1995) model as stable in both surveys. A difference in the River Style Framework (Brierley and Fryirs, 2005) was noted, altering from "meandering, suspended load" in 2017 to "straight, bedload" in 2025. A straight planform appears more consistent with observed mapping, and the relative dominance of suspended and bedload appears to reflect the specific conditions at the time of each assessment. Reach **T3C-R2** is not undergoing significant geomorphological change, with no alteration in conditions between 2017 and 2025

The summary results of both sets of reconnaissance-level field assessments are summarised in **Table 3**. Completed 2025 field assessment sheets for all reaches are presented in **Appendix D**.

Table 3: Summary of reconnaissance-level assessments

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995) Channel Evolution Model	River Styles Framework (Brierley and Fryirs, 2005)
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)		
2017								
T3	0.48	In Adjustment	Widening	23	Fair	Channel Stability	D - depositional	Meandering, mixed load
T3C-R1	0.09	In regime	Degradation	33	Good	Riparian Habitat	S - stable	Meandering, mixed load
T3C-R2	0.08	In regime - Swale	Planimetric Form Adjustment	N/A – Dry Channel			S - stable	Meandering, suspended load
2025								
T3	0.52	In Adjustment	Widening	24	Fair	Channel Stability	D - depositional	Meandering, bedload
T3C-R1	0.07	In regime	Widening	34	Good	Riparian Habitat	S - stable	Meandering, bedload
T3C-R2	0.08	In regime	Planimetric Form Adjustment	26	Good	Physical Instream Habitat	S - stable	Straight, bedload

3.2 Detailed Geomorphological Assessment

Reach **T3** was identified as the reach most susceptible to erosion based on the reconnaissance-level assessments, observed evidence of bank instability, and its relatively high RGA score (0.48). reach **T3** was therefore selected for detailed assessment, which was completed on August 23, 2017 (GEO Morphix, 2018; 2021).

The detailed assessment involved selecting an appropriate survey length based on bankfull channel width (typically 20 times the bankfull width) and the distribution of geomorphic units (riffles, runs, pools). A representative section of the reach was then selected, and eight representative cross sections and a bed longitudinal profile were surveyed within this section of the reach. A modified Wolman (1954) pebble count was completed at each cross-section. The resulting data were used to characterize average bankfull channel dimensions and to estimate bankfull discharge, velocity, shear stress, and sensitivity to erosion and sediment transport. A summary of measured and calculated parameters is presented in **Table 4**.

The detailed assessment confirmed that reach **T3** is underlain by fine-grained bed and bank materials, primarily silt and clay, consistent with the mapped surficial geology of the area. These sediments are susceptible to erosion at flows producing shear stress of around 1.5 Pa, well below the estimated bankfull shear stress of 3.45 Pa.

Long-term monitoring data for reach **T3** cross-sections were updated in November 2025 and showed no significant change in channel geometry since the detailed 2017 assessment. In addition, the reconnaissance-level assessments confirmed that the general channel conditions observed in 2017 are representative of the existing conditions within reach. Accordingly, the 2017 detailed assessment data are considered appropriate for the subsequent erosion-threshold analysis.

Table 4: Detailed assessment summary (GEO Morphix, 2018; 2021)

Channel parameter	Results
Measured (2017)	
Average bankfull channel width (m)	4.29
Average bankfull channel depth (m)	0.70
Bankfull channel gradient (%)	0.19
D_{50} (mm)	< 2 mm
D_{84} (mm)	< 2 mm
Manning's n roughness coefficient	0.037
Computed	
Bankfull discharge (m^3/s) [a]	1.53
Average bankfull velocity (m/s)	0.51
Unit stream power at bankfull discharge (W/m^2)	1.74
Tractive force at bankfull (N/m^2)	3.45
Critical shear stress (N/m^2) [b]	1.46

[a] Based on Manning's equation

[b] Based on Shields diagram from Miller et al. (1997)

4 Erosion Threshold Analysis

Information collected during the detailed geomorphological assessments was used to define an erosion threshold for reach **T3**. This threshold was then used to derive a conservative unitary-based erosion threshold for the upstream reaches located closer to the proposed SWM pond outlet for the subject

lands. Although reach **T3** was identified as the most erosion-sensitive reach of the reaches assessed downstream of the subject lands, the subject lands contribute a small proportion of the total drainage to the reach (approximate 3%; see drainage area analysis provided above). The potential influence of runoff from the subject lands on erosion processes within reach **T3** is therefore expected to be limited relative to the upstream reaches closer to the proposed SWM pond outlet. Nonetheless, to provide a conservative, lower-bound estimate of the erosion threshold for these upstream reaches, the erosion threshold for reach **T3** was used to derive the subject erosion thresholds and to minimize the potential impact on erosion rates within reach **T3**.

Of the upstream reaches, reach **T3C-R1** has been realigned and appears to have been effectively stabilised by the engineering works along the reach. This interpretation is supported by a review of historical air photograph analysis which reveal indicate little observable change in channel form, and by minimal evidence of channel instability documented during reconnaissance-level assessments of the reach. Therefore, reach **T3C-R2** was selected for further analysis as the direct receiving reach of the stormwater from the subject lands. The erosion threshold for this reach was based on the previously determined value for reach **T3** via a unitary approach. This approach establishes a conservative erosion threshold for reach **T3C-R2**, and ensures that release rates from the SWM pond will be scaled to the erosion threshold for reach **T3**, to ensure the proposed SWM plan effectively mitigates any increases in erosion potential for the subject reaches.

4.1 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia, 2008; Villard and Parish, 2003). The erosion threshold is the theoretical point, typically expressed as a critical discharge, shear stress or velocity, at which entrainment of sediment would occur based on bed and bank materials, channel geometry and other characteristics. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials, with the lower of the erosion thresholds adopted, as the more conservative and limiting estimate of erosion potential within the reach.

Changes in the magnitude, duration, and frequency of streamflow may alter the pattern and rates of channel erosion. As such, defined erosion thresholds inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Erosion thresholds were modelled using the results of the detailed assessment in reach **T3**, selected as the most erosion-sensitive reach downstream of the proposed SWM Pond. This erosion threshold was then used to derive a conservative unitary-based erosion threshold for reach **T3C-R2**, the reach immediately downstream of the proposed SWM pond outlet.

4.1.1 Methodology

Erosion threshold targets are determined using different methods that depend on the channel's 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 (Villard & Parish, 2003). For cohesive materials, a method such as that described by Komar (1987), or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994), could be applied. Villard and Parish (2003) emphasize the importance of selecting methods that reflect local sediment conditions and integrating them into site-specific geomorphic assessments.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge (Villard & Parish, 2003; TRCA 2012). Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity (U) or the shear stress (τ) is calculated at various depths for a representative cross-section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using Manning's approach, where Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. A Manning's n value of 0.035 was used for the assessment, based on the physical characteristics of the

subject reach, primarily the coarse pebble-cobble bed material. The reach average bankfull slope of 0.74% was used throughout this analysis. The velocity is mathematically represented as:

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

where *d* is the depth of water, *S* is the channel slope, and *n* is the Manning's roughness.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

$$\tau_0 = d\rho g S \quad \text{[Eq. 2.]}$$

Where, τ_0 is bed shear stress, *d* is the water depth, *ρ* is water density, *g* is acceleration due to gravity, and *S* is the channel slope.

Because only 75% of bed shear stress applies to channel banks in uniform cross sections (Chow, 1959), the erosion threshold for bank material is scaled appropriately for these materials.

4.1.2 Erosion Threshold Results

The bed and bank material of reach **T3** was characterised as fairly compact clay (55% clay, 45% silt, 10% sand); occasional pebbles and small cobbles were present on the bed of the reach. This sediment reflects the local glaciomarine surficial geology. The channel banks showed a clear contact delineating the cohesive glaciomarine clay and a fairly compact to loose clay clayey soil found in the upper section of the channel banks (GEO Morphix, 2021).

Within reach **T3**, the lower fairly compact clay within the banks was identified as the limiting boundary material for the erosion-threshold assessment, as it is expected to be more subject to erosion than the overlaying loose clay soil horizon. The erosion threshold for the lower clay unit was therefore used to establish the erosion threshold (GEO Morphix, 2021). Using the criteria of Chow (1959), this compact, fine material within reach **T3** was determined to have a critical shear stress of 2.4 N/m^2. Utilising this value, the average erosion threshold discharge through each surveyed cross-section was **0.61 m^3/s**; this value was accepted as the erosion threshold for reach **T3**.

The **Tributary 3** watershed covers an area of 466.2 ha, giving a unitary erosion threshold of **0.00131 m^3/s/ha**. This unitary threshold value is updated from previous reporting (e.g., GEO Morphix, 2021) due to a refinement of the original OWIT-derived drainage area to a more accurate LiDAR-based analysis presented here, which better reflects City of Ottawa and RVCA mapping of watershed areas.

The results of the erosion threshold analysis are presented in **Table 4**.

Table 5. Summary of the erosion threshold analysis (GEO Morphix, 2021)

Channel parameter	Reach T3
Average bankfull channel width (m)	4.29
Average maximum bankfull depth (m)	0.91
Bankfull gradient (%)	0.19
D_{50} (mm)	< 2.0
Manning's *n* roughness coefficient	0.035
Drainage Area (ha)*	466.2[a]
Bankfull discharge (m^3/s)	1.53
Average bankfull velocity (m/s)	0.88
Erosion Threshold (Bank Material)	
Material	Fairly compact to loose clay
Reference	Chow (1959)
Critical velocity (m/s)	0.51
Critical depth (m)	0.65
Limiting erosion threshold (m^3/s)	**0.61**
Limiting unitary threshold ($m^3/s/ha$)	**0.00131**

a. Determined from LiDAR-based drainage area analysis; updated from GEO Morphix, 2021

4.2 Unitary erosion threshold

The established unitary threshold value was applied to nearby watercourses, assuming comparable channel conditions and boundary materials. Because reach **T3** was determined to be the most erosion-sensitive reach, scaling to this value creates a conservative erosion threshold estimate for upstream reaches. Establishing a SWM mitigation strategy for an upstream reach using this conservative erosion threshold ensures that all downstream reaches will be minimally impacted.

The unitary erosion threshold of 0.00131 $m^3/s/ha$ determined for reach **T3** was applied to reach **T3C-R2** with a drainage area of 86.1 ha, resulting in an estimated erosion threshold of **0.113 m^3/s**.

The results of the unitary analysis are presented in **Table 6**.

Table 6. Unitary-based erosion thresholds for select reaches within Tributary 3

Reach	Reach T3 unitary erosion threshold ($m^3/s/ha$)	Area (ha)	Unitary-derived erosion threshold (m^3/s)
Subject lands	0.00131	13.4[a]	0.018
T3C-R2		**86.1[b]**	**0.113**
T3C-R1		93.8[c]	0.123

a. Area proposed for development, excluding the lands reserved for the future realigned Leitrim Road (RCI, 2026)
b. Provided by RCI (2026)
c. LiDAR-based drainage area analysis

5 Erosion Exceedance Analysis

To evaluate the proposed SWM plan, an erosion exceedance analysis was completed for reach **T3C-R2** to inform release rates from the proposed SWM Pond. The application of erosion threshold analysis for evaluating the effectiveness of stormwater management facilities in mitigating changes in downstream erosion potential is a concept developed with support by a co-author of the present report (Villard and Parish, 2003)) and used widely across Ontario (e.g., TRCA, 2012; CVC, 2015).

Agency guidance is that post-development erosion exceedance should match pre-development exceedance (TRCA, 2012; CVC, 2015); practically minor differences of less than 5% in the key erosion metric, Cumulative Effective Work Index (CEWI), are considered negligible as they are within the expected uncertainty of the modelling approach and unlikely to produce a measurable geomorphic response in the receiving watercourse.

5.1 Methods

Catchment-wide hydrologic simulations were provided by RCI (2026) for the downstream extent of reach **T3C-R2** at the Limebank Road crossing, comprising pre- and post-development projections of a range of synthetic storms (25 mm four-hour storm, and 3-, 6-, 12- and 24-hour storms; 2-, 5-, 10-, 25-, 50 and 100-year recurrence intervals). Hydrographs for all reaches were provided at 1-minute time steps.

To calculate erosion indices, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge value passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections, and then 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 cross-section for reach **T3C-R2** was determined from in-field measurements taken during the reconnaissance-scale field assessments, applied to a simplified U-shaped channel. The channel bed is inset within a deep artificial channel, represented by 3 m high slopes projecting from the channel banks at 30°. The in-channel value for Manning's n was estimated as 0.05, reflecting a smooth, straight channel with moderate in-channel vegetation, as observed in the field. The valley slopes were assigned a value of 0.08, reflecting grass and herbaceous vegetation. A channel slope of 1.1% was determined from LiDAR DEM data.

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

$$Q_{T=} \sum Q_i \quad \text{[Eq. 1]}$$

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

$$Q_i = U_i w_i d_i \quad \text{[Eq. 2]}$$

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:

$$\tau_{o_{\max}} = d_{\max} \rho g S_{\text{bed}} \quad \text{[Eq. 3]}$$

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:

$$\omega_{tot} = \sum \tau_{0_{max}} . U_{avg} . \Delta t \quad \text{[Eq. 4]}$$

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:

$$CEWI = \sum \tau - \tau_{cr} . U . \Delta t, \omega < 0 = 0 \quad \text{[Eq. 5]}$$

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

Time of exceedance t_{ex} defined as:

$$t_{ex} = \sum \Delta t \ \text{ for } (Q_T > Q_{threshold}) \quad \text{[Eq. 6]}$$

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

The cumulative effective discharge volume (CEV) is defined as the integral of all discharge exceeding the erosion threshold over the time of exceedance:

$$CEV = \sum (Q \cdot t) \ \text{ for } (Q > Q_{threshold})$$

5.2 Event-based projection

A 100-year erosion exceedance projection was calculated from event-based exceedance modelling results using a frequency-weighted approach. The expected number of events in each recurrence interval over the 100-year period was estimated using a cumulative frequency approach. This approach accounts for all larger-magnitude, lower-frequency events that are statistically nested within higher-frequency events, ensuring each event is represented once in the cumulative exceedance analysis.

$$N_R = \frac{100}{R} - \sum_{i>R} N_i \quad \text{[Eq. 8]}$$

Where R is the recurrence interval (years) N_R is the number of events uniquely associated with a given recurrence interval, and $\Sigma_{i>R}N_i$ is the cumulative number of events associated with all larger recurrence intervals.

The 100-year projection of the determined erosion metrics (CEV, CEWI, T_{ex}) was calculated as follows:

$$M_{100} = \sum_R (N_R M_R) \quad \text{[Eq. 9]}$$

Where M_{100} is the total projected value of an erosion metric (CEV, CEWI, etc.) for the 100-year period and M_R is the modelled value of a given erosion metric for a given recurrence interval.

This analysis was conducted separately for the 24-, 12-, 6- and 3-hour modelling scenarios provided by RCI (2026). The 25 mm, 4-hour storm event was analyzed as a single event.

5.3 Results

The erosion-exceedance analysis indicates that the proposed SWM plan is expected to mitigate potential post-development increases in erosion potential within the receiving watercourse. All analysed scenarios show either near parity or a reduction in pre- to post-development CEWI based on the event-based projections. Broadly, these reductions are achieved through a combination of reduced peak flows and CEV, and extended exceedances (T_{ex}). All storm events within the 3- to 24-hour modelling are within 5% of the existing conditions, with the exception of the 2-year, 3-hour storm which shows a reduction of 5.9%. Similarly, the 25 mm, 4-hour storm results in a 9.6% reduction in CEWI. The cumulative 100-year projection of all scenarios is similarly within 5% of the existing conditions.

Summary results of the event-based analysis for each storm duration are presented in **Table 7**. A comparison of existing and proposed hydrographs for all reaches and events is shown in **Appendix D**, with complete results for the event-based analysis **Appendix E**.

Table 7. Summary of results of event-based erosion exceedance analysis

Reach		CEV (m^3)	CEWI (N/m)	t_{ex} (hours)
25 mm, 4-hour (single event)	PRE	1,577	20.9	4.08
	POST	1,417	18.9	4.55
	Change (%)	**-10.15**	**-9.65**	**11.43**
3-hour (cumulative 100-year projection)	PRE	357,676	4,359	268
	POST	350,319	4,309	316
	Change (%)	**-2.06**	**-1.14**	**17.81**
6-hour (cumulative 100-year projection)	PRE	481,282	5,829	325
	POST	483,494	5,896	373
	Change (%)	**0.46**	**1.15**	**14.77**
12-hour (cumulative 100-year projection)	PRE	651,228	7,805	413
	POST	662,303	7,991	450
	Change (%)	**1.70**	**2.38**	**9.02**
24-hour (cumulative 100-year projection)	PRE	676,085	8,179	577
	POST	696,495	8,499	664
	Change (%)	**3.02**	**3.92**	**15.10**

In summary, the proposed development conditions are comparable to existing conditions, with minor reductions in erosive potential during smaller, more frequent storms. The results of the erosion exceedance modelling show that the proposed stormwater management plan will effectively mitigate erosion risk within **Tributary 3** of Mosquito Creek.

6 Discussion

Groupe Montoni retained GEO Morphix Ltd. to assist in assessing the impact of the proposed SWM plan and its effectiveness on mitigating increases in erosion potential in the receiving watercourse downstream of a proposed 15.12 ha development at 4101 Limebank Road, Ottawa. New reconnaissance-scale assessment data confirm that conditions in **Tributary 3** are similar to those in 2017, and that reach T3 is the most erosion-sensitive reach downstream of the proposed SWM Pond. The previous detailed assessment and erosion threshold analysis (**0.61 m^3/s**) remain applicable to the reach. An updated drainage area analysis allowed determination of a new unitary erosion threshold for reach **T3** of **0.00131 $m^3/s/ha$**.

Applying the updated unitary value yields a conservative erosion threshold of 0.113 m^3/s for reach **T3C-R2**, which receives stormwater pond discharge directly from the subject lands. This allowed appropriate scaling of SWM pond discharge to a conservative erosion threshold in reach **T3C-R2**, ensuring that the SWM mitigation strategy would also be effective for the erosion-sensitive reach **T3** downstream. Further, the subject lands contribute only approximately 3% of the total drainage area to reach **T3.** This relatively

small proportional contribution, together with the implementation of the proposed SWM plan, provides additional support for the conclusion that the proposed development is not expected to result in a measurable increase in erosion potential within the receiving watercourses.

Event-based erosion exceedance analysis shows parity in pre- and post-development erosion potential within reach **T3C-R2**, and our understanding is that the SWM pond will be fully drained within 48 hours to reduce wildfowl congregation in proximity to Ottawa International Airport.

The results of this assessment show that the proposed SWM mitigation strategy will successfully mitigate erosion risk within reach **T3C-R2** based on a conservative, unitary-derived erosion threshold estimate for the reach. Accordingly, because the SWM mitigation strategy was developed using a conservative erosion threshold for the upstream receiving reach and the subject lands contribute only a small portion of the total drainage area to Reach **T3**, the proposed SWM plan is expected to effectively mitigate erosion risk in the more erosion-sensitive Reach **T3** located further downstream.

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

Respectfully submitted,



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Director, Principal Geomorphologist



Jan Franssen, Ph.D.
Senior Watershed Scientist, Technical Lead



Jonathan Cripps, Ph.D.
Watershed Scientist

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Appendix A:
Subject Land Maps



GEO MORPHIX™

DRAFT

Study Area

Mosquito Creek
Tributary 3

Ottawa, Ontario

Legend

- Reach Break and ID
- Approximate Study Area

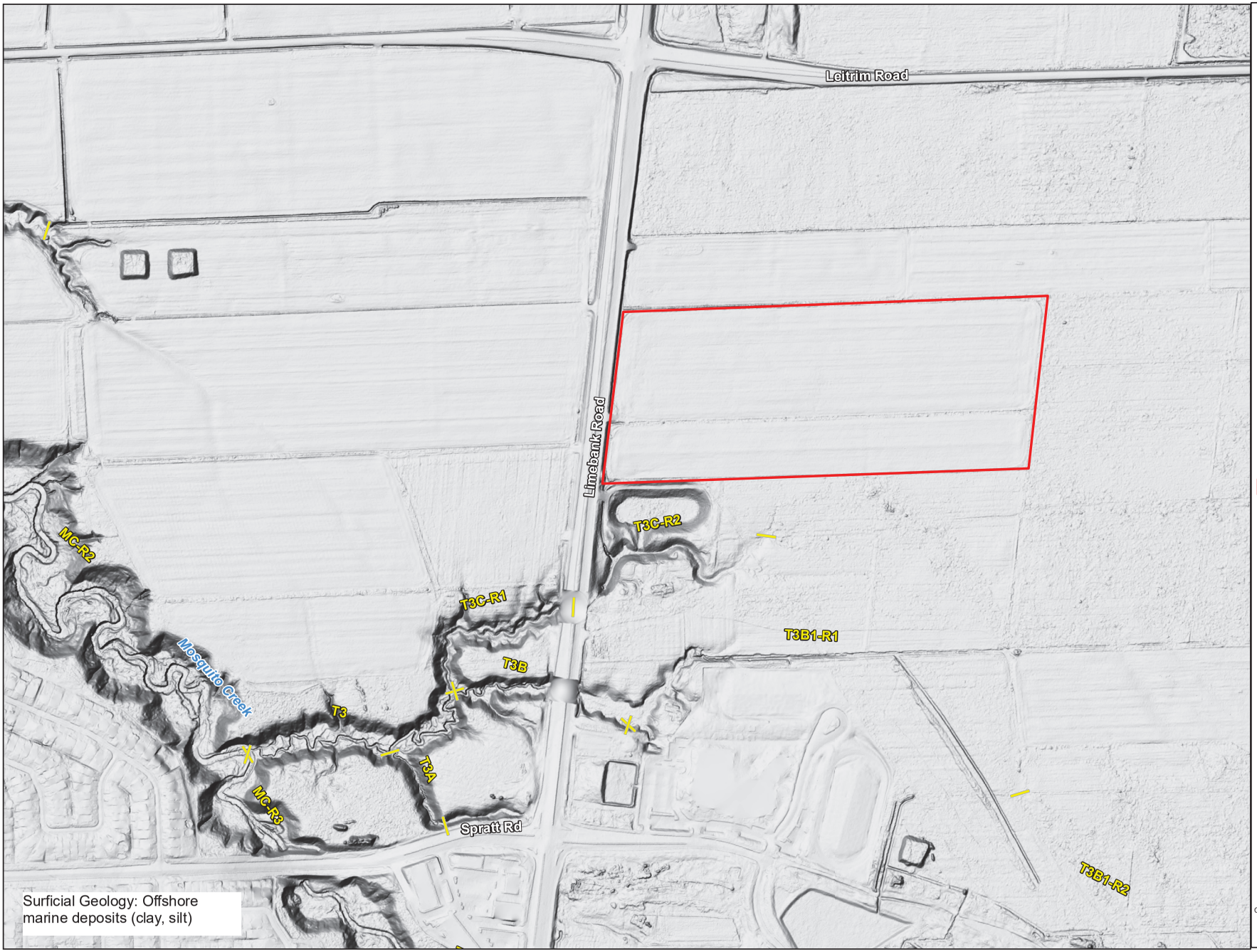
INTERNAL USE ONLY

N

0 100 200

Metres

Hillshade: MNRF, 2020. Watercourse, Municipal Drain: City of Ottawa / MNRF, 2020. HDF: Gemtec, 2024. SGU: MNRF, 2024. Reach Break and ID: Gemtec/GEO Morphix Ltd., 2024. Study Area and 0.25 m Contour: Novatech, 2023. Print Date: November 2025. PN25148. Drawn By: M.O., J.C., G.U.



GEO MORPHIX™

Study Area

Mosquito Creek
Tributary 3

Ottawa, Ontario

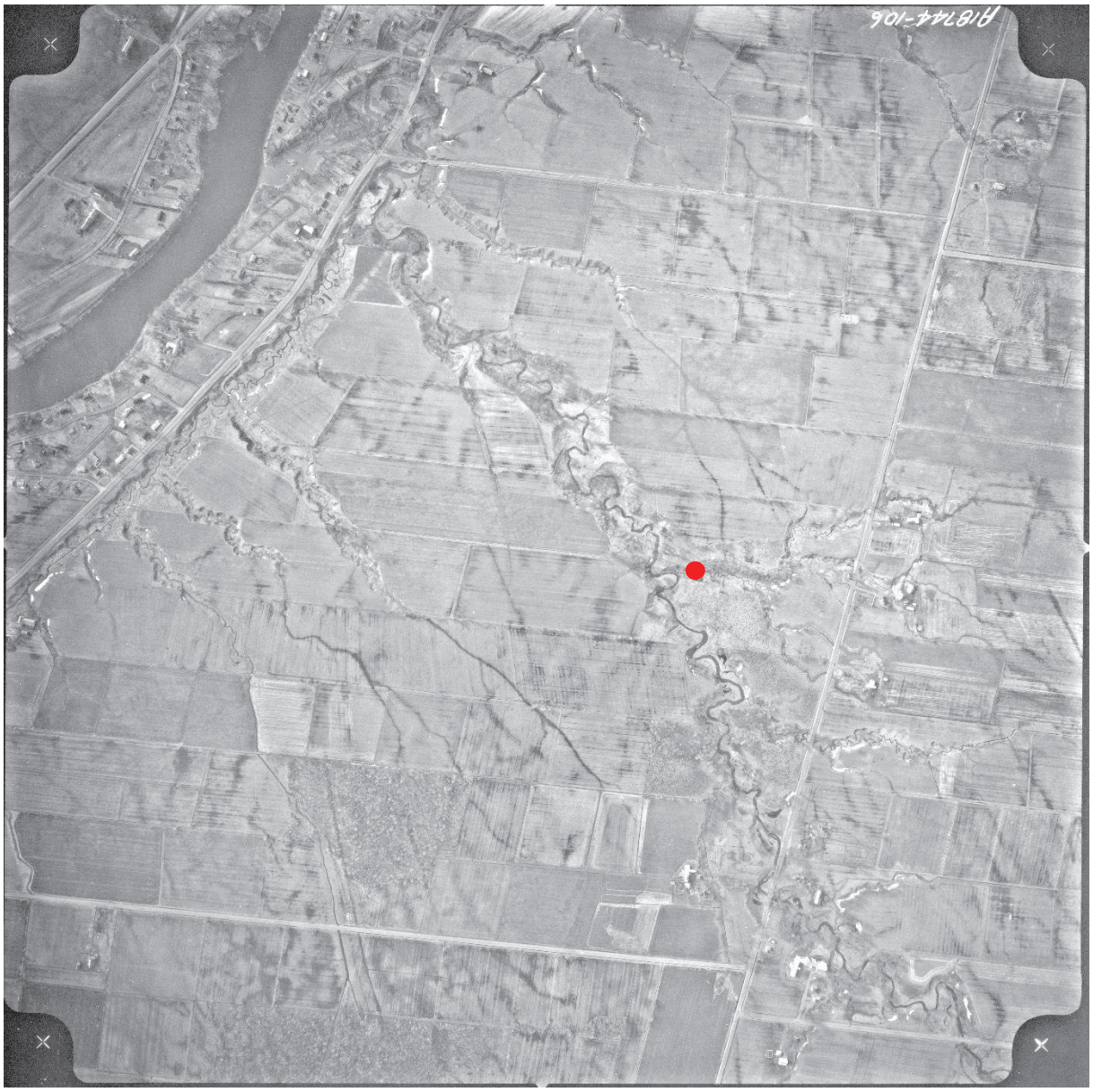
Legend

- Reach Break and ID
- Approximate Study Area

0 100 200
Metres

Hillshade: MNRF, 2020. Watercourse, Municipal Drain: City of Ottawa / MNRF, 2020. HDF: Gemtec, 2024. SGU: MNRF, 2024. Reach Break and ID: Gemtec/GEO Morphix Ltd., 2024. Study Area and 0.25 m Contour: Novatech, 2023. Print Date: November 2025. PN25148. Drawn By: M.O., J.C., G.U.

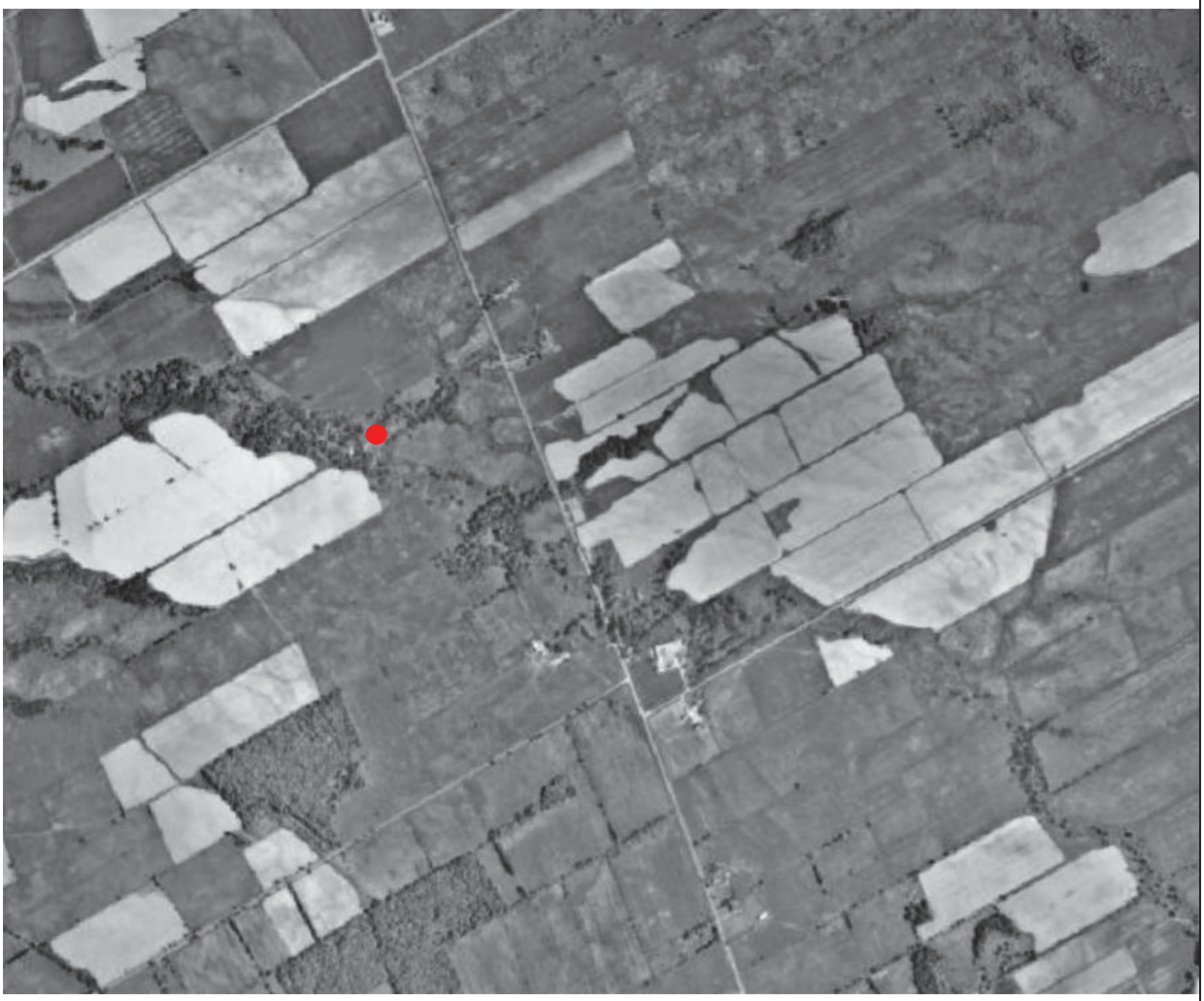
Appendix B:
Historic Air Photographs



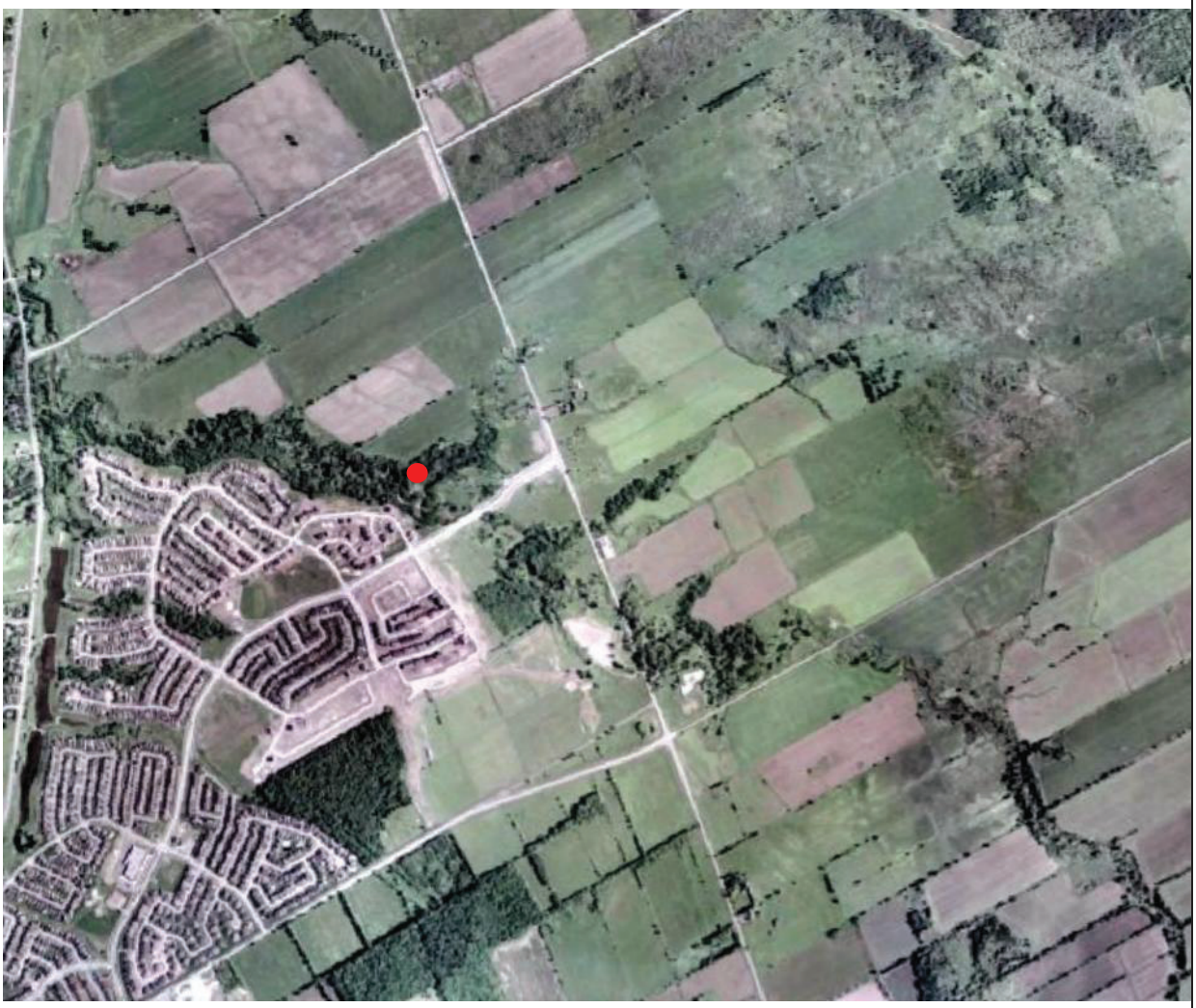
Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 1965
Source: NAPL
Red Dot: Reach T3



Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 1976
Source: City of Ottawa (maps.ottawa.ca/geoottawa/)
Red Dot: Reach T3



Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 1991
Source: City of Ottawa
Red Dot: Reach T3



Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 2005
Source: City of Ottawa
Red Dot: Reach T3



Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 2018
Source: Google Earth Pro
Red Dot: Reach T3



Location: Earl Armstrong Road & Limebank Road, Riverside South, Ottawa ON
Year: 2025
Source: Google Earth Pro
Red Dot: Reach T3

Appendix C:
Photographic Record

Photo 1
Mosquito Creek Tributary 3: Reach **T3**



Reach **T3** comprises a confined meandering channel within a broad riparian zone of established forest.

Photo 2
Mosquito Creek Tributary 3: Reach **T3**



Bank erosion, including undercutting, was common throughout reach **T3**, particularly on meander cut banks.

Photo 3
Mosquito Creek Tributary 3: Reach **T3**



Bank material is predominantly fairly compact to loose clay. Tree roots typically provide additional cohesion, but they are frequently exposed throughout reach T3 due to bank erosion.

Photo 4
Mosquito Creek Tributary 3: Reach **T3**



Slumping was observed where bank erosion has undercut the valley walls.

Photo 5
Mosquito Creek Tributary 3: Reach **T3**



The bed material in reach **T3** is primarily compact clayey silt, reflecting the local glaciomarine surficial geology. This material is generally resistant to erosion, promoting bank erosion rather than bed degradation.

Photo 6
Mosquito Creek Tributary 3: Reach **T3**



Pebble to cobble grade gravel was observed on the bed of reach **T3**, increasing in frequency upstream. The gravel does not generally cover a high proportion of the bed and is unlikely to provide armouring and increased erosion resistance to the underlying silt and clay.

Photo 7
Mosquito Creek Tributary 3: Reach **T3**



Large woody debris was common throughout reach **T3**, resulting from tree falls due to unstable banks. Woody debris blocks flow, resulting in localised sedimentation and/or increased scour.

Photo 8
Mosquito Creek Tributary 3: Reach **T3C-R1**



Reach **T3C-R1** is a gravel-bedded meandering reach within a narrow riparian zone of young trees and shrubs.

Photo 9
Mosquito Creek Tributary 3: Reach **T3C-R1**



Reach **T3C-R1** has been extensively realigned; bank armouring is common.

Photo 10
Mosquito Creek Tributary 3: Reach **T3C-R1**



Woody debris is present in sections along reach **T3C-R1**, causing localised blockages.

Photo 11
Mosquito Creek Tributary 3: Reach **T3C-R2**



Downstream of the proposed SWM pond outfall, reach **T3C-R1** comprises a straight engineered channel with moderate in-channel vegetation. Steep banks create a deepened channel. The riparian zone is grass and herbaceous vegetation.

Photo 12
Mosquito Creek Tributary 3: Reach **T3C-R2**



Upstream of the proposed pond outlet, reach **T3C-R2** comprises an entrenched channel, with abundant pebble gravel overlying local glaciomarine clay. The bank material is largely loose sandy silt loam. The proposed SWM pond outfall will not impact these sections of channel.

Appendix D:
Reconnaissance-level Geomorphic Assessment Data

GEO MORPHIX

General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	9:30 am	**Reach:**	T3
Weather:	1°C, overcast	**Location:**	N of Spruce Road, W of Limebank Rd.
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

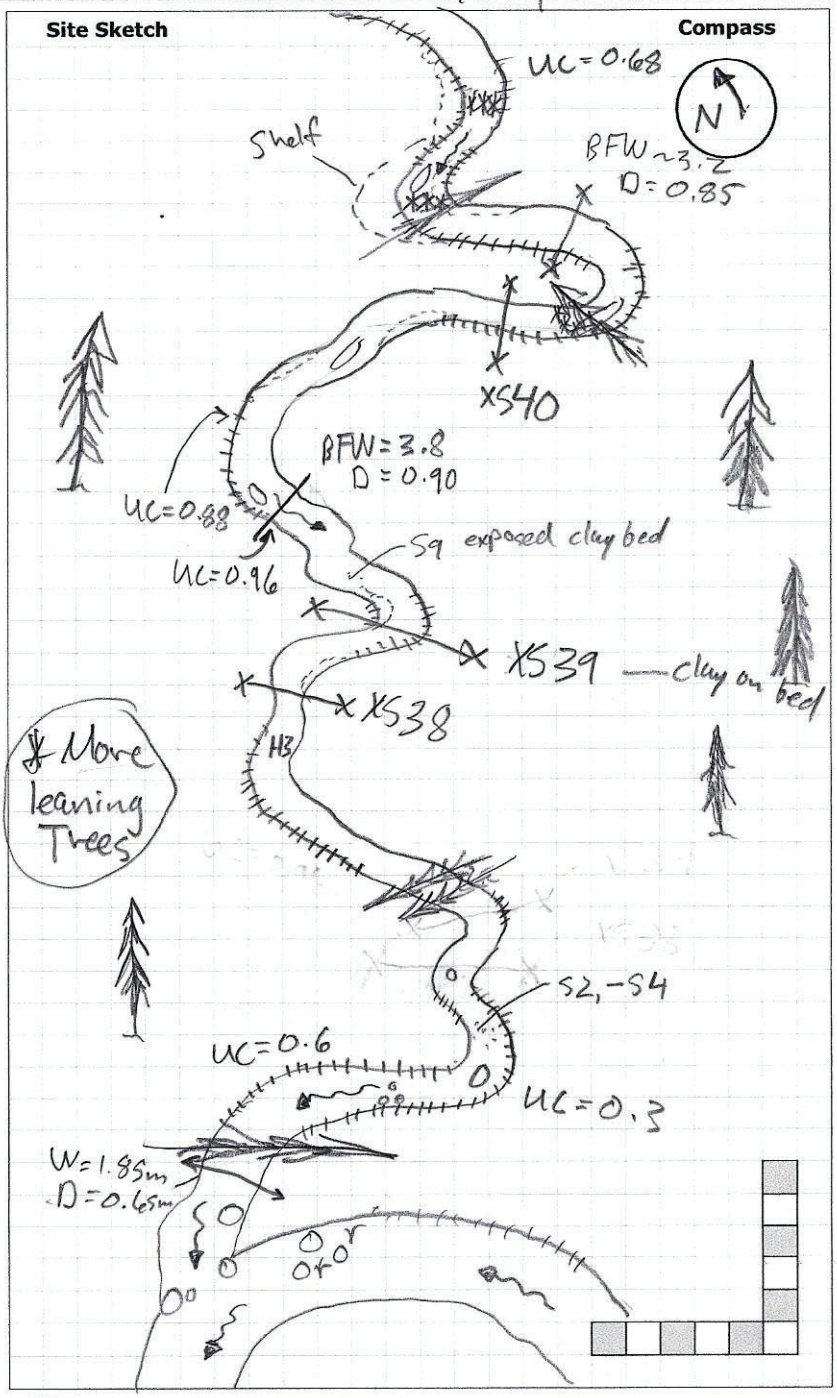
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes: Move leaning trees + woody debris in stream.

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

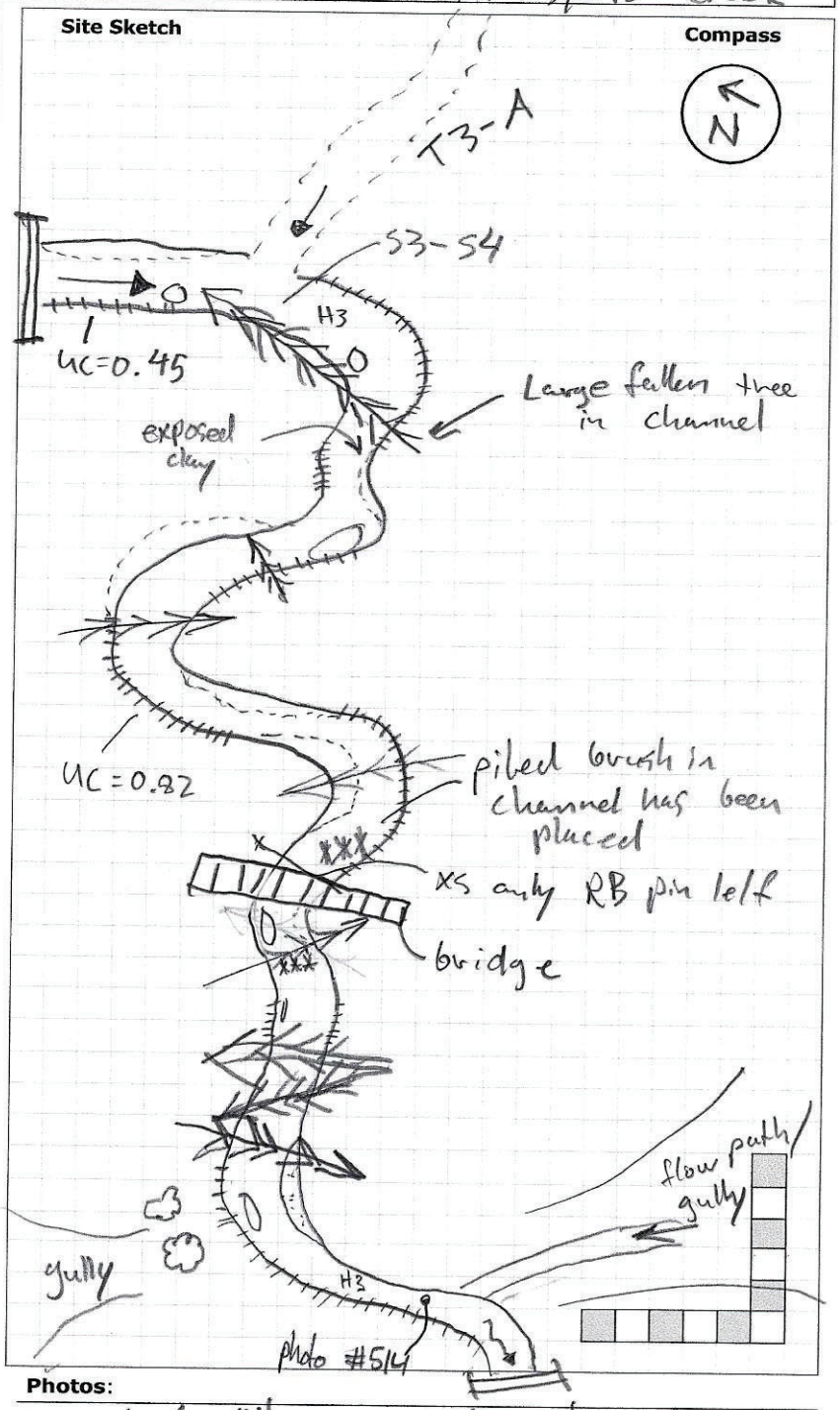
General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	11:00 am	**Reach:**	T3
Weather:	1°C, overcast	**Location:**	NW of Spruce R + Limebank intersect
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Site Sketch



Photos:

Notes: leaf litter on channel bed.

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

GEO MORPHIX™

General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	12:30 am	**Reach:**	T3
Weather:	1°C, overcast	**Location:**	NW of Sprott/Linebank Rd. intersect
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

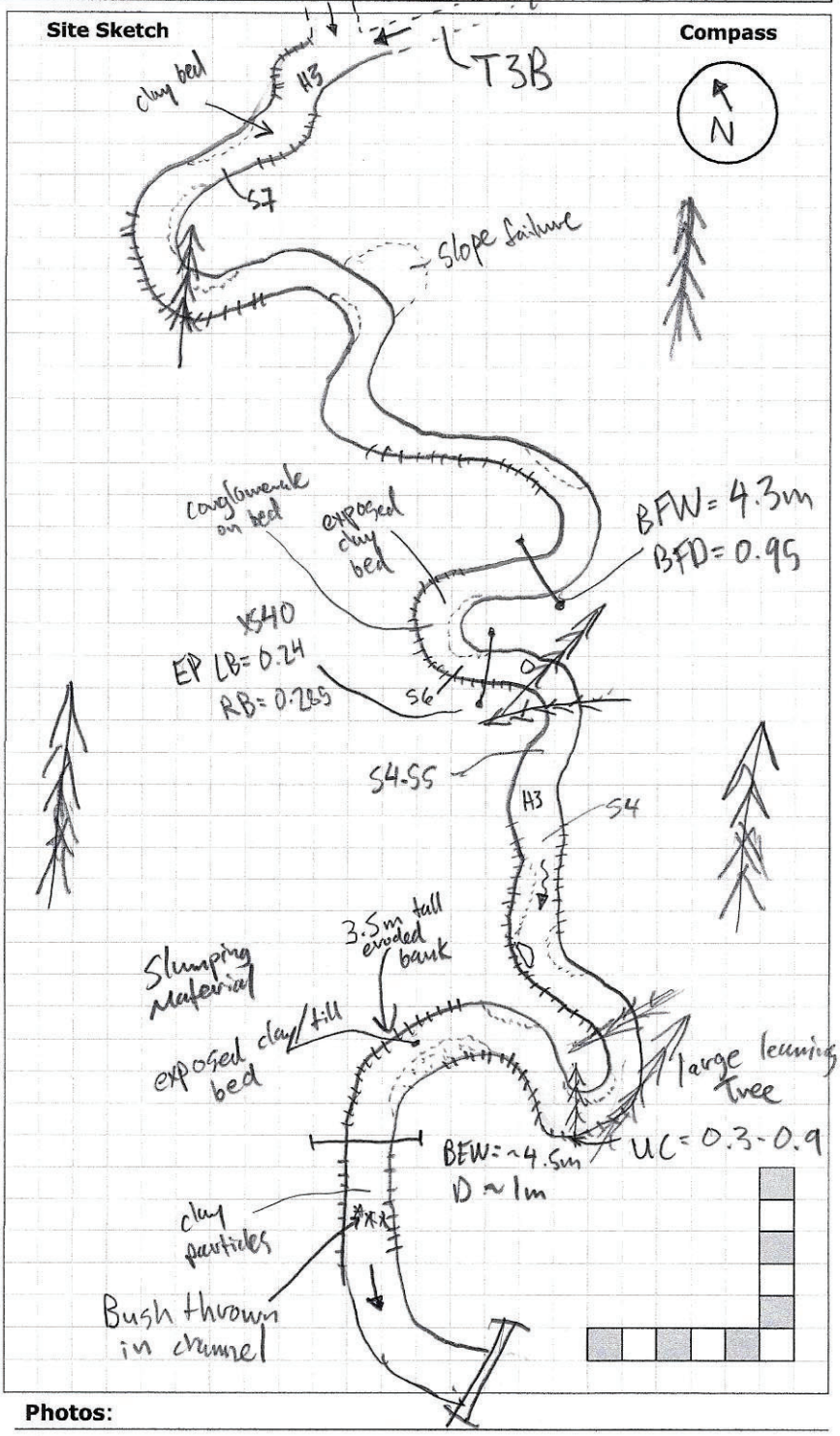
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

GEO MORPHIX

Rapid Geomorphic Assessment

Project Number: 25148

Date:	2025/11/19	**Stream:**	TR63
Time:	10:21	**Reach:**	T3
Weather:	1°C, overcast	**Location:**	Limebank Road / Spratt Road
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	4/7
	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 =	4	3	0.57
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			1/5
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint 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 =	1	4	0.2
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		6/7
	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.			
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank	✓		
	10	Exposed building foundation			
		Sum of indices =	6	1	0.86
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

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.515

In Regime	In Transition/Stress	In Adjustment
☐ 0.00 – 0.20	☐ 0.21 – 0.40	☑ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

Date:	2025/11/19	PN:	25148	Location:	Mosquito Creek

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	• 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) = 24	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:		**Reach:**	T3
Weather:	1°C, Overcast	**Location:**	Lime bank Road / Spratt Road
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

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

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX™

Reach Characteristics Project Number: 25148

Date:	2025/11/19	**Field Staff:**	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek
Time:		**Stream:**	Trib 3	**UTM (Upstream):**	
Weather:	1°C overcast	**Reach:**	T3	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): * 2/3 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): No | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 1

Encroachment (Table 7): 2

Coverage	Channel Widths	Age (yrs)
☐ None	☐ 1 - 4	☐ Immature (<5)
☐ Fragmented	☐ 4 - 10	☐ Established (5-30)
☑ Continuous	☐ > 10	☑ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8):

Reach Coverage %: 0

Woody Debris	WD Density
☑ In Cutbank	☐ Low
☑ In Channel	☐ Mod
☐ Not Present	☑ High

WDJ/50m: * 3

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 3

Channel Characteristics

Sinuosity Type (Table 9): 2

Gradient (Table 11): 2

Entrenchment (Table 13): 2

Down's Model (Table 15): M/m

Sed Sorting (Table 20): Mod

Transport Mode (Table 21): 3

Geomorphic Units (Table 22): 5/6/8

Riffle-Pool Spacing (m): irregular

Sinuosity Degree (Table 10): 3

# of Channels (Table 12): 1

Bank Failure (Table 14): 2

Bankfull Indicators (Table 18): 5/7 *

Sediment Transport Observed? ☐ Yes ☑ No ☐ Not Visible

% of Bed Active:

Mass Movement (Table 23): 1/4

% Riffles: 10 **% Pools:** 20

Bank Angle	Bank Erosion
☐ 0 – 30	☐ < 5%
☐ 30 – 60	☐ 5 – 30%
☐ 60 – 90	☐ 30 – 60%
☑ Undercut	☑ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☑	☑	☐	☐	☐	☑	☐
Riffle	☐	☐	☑	☑	☑	☐	☐
Pool	☑	☑	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	1.85	3.8	3.2	**Wetted Width (m)**			
Bankfull Depth (m)	0.65	0.9	0.85	**Wetted Depth (m)**			
Undercuts (m)	0.3	0.96	0.68	**Velocity (m/s)**			
Pool Depth (m)				**Velocity Estimate Method**			
Riffle Length (m)				**Meander Amplitude (m)**			

Notes:

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

GEO MORPHIX

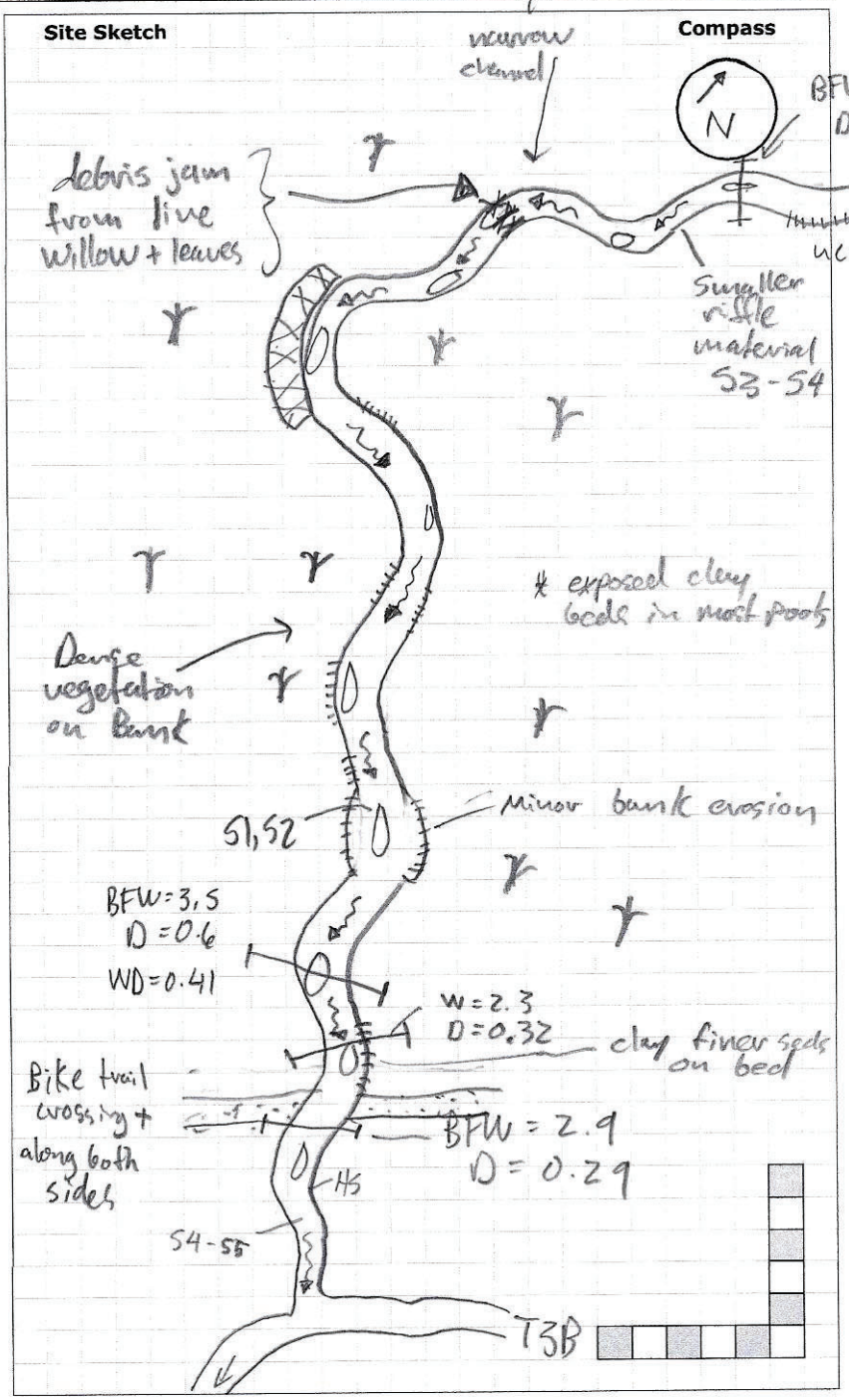
General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	13:00	**Reach:**	T3C-R1
Weather:	Sunny, 1°C	**Location:**	NW of sprott/Limebank intercept
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch



Flow Type			
H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate			
S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other			
BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Photos:

Notes:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX™

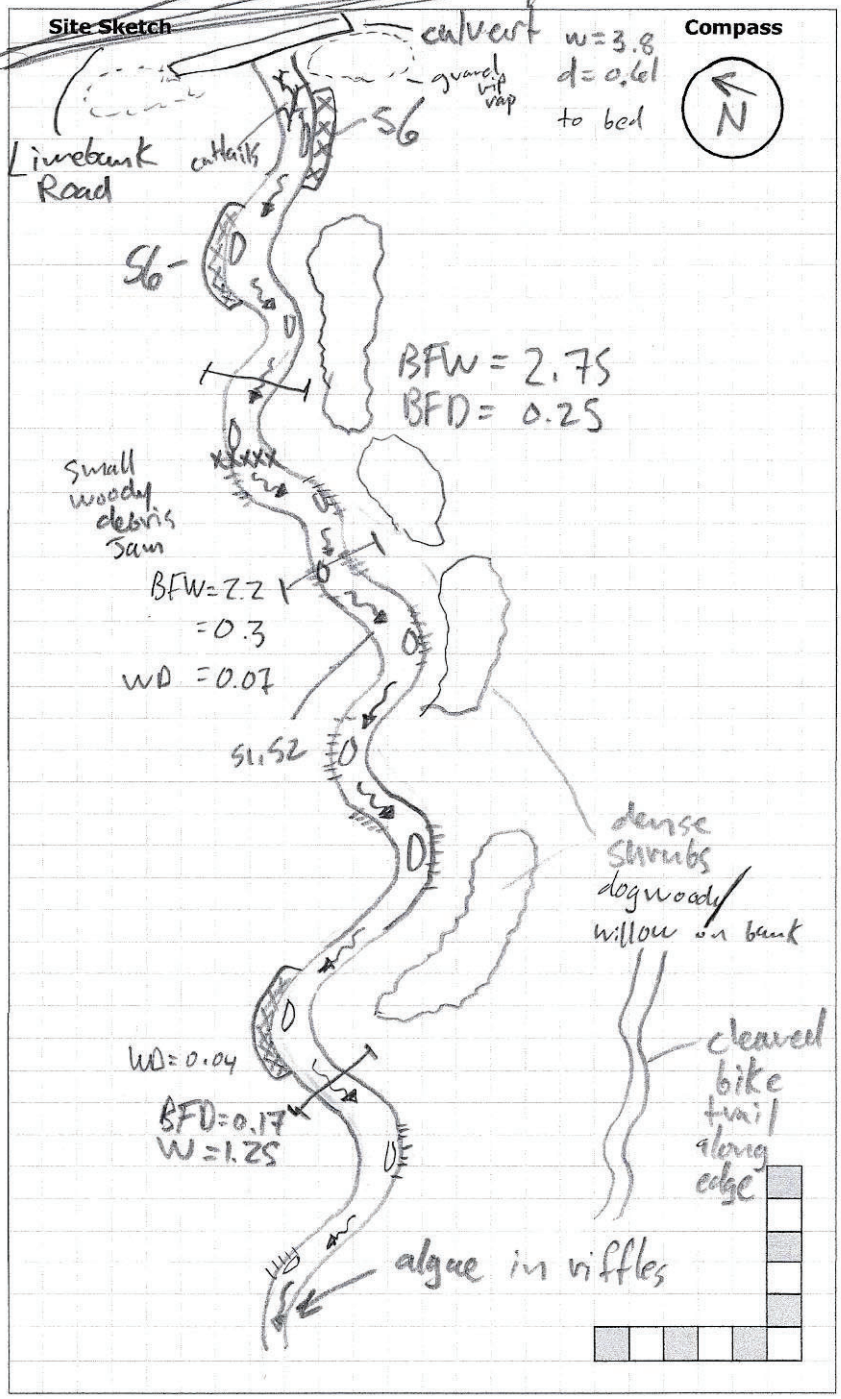
General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	14:00	**Reach:**	T3 C - R1
Weather:	Sunny, 1°C	**Location:**	NW of Spruitt / Limebank intercept
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch



Photos:

Notes:

Flow Type			
H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate			
S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other			
BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

GEO MORPHIX

Rapid Geomorphic Assessment

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:		**Reach:**	T3C-R1
Weather:	1°C, overcast	**Location:**	Crowbank Road / Spratt Road (NW)
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	0/7
	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 =		0	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			0/6
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint 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 =	0	6	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1/7
	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.			
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation			
		Sum of indices =	1	6	0.14
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	1/7
	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 =	1	6	0.14

Notes: Channel previously constructed → riffles + pools abundant + consistent.
- New trails (bike, skiing etc) established near and over the tributary. Riparian veg cut and many thrown into creek.

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.07

In Regime	In Transition/Stress	In Adjustment
☑ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

Rapid Stream Assessment Technique Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:		**Reach:**	T3C-R1
Weather:	1°C overcast	**Location:**	NW of Spratt/Limebank Road intersection
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

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**

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX™

Date:	2025/11/19	PN:	25149	Location:	Mosquito Creek

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	• 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) = 34	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX™

Reach Characteristics Project Number: 25148

Date:	2025/11/19	**Field Staff:**	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek
Time:		**Stream:**	Trib 3	**UTM (Upstream):**	
Weather:	1°C, overcast	**Reach:**	T3C-R1	**UTM (Downstream):**	

Land Use (Table 1): 1, 2 | **Valley Type** (Table 2): 2/3 | **Channel Type** (Table 3): 9 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 12

Encroachment (Table 7): 3

Coverage	Channel Widths	Age (yrs)
☐ None	☐ 1 - 4	☐ Immature (<5)
☐ Fragmented	☑ 4 - 10	☑ Established (5-30)
☑ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1

Reach Coverage %: 30

Woody Debris	WD Density
☐ In Cutbank	☑ Low
☑ In Channel	☐ Mod
☐ Not Present	☐ High

WDJ/50m: 0.5

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 2

Gradient (Table 11): Mod

Entrenchment (Table 13): Mod

Down's Model (Table 15): S

Sed Sorting (Table 20): Wells.

Transport Mode (Table 21): 3.

Geomorphic Units (Table 22): S/G/R

Riffle-Pool Spacing (m): 3

Sinuosity Degree (Table 10): 3

# of Channels (Table 12): 1

Bank Failure (Table 14): None

Bankfull Indicators (Table 18): 5

Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible

% of Bed Active:

Mass Movement (Table 23): 1

% Riffles: 35 **% Pools:** 35

Bank Angle	Bank Erosion
☐ 0 – 30	☐ < 5%
☑ 30 – 60	☑ 5 – 30%
☑ 60 – 90	☐ 30 – 60%
☐ Undercut	☐ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☑	☐	☐	☐	☐	☑	☐
Riffle	☐	☐	☑	☑	☑	☐	☐
Pool	☑	☑	☐	☐	☐	☑	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	2.75	2.2	1.25	**Wetted Width (m)**
Bankfull Depth (m)	0.25	0.30	0.17	**Wetted Depth (m)**
Undercuts (m)	0	0	0	**Velocity (m/s)**
Pool Depth (m)	0.4			**Velocity Estimate Method**
Riffle Length (m)	0.07			**Meander Amplitude (m)**

Wetted Width (m)			
Wetted Depth (m)	0.04	0.07	0.41
Velocity (m/s)			
Velocity Estimate Method			
Meander Amplitude (m)			

* Add

Notes:

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

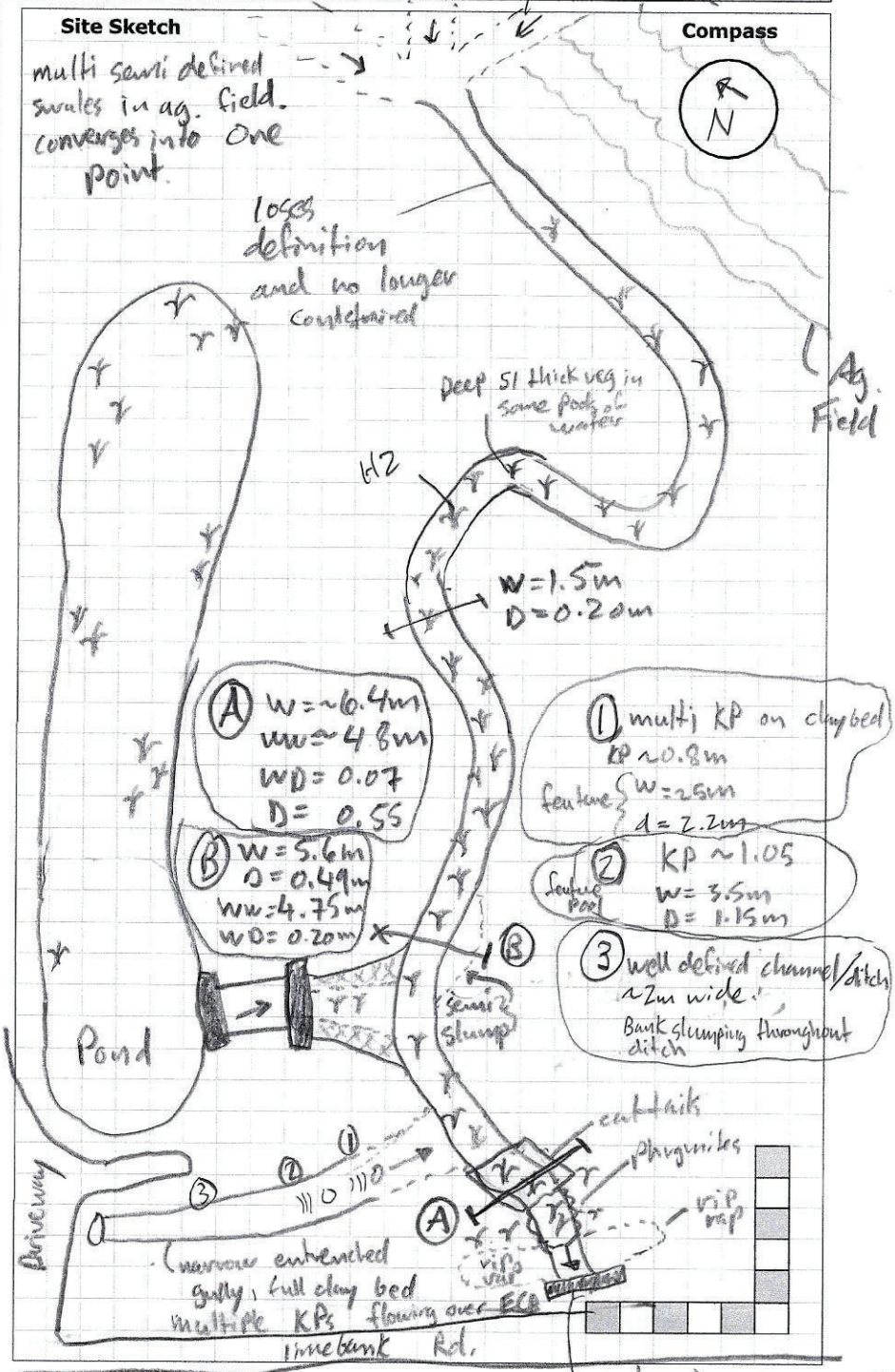
General Site Characteristics

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:	14:00	**Reach:**	T3C-R2
Weather:	Sunny, 10°C	**Location:**	NE of Sprucebank/Limebank intersept
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch



Photos:

Notes:

- Tributary lacks channel definition
- No defined geomorphological units
- Highly vegetated
- RSAT not completed due to conditions

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

*No previous RSAT, Not to submit in Report

GEO MORPHIX

Rapid Stream Assessment Technique Project Number:

Date:	2025/11/19	**Stream:**	Trib 3
Time:		**Reach:**	T3C-R2
Weather:	Sunny, 1°C	**Location:**	NE of Spratt/Limebank Rd. intersect
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Category	Poor	Fair	Good	Excellent
T3C R2 → = Stable, but, small trench and a lot of erosion	• < 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
Channel Stability	• 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

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

Date:	2025/11/19	PN:	25148	Location:	Mosquito Creek

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	• 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 (water not deep enough)	• 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) = 26	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

Rapid Geomorphic Assessment

Project Number: 25148

Date:	2025/11/19	**Stream:**	Trib 3
Time:		**Reach:**	T3C-R2
Weather:	Sunny, 1°C	**Location:**	NE of Spruth/Limestone Rd. intersection
Field Staff:	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	0/5
	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 =	0	5	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			0/6
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint 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 =	0	6	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	0/7
	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.			
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
		Sum of indices =	0	7	0
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	2/6
	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 =	2	4	0.33

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.08

In Regime	In Transition/Stress	In Adjustment
☑ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

GEO MORPHIX

Reach Characteristics

Project Number:

Date:	2025/11/19	**Field Staff:**	EG, BM	**Watershed/Subwatershed:**	Mosquito Creek
Time:		**Stream:**	Trib 3	**UTM (Upstream):**	
Weather:	Sunny, 10°C	**Reach:**	T3C-R7	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 3

Encroachment (Table 7): 4

Coverage	Channel Widths	Age (yrs)
☐ None	☐ 1 - 4	☑ Immature (<5)
☐ Fragmented	☑ 4 - 10	☐ Established (5-30)
☑ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1

Reach Coverage %: 100

Woody Debris	WD Density
☐ In Cutbank	☑ Low
☐ In Channel	☐ Mod
☑ Not Present	☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 3

Gradient (Table 11): 2.1

Entrenchment (Table 13): 1

Down's Model (Table 15): 5

Sed Sorting (Table 20): WS

Transport Mode (Table 21): 3

Geomorphic Units (Table 22): 8

Riffle-Pool Spacing (m):

Sinuosity Degree (Table 10): 3

# of Channels (Table 12): 1

Bank Failure (Table 14): None

Bankfull Indicators (Table 18): 5

Sediment Transport Observed? ☐ Yes ☑ No ☐ Not Visible

% of Bed Active

Mass Movement (Table 23)

% Riffles:

% Pools:

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

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

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☑	☑	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	1.5	6.4	5.6	**Wetted Width (m)**	4.8	4.75
Bankfull Depth (m)	0.2	0.55	0.49	**Wetted Depth (m)**	0.07	0.2
Undercuts (m)				**Velocity (m/s)**		
Pool Depth (m)				**Velocity Estimate Method**		
Riffle Length (m)				**Meander Amplitude (m)**		

Notes:

Photos:

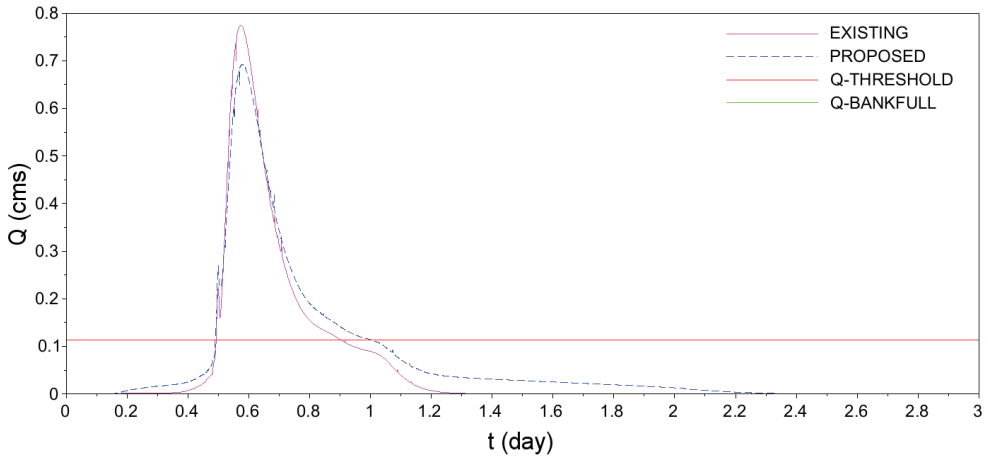
Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: EG

Appendix E:
Erosion Exceedance Hydrographs

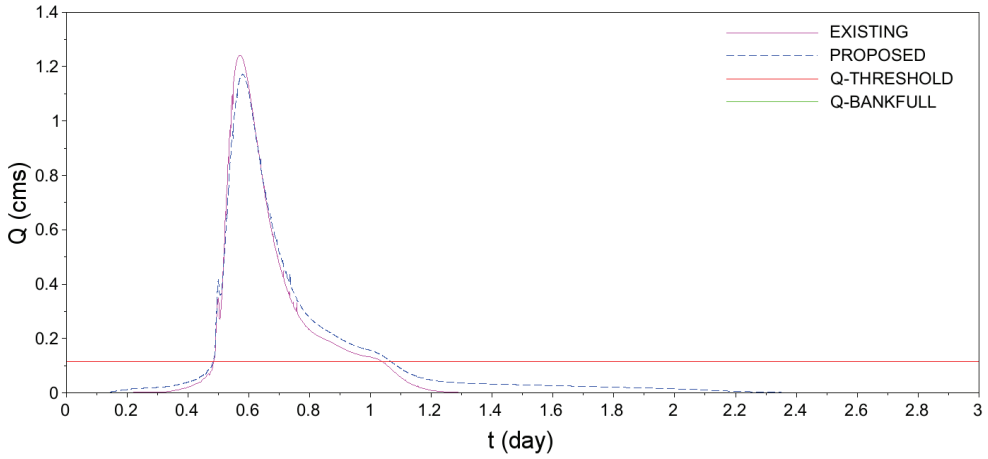
24 hours

2-year SCS



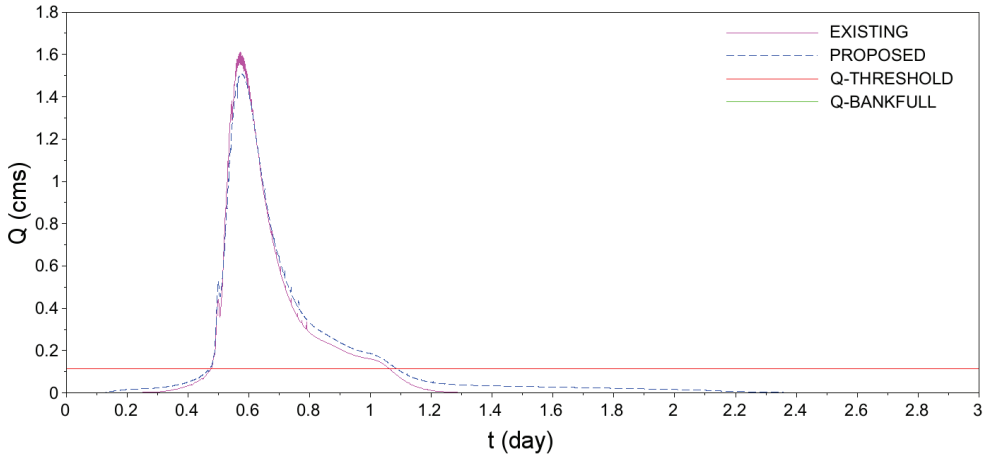
24 hours

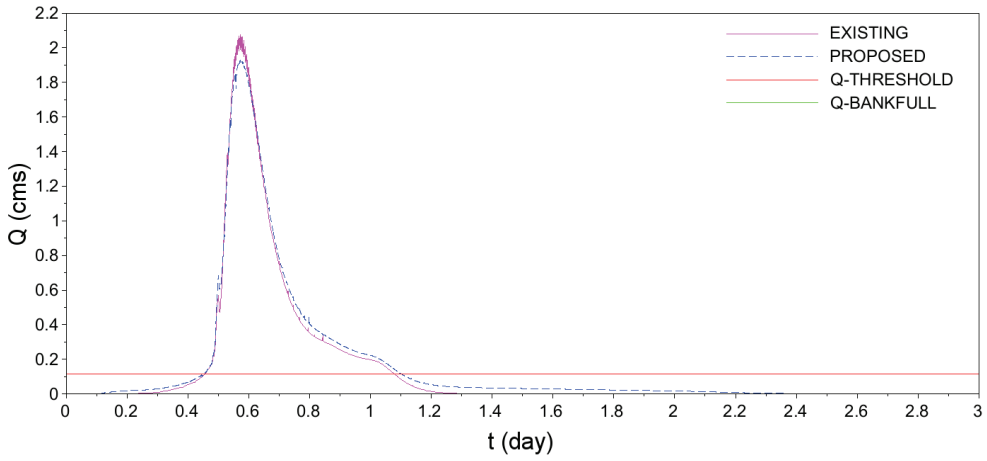
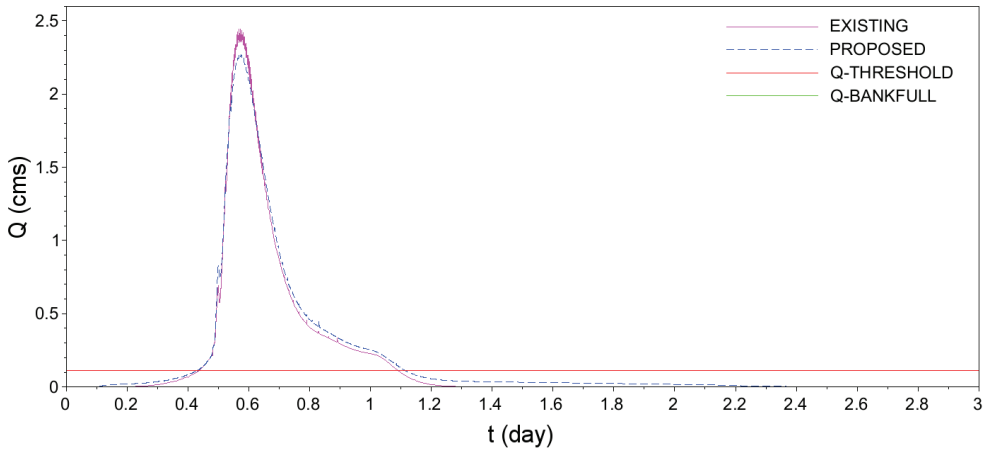
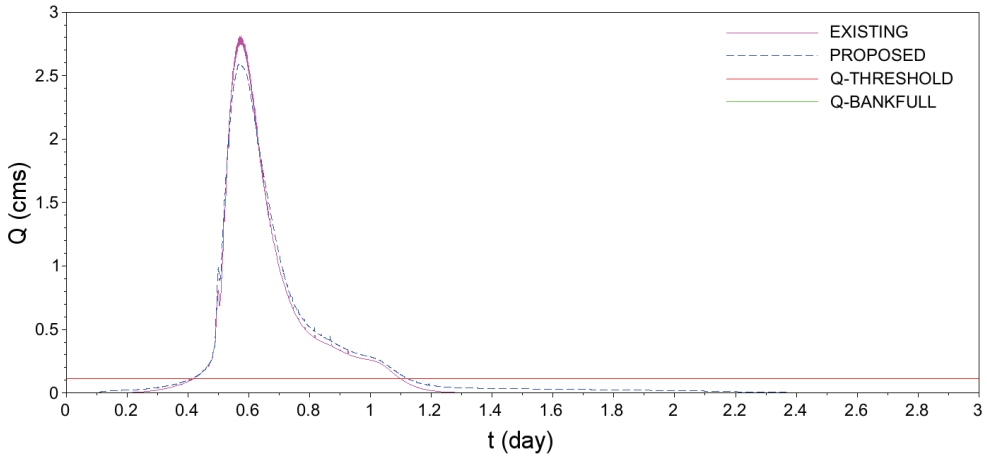
5-year SCS

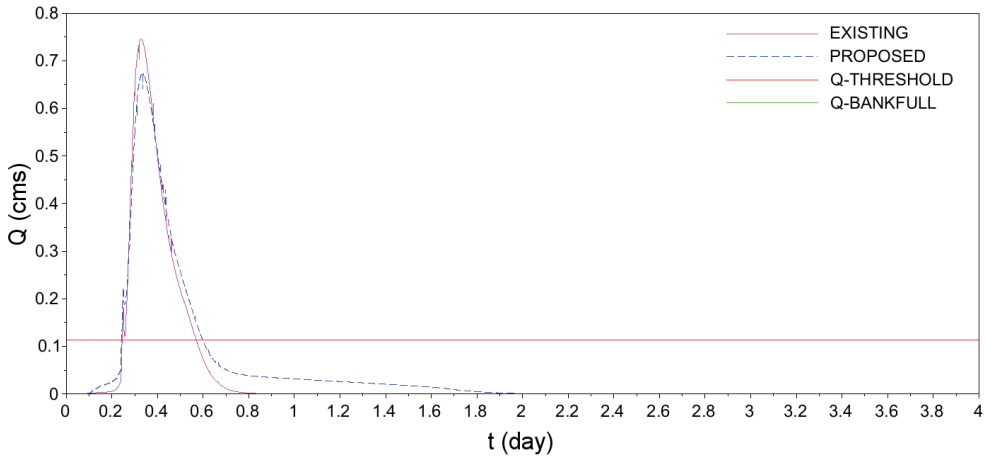
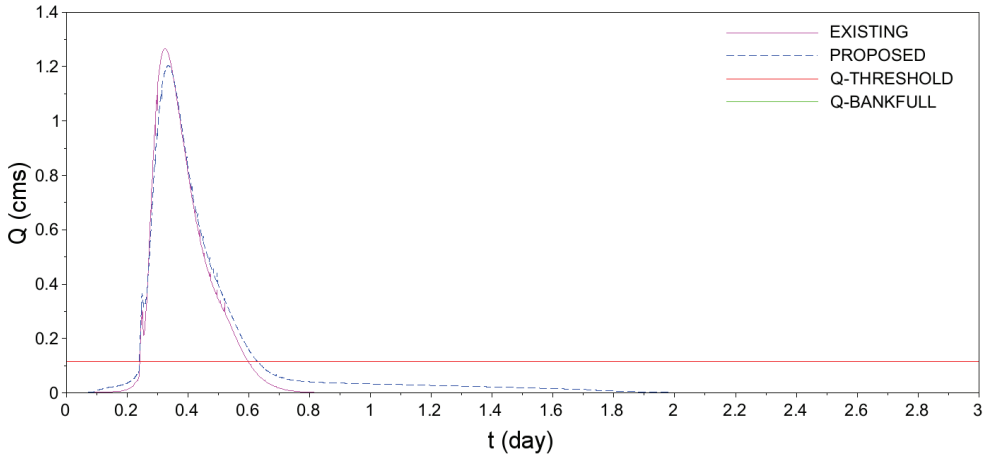
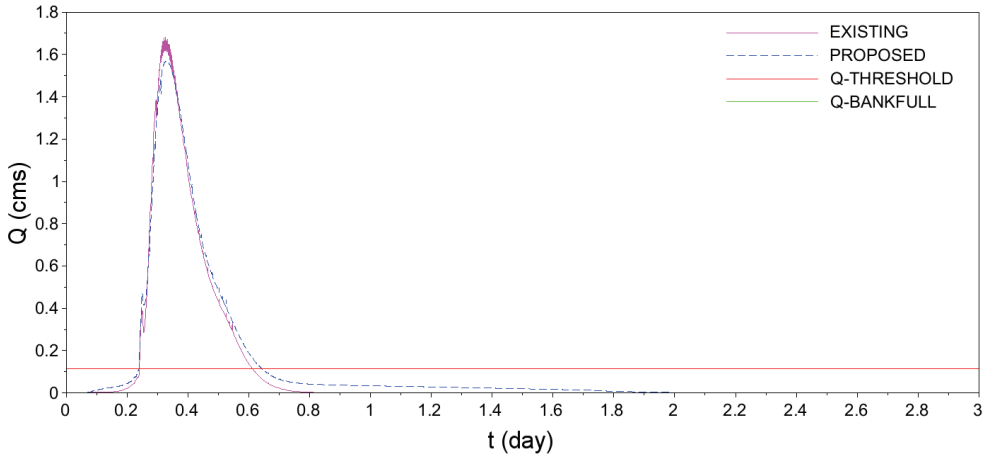


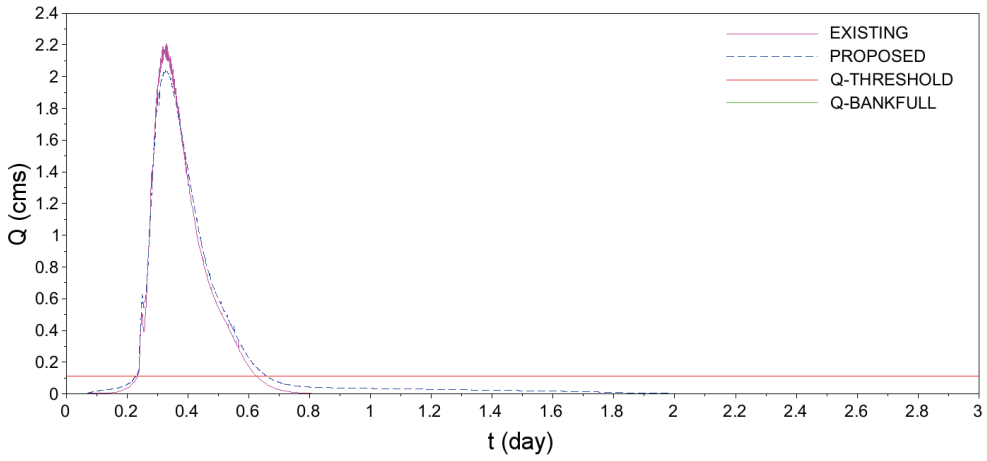
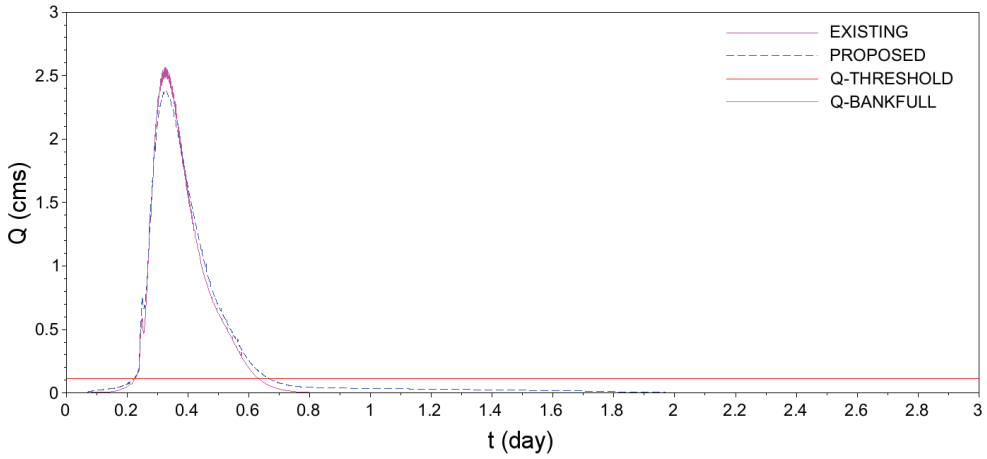
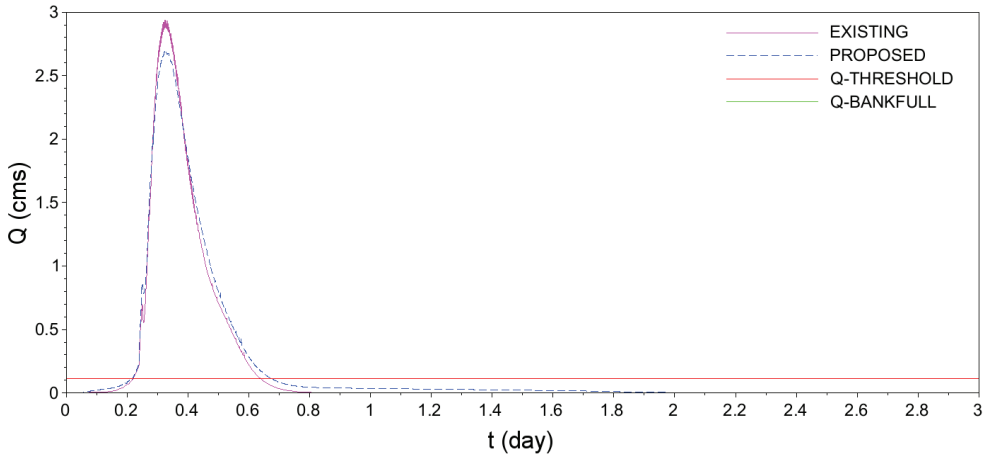
24 hours

10-year SCS



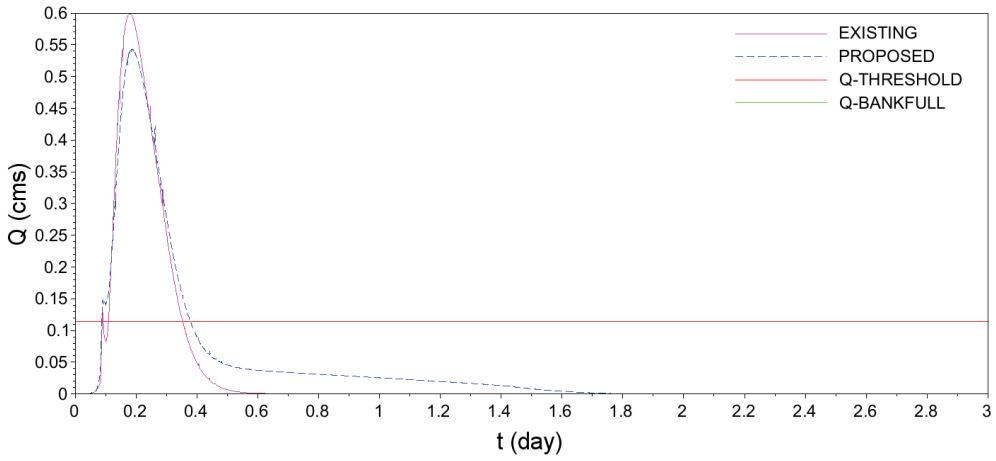
24 hours **25-year SCS**	
24 hours **50-year SCS**	
24 hours **100-year SCS**	

12 hours **2-year SCS**	
12 hours **5-year SCS**	
12 hours **10-year SCS**	

12 hours 25-year SCS	
12 hours 50-year SCS	
12 hours 100-year SCS	

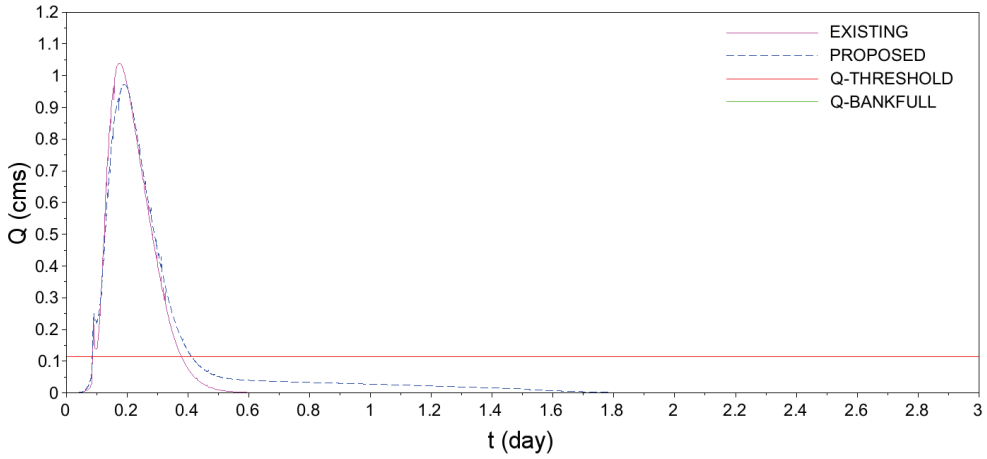
6 hours

2-year Chicago



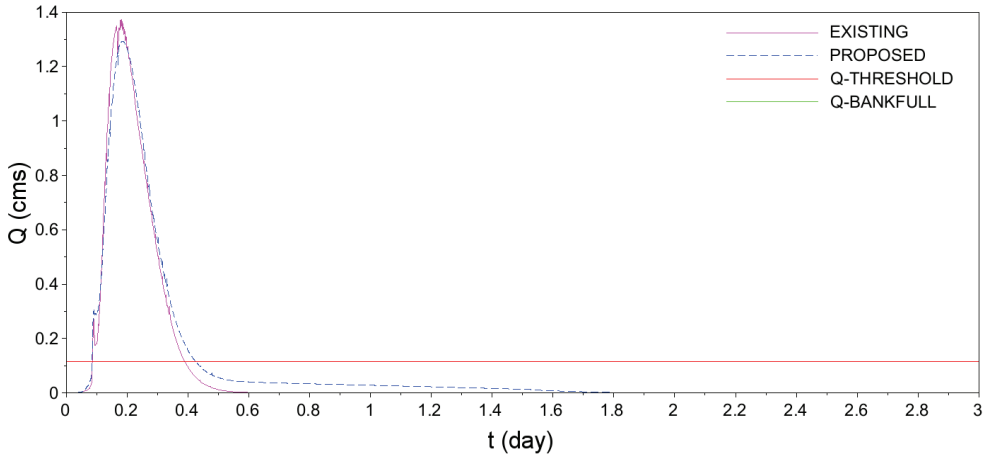
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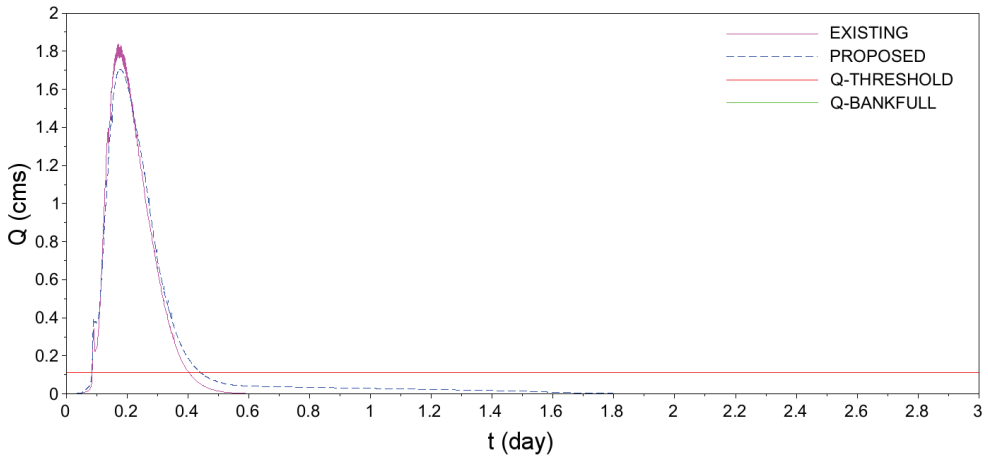
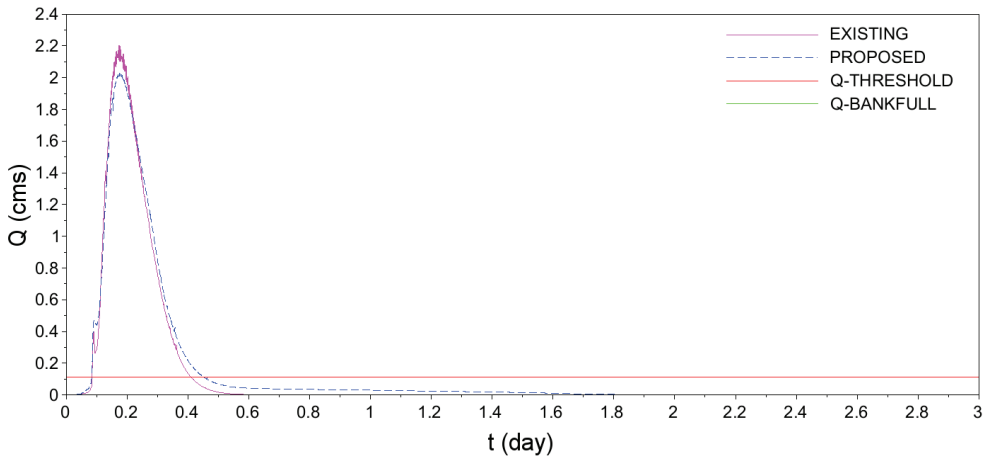
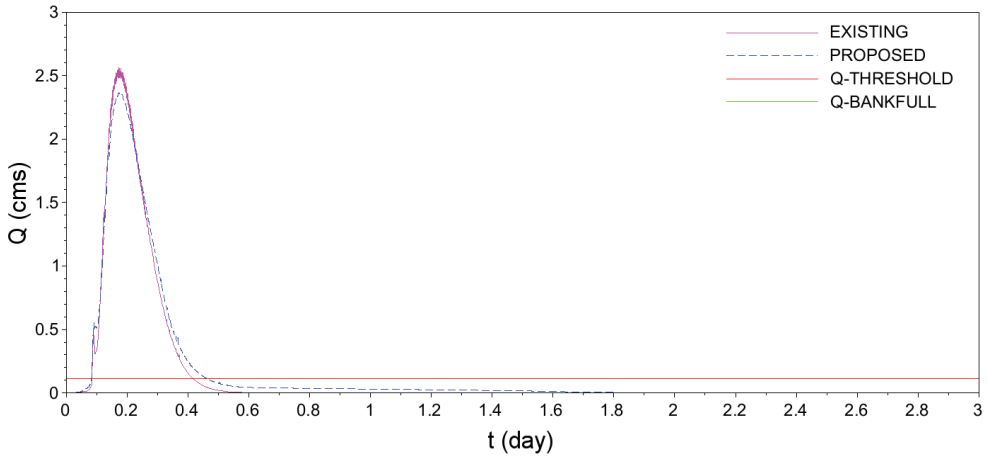
5-year Chicago



6 hours

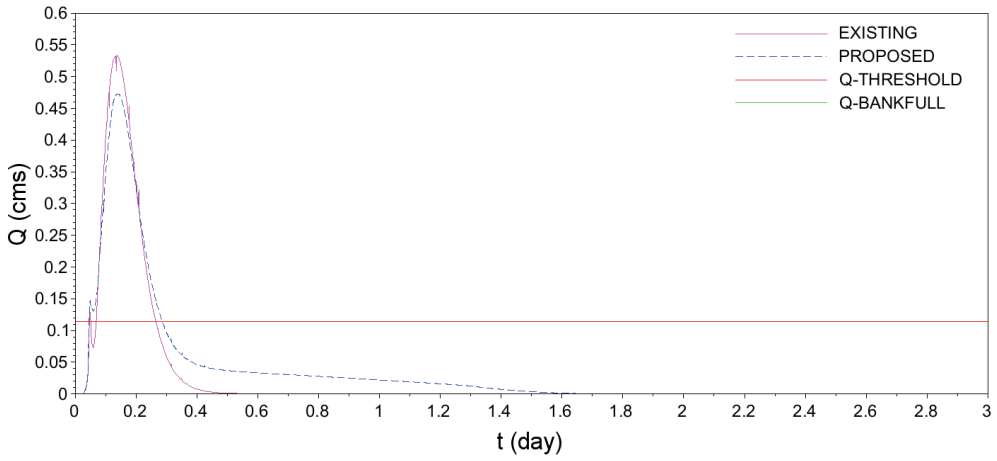
10-year Chicago



6 hours **25-year Chicago**	
6 hours **50-year Chicago**	
6 hours **100-year Chicago**	

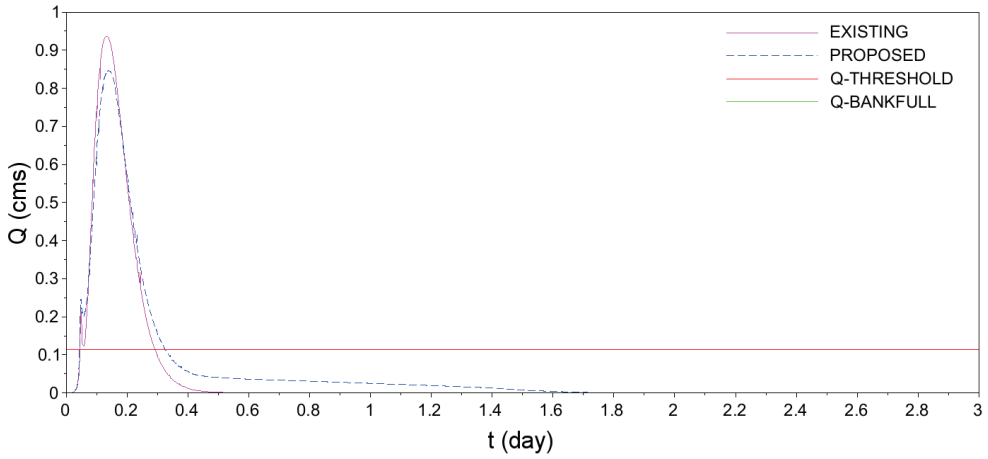
3 hours

2-year Chicago



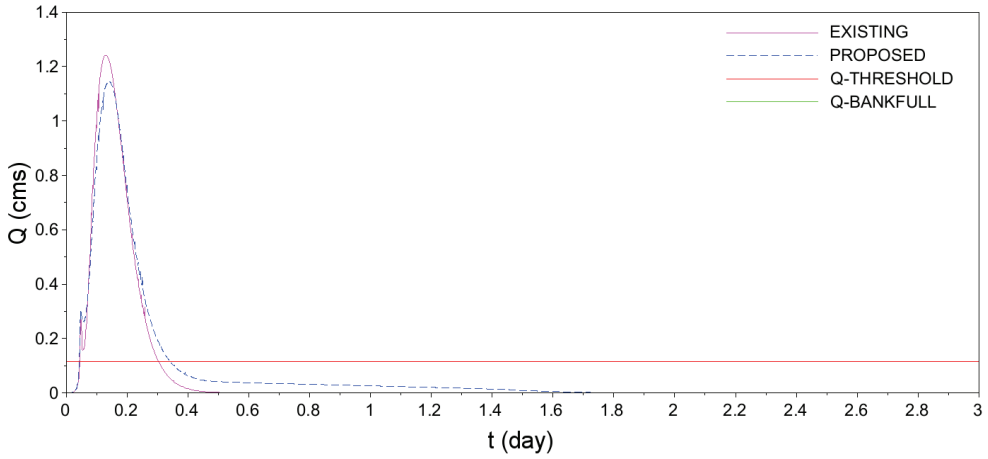
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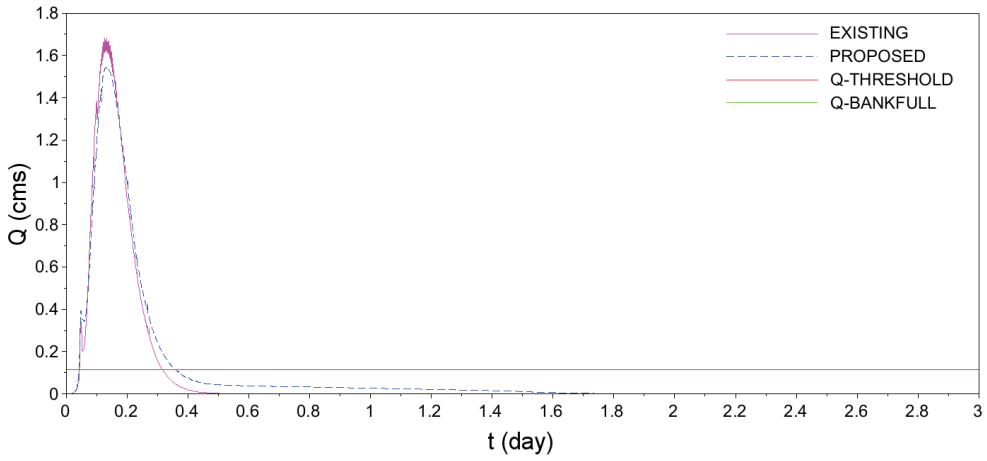
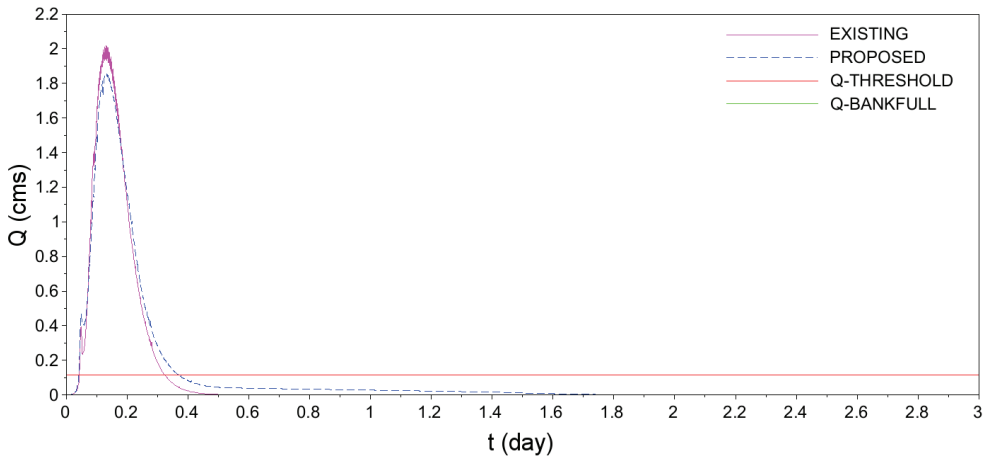
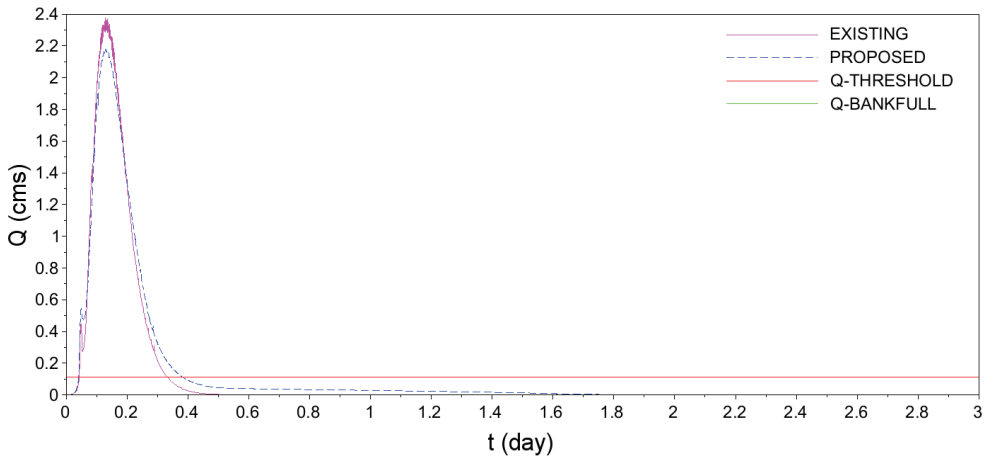
5-year Chicago



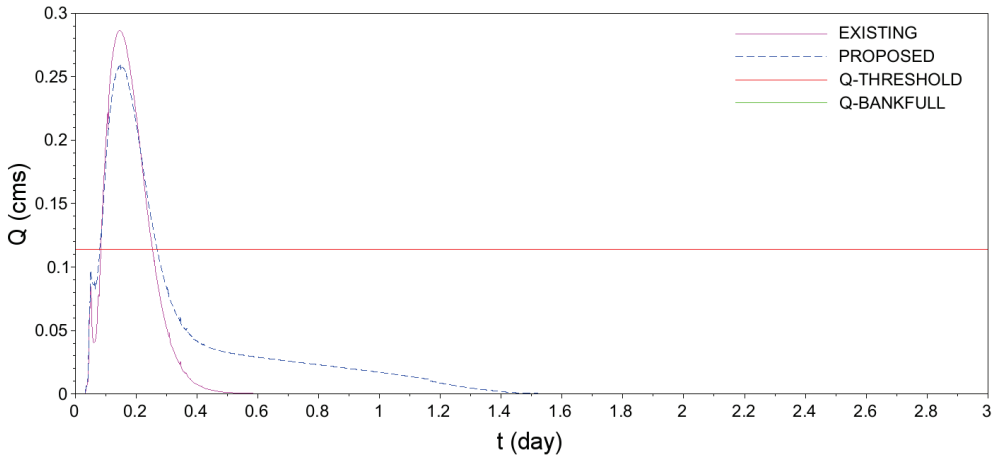
3 hours

10-year Chicago



3 hours **25-year Chicago**	
3 hours **50-year Chicago**	
3 hours **100-year Chicago**	

25 mm, 4-hour


EXISTING
PROPOSED
Q-THRESHOLD
Q-BANKFULL
Q (cms)
t (day)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3

Appendix F:
Event-based Erosion Exceedance Results

Table G.1. Erosion exceedance results for simulated 25 mm, 4-hour storm event

Return Interval Scenario	Peak Discharge (m^3/s)	CEV	CEWI	t_{ex}
		(m^3)	(N/m)	(hrs)
25 mm	0.286	1,577	20.9	4.08
	0.259	1,417	18.9	4.55
	-9.62	**-10.15**	**-9.65**	**11.43**

Table G.2. Erosion exceedance results of cumulative 100-year projection for simulated 24-hour SCS Type II storms

Return Interval Scenario	Events per 100 years		Peak Discharge (m^3/s)	CEV	CEWI	t_{ex}
				(m^3)	(N/m)	(hrs)
2-year	**30**	PRE	0.774	8,443	106	9.88
		POST	0.691	8,618	109	12.35
		Change (%)	**-10.70**	**2.08**	**3.15**	**24.96**
5-year	**10**	PRE	1.241	15,903	193	13.37
		POST	1.171	16,518	202	14.03
		Change (%)	**-5.71**	**3.87**	**4.83**	**4.99**
10-year	**6**	PRE	1.613	21,501	255	14.10
		POST	1.507	22,287	267	14.75
		Change (%)	**-6.61**	**3.66**	**4.43**	**4.61**
25-year	**2**	PRE	2.079	28,947	335	15.00
		POST	1.926	29,921	349	15.63
		Change (%)	**-7.38**	**3.36**	**4.04**	**4.22**
50-year	**1**	PRE	2.446	35,204	399	15.67
		POST	2.268	36,308	415	16.30
		Change (%)	**-7.26**	**3.14**	**3.81**	**4.04**
100-year	**1**	PRE	2.816	41,676	464	16.30
		POST	2.591	42,896	481	16.93
		Change (%)	**-7.96**	**2.93**	**3.64**	**3.89**
Frequency Weighted	**50**	(PRE)	**-**	676,085	8,179	577
		(POST)	-	696,495	8,499	664
		Change (%)	-	**3.02**	**3.92**	**15.10**

Table G.3. Erosion exceedance results of cumulative 100-year projection for simulated 12-hour SCS Type II storms

Return Interval Scenario	Events per 100 years		Peak Discharge (m^3/s)	CEV	CEWI	t_{ex}
				(m^3)	(N/m)	(hrs)
2-year	**30**	PRE	0.746	7,987	100	7.82
		POST	0.673	8,020	102	8.53
		Change (%)	**-9.78**	**0.41**	**1.20**	**9.17**
5-year	**10**	PRE	1.267	15,486	186	8.58
		POST	1.202	15,840	192	9.35
		Change (%)	**-5.10**	**2.29**	**2.95**	**8.93**
10-year	**6**	PRE	1.683	21,055	246	8.93
		POST	1.568	21,598	254	9.72
		Change (%)	**-6.87**	**2.58**	**3.18**	**8.77**
25-year	**2**	PRE	2.209	28,474	322	9.38
		POST	2.038	29,217	333	10.22
		Change (%)	**-7.73**	**2.61**	**3.28**	**8.88**
50-year	**1**	PRE	2.567	33,925	376	9.75
		POST	2.376	34,790	388	10.57
		Change (%)	**-7.46**	**2.55**	**3.32**	**8.38**
100-year	**1**	PRE	2.938	39,560	429	10.07
		POST	2.698	40,497	443	10.92
		Change (%)	**-8.18**	**2.37**	**3.30**	**8.44**
Frequency Weighted	**50**	(PRE)	**-**	651,228	7,805	413
		(POST)	-	662,303	7,991	450
		Change (%)	-	**1.70**	**2.38**	**9.02**

Table G.4. Erosion exceedance results of cumulative 100-year projection for simulated 6-hour Chicago storms

Return Interval Scenario	Events per 100 years		Peak Discharge (m^3/s)	CEV	CEWI	t_{ex}
				(m^3)	(N/m)	(hrs)
2-year	**30**	PRE	0.599	5,681	72	5.98
		POST	0.543	5,548	71	7.00
		Change (%)	**-9.30**	**-2.33**	**-1.64**	**16.99**
5-year	**10**	PRE	1.040	11,490	140	7.03
		POST	0.971	11,647	143	7.87
		Change (%)	**-6.56**	**1.37**	**2.16**	**11.85**
10-year	**6**	PRE	1.373	15,829	188	7.33
		POST	1.291	16,190	193	8.20
		Change (%)	**-5.94**	**2.28**	**2.98**	**11.82**
25-year	**2**	PRE	1.839	21,644	249	7.63
		POST	1.703	22,193	257	8.57
		Change (%)	**-7.36**	**2.54**	**3.33**	**12.23**
50-year	**1**	PRE	2.205	26,305	295	7.80
		POST	2.026	26,948	305	8.80
		Change (%)	**-8.12**	**2.44**	**3.41**	**12.82**
100-year	**1**	PRE	2.568	31,389	344	7.98
		POST	2.364	32,097	356	9.08
		Change (%)	**-7.94**	**2.26**	**3.43**	**13.78**
Frequency Weighted	**50**	(PRE)	**-**	481,282	5,829	325
		(POST)	-	483,494	5,896	373
		Change (%)	-	**0.46**	**1.15**	**14.77**

Table G.5. Erosion exceedance results of cumulative 100-year projection for simulated 3-hour Chicago storms

Return Interval Scenario	Events per 100 years		Peak Discharge (m^3/s)	CEV	CEWI	t_{ex}
				(m^3)	(N/m)	(hrs)
2-year	**30**	PRE	0.533	3,997	51	4.80
		POST	0.473	3,727	48	5.78
		Change (%)	**-11.40**	**-6.75**	**-5.94**	**20.49**
5-year	**10**	PRE	0.936	8,582	105	5.95
		POST	0.846	8,491	106	6.78
		Change (%)	**-9.66**	**-1.05**	**0.05**	**14.01**
10-year	**6**	PRE	1.241	12,094	145	6.27
		POST	1.144	12,157	147	7.20
		Change (%)	**-7.76**	**0.52**	**1.64**	**14.89**
25-year	**2**	PRE	1.682	16,875	196	6.60
		POST	1.542	17,118	201	7.60
		Change (%)	**-8.35**	**1.44**	**2.64**	**15.15**
50-year	**1**	PRE	2.021	20,725	235	6.78
		POST	1.850	21,073	242	7.88
		Change (%)	**-8.48**	**1.68**	**3.01**	**16.22**
100-year	**1**	PRE	2.379	24,921	276	6.97
		POST	2.177	25,351	285	8.18
		Change (%)	**-8.50**	**1.73**	**3.26**	**17.46**
Frequency Weighted	**50**	(PRE)	**-**	357,676	4,359	268
		(POST)	-	350,319	4,309	316
		Change (%)	-	**-2.06**	**-1.14**	**17.81**