Erosion Mitigation Assessment
West Credit River (Erin Branch)

Town of Erin, Wellington County

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Geomorphology
Earth Science
Observations

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1 Introduction

GEO Morphix Ltd. was retained by Mattamy Homes to complete an erosion mitigation assessment in support of the stormwater management (SWM) strategy associated with the proposed development at Sideroad 17 and 8th Line in the Town of Erin, ON. The proposed development site, hereafter referred to as the "subject lands", are bounded by Sideroad 17 to the north, agricultural properties to the west, a woodlot to the south, and 8th Line to the east. Current land use consists predominantly of agricultural fields, rural residences, woodlots, wetlands, and other natural areas. A branch of the West Credit River (Erin Branch) bisects the northeast corner of the subject lands, flowing in a southeasterly direction, entering through a culvert crossing beneath Sideroad 17 and exiting through a bridge crossing at 8th Line.

David Schaeffer Engineering (DSEL) is preparing overall civil engineering design and stormwater management strategy for the proposed development. Stormwater management (SWM) facilities and outfall treatments are required to address water quality, infiltration, and quality controls for the site. Outflows from the subject lands will ultimately be directed into the West Credit River. The downstream watercourse crossing at 8th Line will be replaced by Mattamy Homes and the upstream watercourse crossing will be replaced by the Town of Erin. Credit Valley Conservation (CVC) has indicated that the 8th Line crossing replacement will require an assessment of channel form and function and delineation of the erosion hazard. Further,.

To help address the requirements and concerns raised by CVC, GEO Morphix has completed an erosion threshold and mitigation assessment of the receiving watercourse associated with the SWM facilities and has provided geomorphological recommendations the 8th line watercourse crossing replacement. The following activities were completed as part of the assessment:

- Review of available reports and mapping (i.e., watershed/subwatershed studies, surficial geology and topographic mapping, conceptual development plans)
- Rapid geomorphic assessments using standard, industry accepted tools such as the rapid geomorphic assessment (RGA) and rapid stream assessment technique to evaluate existing instream and riparian conditions, channel stability, and erosion sensitivity
- Completion of a detailed geomorphic assessment, downstream of the proposed outlet location, the primary objective of which is to support the critical flow or erosion threshold
- Determine erosion thresholds for, and assess the erosion-sensitivity of the receiving watercourse
- Develop recommendations for the replacement of the crossing along 8th Line from a geomorphological perspective to ensure the erosion hazard and natural channel processes are appropriately addressed

2 Background Review

2.1 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics and potentially how past changes may affect channel planform in the future.

Various aerial photographs and satellite images from 1930 to 2021 were reviewed to complete the historical assessment. Specifically, aerial photographs from 1930, 1951, 1980, 1990 provided by the National Air Photo Library, and recent satellite images from 2004, 2016, and 2021 (Google Earth Pro, 2019) were reviewed and are provided in **Appendix B**, for reference.

In 1930, the subject lands were primarily cultivated. The watercourse was surrounded by mature trees, reducing the visibility of the channel. There were approximately 3 houses within the subject lands and no surrounding residential areas. Major road networks, including Sideroad 17 and 8th Line were all established.

Due to the low resolution of the 1951 and 1980 aerial photographs, the channel is difficult to distinguish. Few changes were identified between 1930-1981 to the subject lands. Surrounding land use remained consistent, with the exception of the adjacent Erin Heights Golf Course development in 1952 and residential development southwest of the subject lands, east of 8th Line. No major land use changes or changes to visible watercourse characteristics occurred between 1981 and 2021 within the subject lands.

2.2 Subwatershed Characteristics

The West Credit River (Erin Branch) is situated within the West Credit River Subwatershed. The West Credit River Subwatershed captures an area of approximately 105 km^2 and drains southeast towards Forks of the Credit. The subwatershed area contains many wetlands and tributaries of the West Credit River (Ministry of Natural Resources, 2002). In terms of land use, approximately 68% of land cover is utilized for agricultural purposes, 15% is woodland, 14% is wetland, and 3% is urbanized (County of Wellington, 1998).

The West Credit River (Erin Branch) traverses through the northeastern portion of the subject lands, entering at Sideroad 17 and exiting at 8th Line. The riparian zone is largely characterized by continuous forest cover and wetland vegetation. A small pond exists in the adjacent property south of the tributary. Surrounding the tributary and encompassing the northeast corner of the subject lands is a provincially evaluated wetland, identified specifically as a swamp. Three other wetlands are identified within the western portion of the subject lands (Ministry of Natural Resources and Forestry, 2019).

2.3 Physiography and Geology

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

The subject lands are located within the Guelph Drumlin Field physiographic region. This region is characterized by variable-sized drumlins generally comprised of loamy and calcareous material (Chapman and Putnam, 1984). The intervening low-ground between the drumlins typically contain fluvial materials. There are no evident drumlins located on the subject property. The physiographic landforms present on the subject lands include spillways to the northeast of the property and drumlinized till plains to the southwest (Chapman and Putnam, 1984).

Published mapping indicates several surficial geology types present on the subject lands. Southwest of the property is characterized by ice-contact stratified deposits consisting of sand, gravel, minor silt, clay, and till. The middle-portion of the subject lands is characterized by till with a stone-poor, sandy-silt to silty-sand texture. Northeast of the subject lands is characterized by glaciofluvial deposits consisting of river deposits and delta topset facies. The remaining area within the subject is characterized by organic deposits consisting of peat, muck, and marl (OGS, 2010). The surficial organic deposit area generally coincides with the footprint of the West Credit River channel that traverses the subject property.

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. 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
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards *et al.* (1997), Brierley and Fryirs (2005), and the Toronto and Region Conservation Authority (2004). Reach delineation was completed through a desktop assessment and field-verified thereafter. As the length of channel within the subject lands displays relatively homogenous characteristics, a single reach named **WC-1** was delineated adjacent to the proposed development and within the immediate zone of impact, extending from Sideroad 17 to 8th Line. A map of the study area and reach delineation is provided in **Appendix A**.

3.2 Field Observations

Rapid and detailed field assessments were completed along reach **WC-1** by GEO Morphix Ltd. during one site visit on October 18, 2021. Photographs from the field assessments are provided in **Appendix C**, rapid field observations are provided in **Appendix D**, and the detailed assessment summary is provided in **Appendix E** for reference.

General Reach Observations

Reach **WC-1** is a meandering channel with a low gradient conveying flows through an unconfined valley. The channel's riparian buffer is composed of mainly of trees and shrubs, with moderate encroachment along the margins of the bankfull channel. Pockets of wetland-type vegetation were noted within the riparian area. Many instances of leaning and fallen trees, exposed roots, and large woody debris were noted on the banks and within the channel. The reach has marginally defined riffle-pool sequences with several instances of deep, slow-velocity scour pools. The bed substrate is primarily composed of sand with isolated loose silt deposits. Gravel and occasional small cobbles were observed within the channel adjacent to the 8th Line bridge crossing. The average width of the bankfull channel is 6.94 m, and the average maximum bankfull depth is 0.98

m. On the day of the assessment the average wetted width was 6.50 m, and the average wetted depth was 0.50 m. Discharge measured on the day of the assessment was 0.38 m^3/s.

A summary of the general observations characterizing the reach is presented in **Table 1**.

Table 1: Reach characteristics summary

Reach Name	Date Visited	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Notes
WC-1	2021-10-18	6.94	0.98	Sand	Silt, Sand	Mature trees, shrubs	Slow flow velocities throughout. Leaning trees common on banks. Saturated floodplain with wetland vegetation.

Rapid Field Assessment

Rapid field assessments were completed for each of the identified reaches of the receiving watercourse. The rapid assessments were completed to identify the dominant local geomorphic processes, document stream health, and to identify any areas of concern regarding erosion or instability. This included the following observations for each reach:

- Characterization of stream form, process, and evolution using the Rapid Geomorphological Assessment (RGA) (MOE, 2003; VANR, 2007), which evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale
- Assessment of the ecological function of the watercourse using the Rapid Stream Assessment Technique (RSAT) (Galli, 1996), which evaluates stream health based on a number of biological indicators
- Stream classification following a modified Downs (1995) and a modified Brierley and Fryirs (2005) River Styles Classification approach which evaluate the magnitude and potential for channel instability and indicate dominant sediment loads, respectively
- Instream estimates of bankfull channel geometry
- Bed and bank material composition and structure
- Georeferenced photographs to document the location of all observed erosion and infrastructure

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment (MOE; 2003) Rapid Geomorphic Assessment (RGA) technique. The RGA evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The end result of the RGA is to produce a score, or stability index, which evaluates the degree to which a stream has departed from its equilibrium condition. A stream with a score of less than 0.20 is in regime, indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that a stream is in transition or stress and is experiencing major changes to process and form outside the natural range of variability. A score of greater than 0.41 indicates that a stream is in extreme adjustment, exhibiting a new stream type, or in the process of adjusting to a new equilibrium (MOE, 2003; VANR, 2007).

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

The reaches were also classified according to the Downs (1995) Model of Channel Evolution and the River Styles Framework (Brierley and Fryirs, 2005). The Downs (1995) model describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system. The River Styles Framework provides a geomorphological approach to examining river character, behaviour, condition, and recovery potential.

A summary of the reach classifications and rapid assessment scores is provided in **Table 2**.

Table 2: Reach classifications summary

Reach Name	Date Visited	RGA Score	Dominant Process	RSAT Score	Downs Model Classification	River Styles Framework
WC-1	2021-10-18	0.24 "In transition"	Aggradation	33 "Good"	"S" - Stable	12 – Suspended load meandering

With an overall score of 0.24, the RGA score placed reach **WC-1** in the lower end of the 'In Transition/Stress' classification. The dominant geomorphic process was determined to be aggradation, evidenced by siltation in pools, medial bars, and deposition in the overbank zone. Bank erosion (channel widening) and bed scour were not significant. For the RSAT, reach **WC-1** had a total score of 33 and was classified as having 'good' stream health, with channel stability as the limiting factor.

Detailed Geomorphological Assessment

A detailed geomorphological field assessment of reach **WC-1** was completed on October 18, 2021. This assessment provided updated bankfull channel characteristics, including cross-sectional geometry and hydraulics, and bed and bank material characterizations for the purpose of informing the erosion threshold assessment. The downstream portion of reach **WC-1** was selected for the detailed assessment, as it is situated downstream of the proposed outlets and will receive discharges originating from the site. Activities completed for the detailed assessment included the following:

- Long-profile survey of the channel centre line
- Six detailed cross-sectional surveys of the watercourse
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Bed material sampling at each cross-section following a modified Wolman's (1954) Pebble Count Technique or substrate sample for fine materials
- Velocity and discharge measurements at select representative cross-sections

A summary of measured and computed values is presented in Error! Reference source not found. a nd the detailed assessment summary is provided in **Appendix E.**

4 Erosion Threshold Assessment

4.1 Methodology

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank materials. As such, they may be used to inform erosion reduction strategies in channels influenced by conceptual flow management plans. The erosion threshold analysis provides a discharge at which sediment of a particular size may potentially be entrained.

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied. 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.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, *U*, or Shear Stress, *t*, is calculated at various depths for a representative cross section until the average velocity or shear stress in slightly exceeds the critical threshold of the bed material. The velocity is determined using a Manning's approach, where the Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. A Manning's n value of 0.040 was used for the assessment. The velocity is mathematically represented as:

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

where, d is depth of water, S is 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:

$$t = d\rho g S_{bed} \quad \text{[Eq. 2]}$$

Where, t is shear stress, d is the water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

In uniform cross sections, only 75% of bed shear stress applies to the adjacent channel banks (Chow, 1959). As such, the erosion threshold is scaled appropriately for these materials.

4.2 Results

The dominant bed materials within reach **WC-1** were determined to be sand (Julien, 1998). Analysis of the bank material showed they were composed of a silty, sandy loam (Julien, 1998). Based on the type of material observed, a critical velocity approach was taken using the criteria of Julien (1998) for the sandy bed material. This material is estimated to have a critical velocity of 0.46 m/s which was used to determine the material's threshold discharge, the point at which sediment entrainment begins to occur. The semi-cohesive bank material is estimated to have a critical velocity of 0.53 m/s (Julien, 1998). As the bank material critical velocity is higher than that of the bed material, the bed material threshold is the controlling factor with regards to the initiation of sediment entrainment. The results of the erosion threshold assessment are provided in **Table 3**.

Table 3: Reach WC-1 measured bankfull conditions and computed erosion thresholds

Channel parameter	Results by Reach
	WC-1
Bankfull Conditions	
Average bankfull width (m)	6.94
Average bankfull depth (m)	0.58
Channel gradient (%)	0.09
D_{50} (mm)	<2
D_{84} (mm)	<2
Manning's n roughness coefficient	0.040
Bankfull discharge (m^3/s)	2.12
Bankfull velocity (m/s)	0.52
Channel Bed Erosion Threshold	
Bed Material	Sand (Julien, 1998)
Apparent shear stress acting on bed (N/m^2)	3.78
Critical velocity at the bed (m/s)	0.46
Critical discharge for bed material (m^3/s)	1.41
Channel Banks Erosion Threshold	
Bank Material	Silty sandy loam (Julien, 1998)
Apparent shear stress acting on banks (N/m^2)	6.03
Critical velocity at the banks (m/s)	0.46
Critical discharge for bank material (m^3/s)	6.70
Limiting Critical Discharge (m^3/s)	**1.41**
Unitary Erosion Threshold ($m^3/s/ha$)	**0.00043**

The erosion threshold for reach **WC-1** was determined to be a critical discharge of 1.41 m^3/s based on a critical velocity of 0.46 m/s for the sandy bed material (Julien, 1998). Using a drainage area of 3571 ha for reach **WC-1,** obtained from the Ontario Flow Assessment Tool (OFAT), the unitary erosion threshold equates to 0.00043 $m^3/s/ha$. The critical discharge and unitary erosion threshold provide guidance regarding SWM facility sizing and retention targets within the subject lands. Given the large drainage area associated with reach **WC-1**, the resulting unitary value is considerably conservative in nature and consequently serves as a larger, overall target for the watershed. Considering the unitary threshold when forming design targets for developments within the West Credit River watershed will ensure that the associated stormwater management plans provide resilience under future climate scenarios that predict more frequent and severe storm events by controlling impacts due to urbanization, which are generally more significant than impacts associated with climate change.

5 Erosion Sensitivity Assessment

Erosion sensitivity was assessed using an assessment framework that considers multiple factors associated with catchment area land development and its affect on sedimentation and erosion rates within impacted watercourses. A channel that is determined to be stable will typically not require a full erosion exceedance analysis using continuous hydrological modelling, as the hydrological changes associated with the development activities are unlikely to exert any discernable geomorphic impacts.

Several characteristics of the receiving channel suggest that reach **WC-1** is stable and not particularly sensitive to erosion following alterations to its hydrological regime associated with the proposed development. The 3571-ha drainage area of reach **WC-1** is considerably large compared to the development footprint, which comprises roughly one percent of this area. Developments with similarly small relative footprints are unlikely to have any meaningful impact on the rates of sedimentation or erosion within the receiving watercourses. The channel itself is evidently non-sensitive, as flow velocities are slow, the gradient is shallow, and no significant active erosion was observed within or downstream of the subject lands. The channel is also very well connected with the surrounding floodplain, evidenced by the extensive wetland systems bordering the channel and the fresh sandy deposits observed along the banks. Such connectivity helps to dissipate flows and erosive forces across the floodplain during high-magnitude events, consequently reducing the cumulative impacts of increased peak flows on channel erosion.

The bankfull flows, shear stresses, and flow velocities relative to that of the established erosion threshold further suggest that the channel is not erosion sensitive. A summary of these parameters is provided in **Table 4**, below. The flow, shears stress, and velocity required to entrain the silty, sandy loam bank materials greatly exceeds each of the corresponding values during a modelled bankfull event. This is supported by the sandy deposits observed atop several banks, indicating aggradation-dominant conditions in the overbank areas during bankfull stages. Thus, a typical bankfull event is unlikely to cause significant erosion of the channel banks, indicating an active but stable, non-sensitive channel.

The flow, shears stress, and velocity required to entrain the sandy bed materials are similar to, but slightly lower than their respective bankfull event counterparts (**Table 4**). This suggests that the bed material would only be significantly mobilized during events that approach the magnitude of a bankfull event, indicating a non-sensitive channel. The sandy channel bed material is considered largely transient and a source of sediment for downstream reaches. Due to the low entrainment thresholds, a portion of this material is likely to be mobilized during most storm events in the existing conditions, regardless of the magnitude. As such, it is beneficial to maintain a dynamically stable geomorphological regime that continues to periodically mobilize the bed sediments, rather than striving to achieve absolute stability, in order to maintain the sediment source for downstream reaches.

Table 4: Erosion threshold and bankfull stage critical parameter comparison

Threshold Parameter	Bankfull Stage	Bed Material Threshold	Ratio of Bed : Bankfull	Bank Material Threshold	Ratio of Bank : Bankfull
Discharge (m^3/s)	2.12	1.41	0.67	6.70	3.16
Velocity (m/s)	0.52	0.46	0.88	0.53	1.02
Shear Stress (N/m^2)	5.12	3.78	0.74	6.03	1.18

6 Watercourse Crossing Recommendations

Crossings can have significant impacts on valley and stream corridors. Rivers and streams are also dynamic systems and can easily migrate across their floodplains over time impacting crossing infrastructure. Therefore, it is important to recognize and account for natural hazards in association with watercourse crossings. The assessment outlined herein is based on the guidance and recommendations outlined by the Credit Valley Conservation Authority (CVC) *Fluvial Geomorphic Guidelines* (2015). This is a standard and accepted approach for crossing design and implementation.

With respect to the crossing span, CVC (2015) guidelines note the following design considerations from a geomorphological perspective:

- Address potential channel erosion without the use of armouring or impacting local erosion or channel adjustment to the extent feasible
- Avoid impacts to sediment transport processes and velocities for frequent storm events
- Span the current and potential future location of the channel to the extent feasible
- For channels that are less than 4 m wide, span three times the width of the bankfull channel or as refined through a detailed geomorphic study

With respect to the crossing type, CVC (2015) guidelines note the following design considerations:

- Open arches and bridges are required unless there is a significant social, economic, or environmental benefit for another structure type
- Closed bottom culverts are to be embedded a minimum of 10% of the structure height if no substrate (engineered material) is included in the design
- Closed bottom culverts are to be embedded an equivalent of two times the depth of the substrate if an engineered substrate is proposed
- Natural substrates should be installed within the crossing that are similar to upstream and downstream substrates and should be stable during frequent flow events

The current crossing structure on 8th line consists of a concrete bridge and is to be replaced as part of the proposed external works proposed for the development. The current crossing structure is undersized relative to the underlying channel dimensions, as the wetted width extends to the bridge footings on both banks. Despite the apparent under-sizing, outflanking of the bridge footings has not occurred to a significant level. The channel gradient is slightly steeper beneath the existing crossing, causing a moderate increase in underlying stream velocities. Directly downstream of the crossing, the channel enters a sharp meander bend with evident outer bank erosion and a small, vegetated island adjacent, indicating some level of crossing planimetric misalignment. Outside of the immediate crossing vicinity, the channel banks are relatively stable, and evidence of active erosion is limited.

The proposed structure is consistent with that recently installed at 8th Line north of Sideroad 17, upstream of the subject lands. The 8th Line northern crossing has an open-bottom, precast rigid concrete frame spanning approximately 9.14 m across the West Credit River (Erin Branch). Modular block retaining walls extend from the frame along the road margins. The underlying channel banks are reinforced with 750 mm keystones overlain with 200-500 mm smooth run stone to prevent scour. The existing channel bed elevation and channel width were retained in the final construction.

As the average bankfull channel width at the proposed crossing location is 6.94 m, the crossing span will not be required to extend to three times the bankfull width. A crossing span consistent with the 8th Line crossing north of Sideroad 17 (i.e. >9.14 m) is appropriate in regards to maintaining existing channel form and function. The channel bed at the crossing location is predominantly comprised of sand and silt, indicating a relatively 'active' system where sediment transport is common. Thus, an open bottom crossing is recommended as to not inhibit sediment transport and to preserve the underlying sediment supply. Appropriately sized natural stone can be introduced to prevent scouring, where necessary.

The recommendations provided here are based on an assessment of fluvial geomorphological considerations only. We note that the proposed crossing should also be reviewed in the context of local ecological and hydraulic constraints.

7 Summary

GEO Morphix was retained to complete an erosion mitigation assessment in support of future developments for the property located southwest of the intersection of Sideroad 17 and 8th Line in the Town of Erin, Ontario. Our assessment included a review of previously completed reports and secondary source information, an examination of site history using historical aerial imagery, reconnaissance-level field assessments to characterize the system and identify erosion-sensitive locations, and an erosion threshold and mitigation assessment based on the detailed geomorphological field assessment completed in October 2021.

Reach **WC-1** was delineated along the section of the Credit River Tributary (West Credit River – Erin Branch) that traversed the subject lands. The site history assessment was completed using a series of historical images ranging from 1930 to 2021. Land use change within and upstream of the subject lands has been relatively limited throughout the period of available record. No significant changes in channel planform were noted for reach **WC-1** during this period.

From the reconnaissance-level field assessments, the reach was determined to be relatively stable, as evidenced by the lack of any significant active erosion and the RGA score of 24. No erosion concerns were noted at either of the bounding bridge crossings. Stream health and aquatic habitat conditions were documented and assigned a relatively high RSAT score of 31, indicating "Good" conditions.

The purpose of the erosion threshold analysis was to provide an appropriate critical discharge (the theoretical discharge at which the bed or bank materials will become entrained) to support the sizing and release rate planning procedures associated with the proposed SWM facilities. An erosion threshold was determined from the detailed field observations. Based on a critical velocity of 0.46 m/s for the sandy bed material, the resulting erosion threshold was expressed as a critical discharge of 1.41 m^3/s. Maintaining a post-development flow regime that exceeds this threshold discharge at similar frequencies and magnitudes to the existing conditions will help preserve the function and stability of the receiving watercourse. Considering the non-sensitive nature of the channel and the small development footprint relative to the reach **WC-1**'s drainage area, potential excess erosion is expected to be sufficiently mitigated by working towards the proposed 5 mm on-site retention target. We therefore support the proposed SWM strategy, as the assimilative capacity of the receiving channel is adequate given the expected hydrological impacts of the development.

As part of the proposed external works proposed for the development, the existing bridge crossing on 8th line is to be replaced. The existing structure is undersized relative to the underlying channel dimensions and displays evidence of planimetric misalignment. We expect these issues relating to fluvial geomorphology to be adequately addressed by the proposed replacement structure, which is described in Section 6 and is consistent with the crossing recently installed at 8th Line north of Sideroad 17.

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

Respectfully submitted,

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Director, Principal Geomorphologist

John Tweedie, M.Sc.
Environmental Scientist

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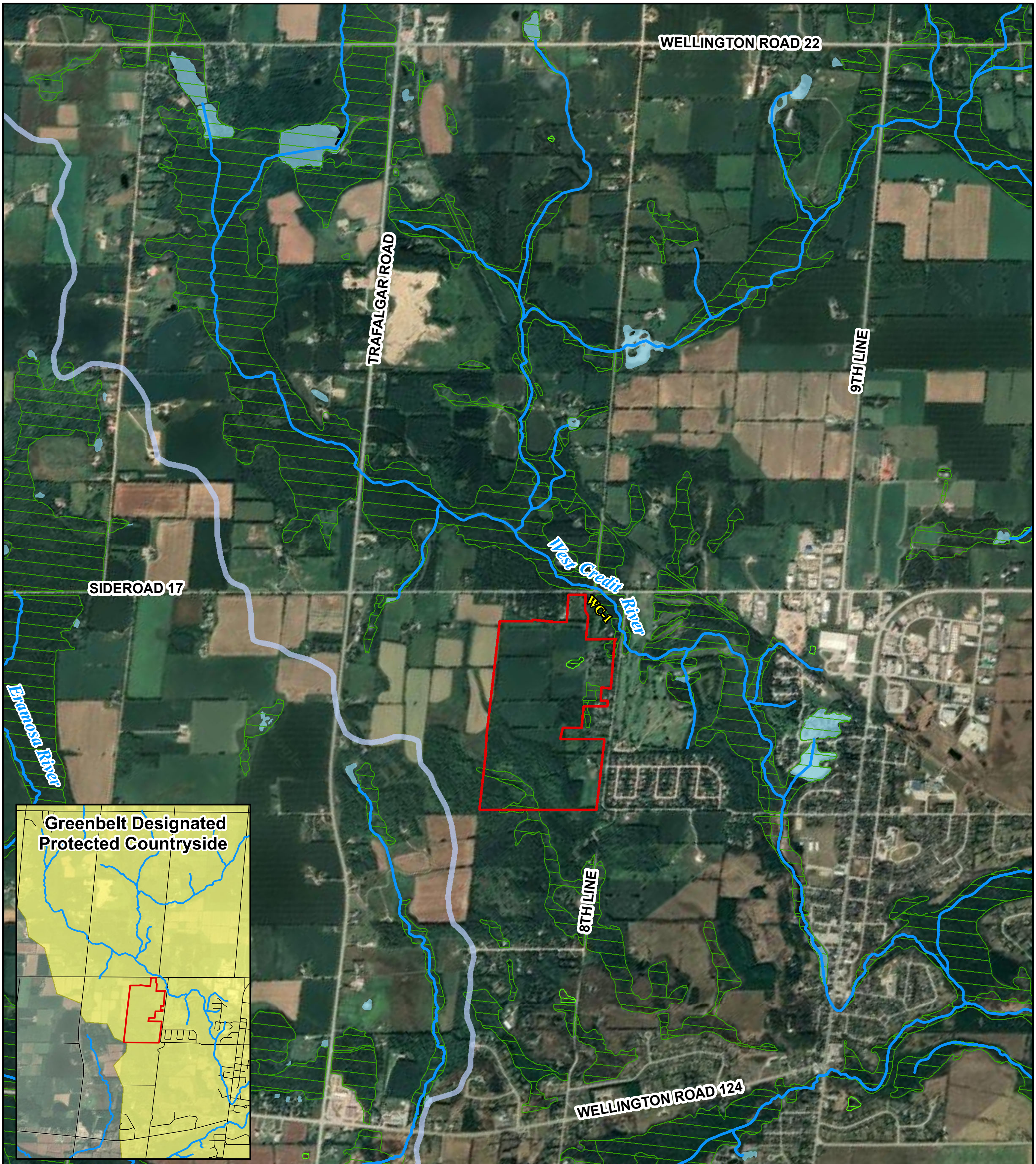
Appendix A
Study Area Mapping



Legend

- Watercourse
- Waterbody
- Unevaluated Wetland (2019 Dataset)
- Provincially Significant Wetland (2019 Dataset)
- Quaternary Watershed Boundary
- Subject Property

Mattamy Homes Geomorphology Study

Subject Property and Surrounding Area

Town of Erin, Ontario

GEO MORPHIX™

0 250 500
Metres

Imagery: Google Earth Pro, 2018.
Subject Property: DSEL, 2021.
Watercourse, Waterbody, Greenbelt Designated Area, and Watershed Boundary: MNRF, 2021.
Wetlands: MNRF, 2019.
Printed: June 2021. PN21060. Drawn by M.H., S.S.

Legend

- Reach Break and Label
- Detailed Assessment
- Watercourse
- 1 m Contour
- Provincially Significant Wetland (2019 Dataset)
- Subject Property

Mattamy Homes

Reach Delineation and Rapid Assessment

Town of Erin, Ontario

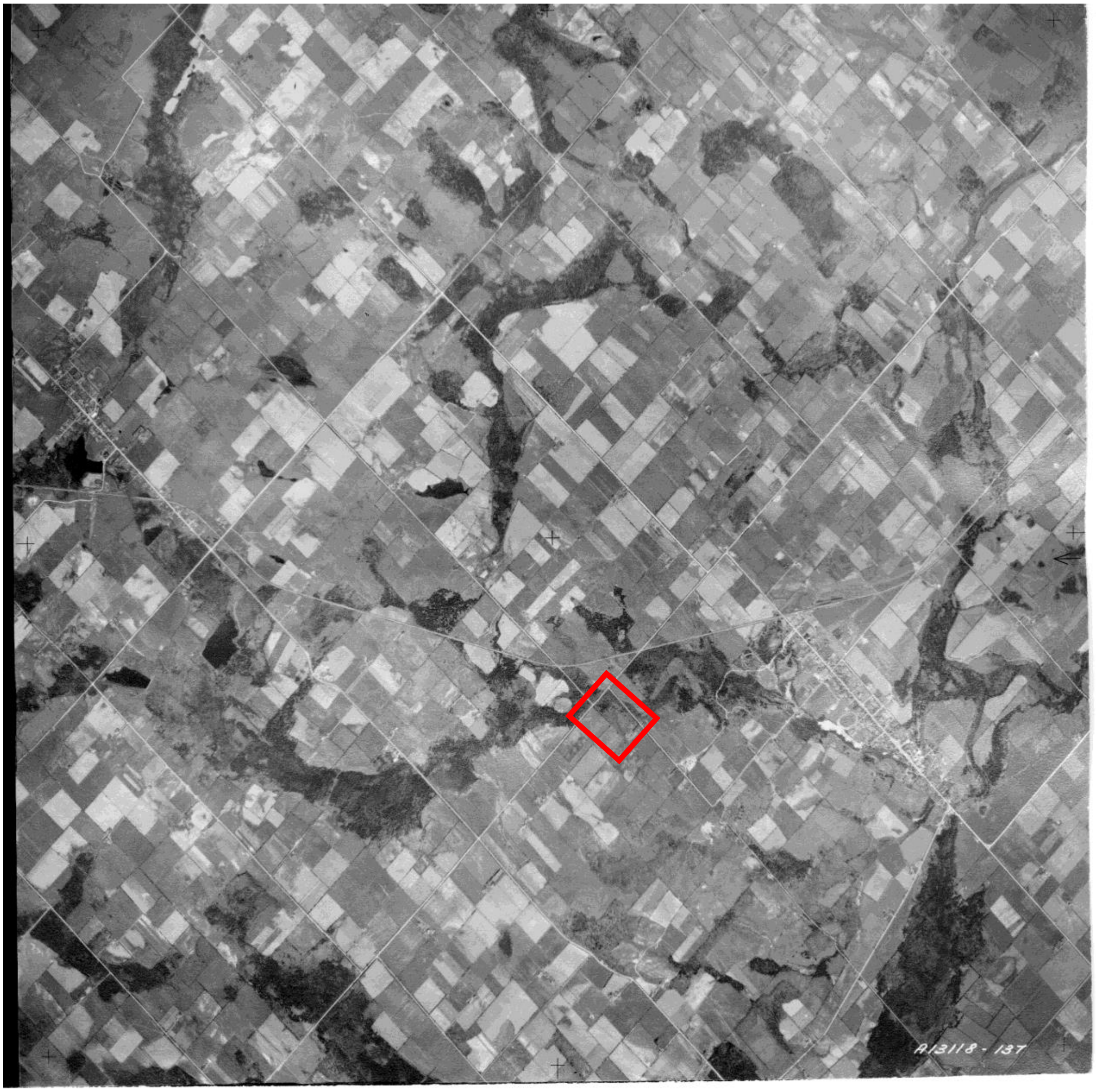
GEO MORPHIX™

0 20 40
Metres

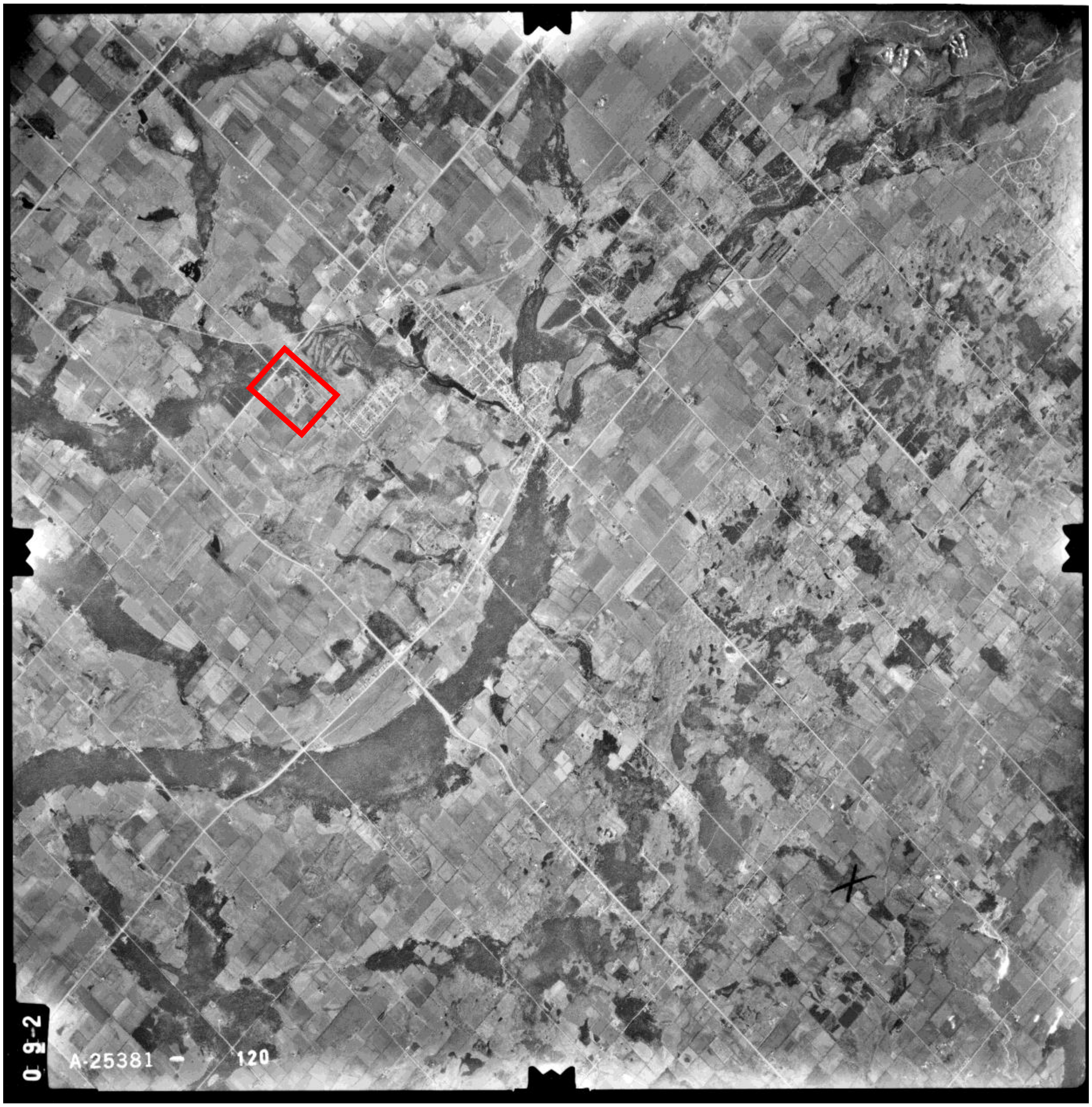
Imagery: Google, 2021.
Subject Property: DSEL, 2021.
Watercourse, Wetlands: MNRF, 2021/2019.
1 m Contour: MNRF, 2017.
Reach Break and Label, Detailed Assessment: GEO Morphix Ltd., 2022.
Printed: June 2022. PN21060. Drawn by M.O., J.T.

Appendix B
Historical Aerial Photographs

Location: Sideroad 17 and 8th Line, Erin, ON
Year: 1930
Source: National Air Photo Library



Location: Sideroad 17 and 8th Line, Erin, ON
Year: 1951
Source: National Air Photo Library



Location: Sideroad 17 and 8th Line, Erin, ON
Year: 1980
Source: National Air Photo Library

Location: Sideroad 17 and 8th Line, Erin, ON
Year: 1990
Source: National Air Photo Library

Location: Sideroad 17 and 8th Line, Erin, ON
Year: 2004
Source: Google Earth

Location: Sideroad 17 and 8th Line, Erin, ON
Year: 2016
Source: Google Earth

Location: Sideroad 17 and 8th Line, Erin, ON
Year: 2021
Source: Google Earth

Appendix C
Photographic Record

Photo 1 Reach **TCR-1**	
	Photo taken facing upstream at the 8th Line bridge crossing. The yellow arrow denotes flow direction.
Photo 2 Reach **TCR-1**	
	Despite the wetted width of the channel extending to both footings, no significant evidence of instability was observed for the 8th Line bridge crossing.

Photo 3 Reach **TCR-1**	
	Directly upstream of the 8th Line bridge is a slow-flowing run feature. The right banks contain thick, stabilizing vegetation whereas the left bank contains mostly grasses.
Photo 4 Reach **TCR-1**	
	Large, deep scour pools are common throughout the reach, and are often associated with woody debris structures.

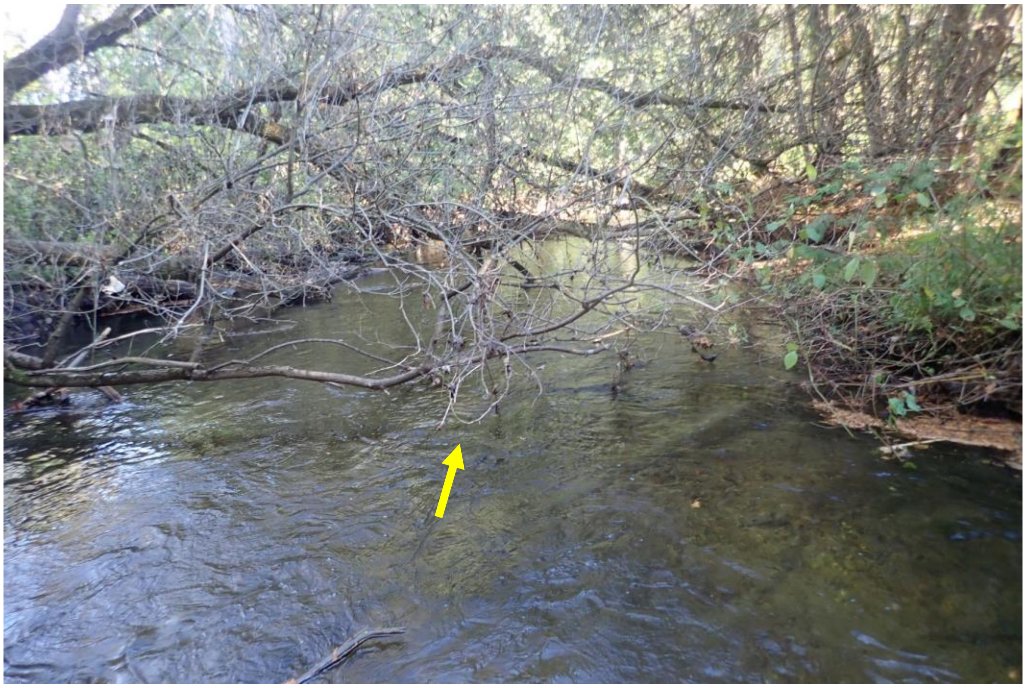
Photo 5 Reach **TCR-1**	
	Shallow, run-type sections with rippled flow are intermittent throughout the reach.
Photo 6 Reach **TCR-1**	
	Overhanging mature trees, large woody debris, and exposed roots are common.

Photo 7 Reach **TCR-1**	
	Exposed roots were predominantly from mature trees. Minor bank undercutting was observed in several locations.
Photo 8 Reach **TCR-1**	
	The channel substrate is predominantly sand and silt.

Photo 9 Reach **TCR-1**	
	A small beaver damn was observed in the upstream portion of the reach.
Photo 10 Reach **TCR-1**	
	The 17th Sideroad crossing defines the upstream extent of Reach **TCR-1**.

Appendix D
Field Observations

GEO | MORPHIX
Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: 21060

Date:	2021-10-18	**Stream/Reach:**	Credit River
Weather:	Sunny 12°C	**Location:**	17th Sideroad & 8th Line
Field Staff:	JV JT	**Watershed/Subwatershed:**	Credit River

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

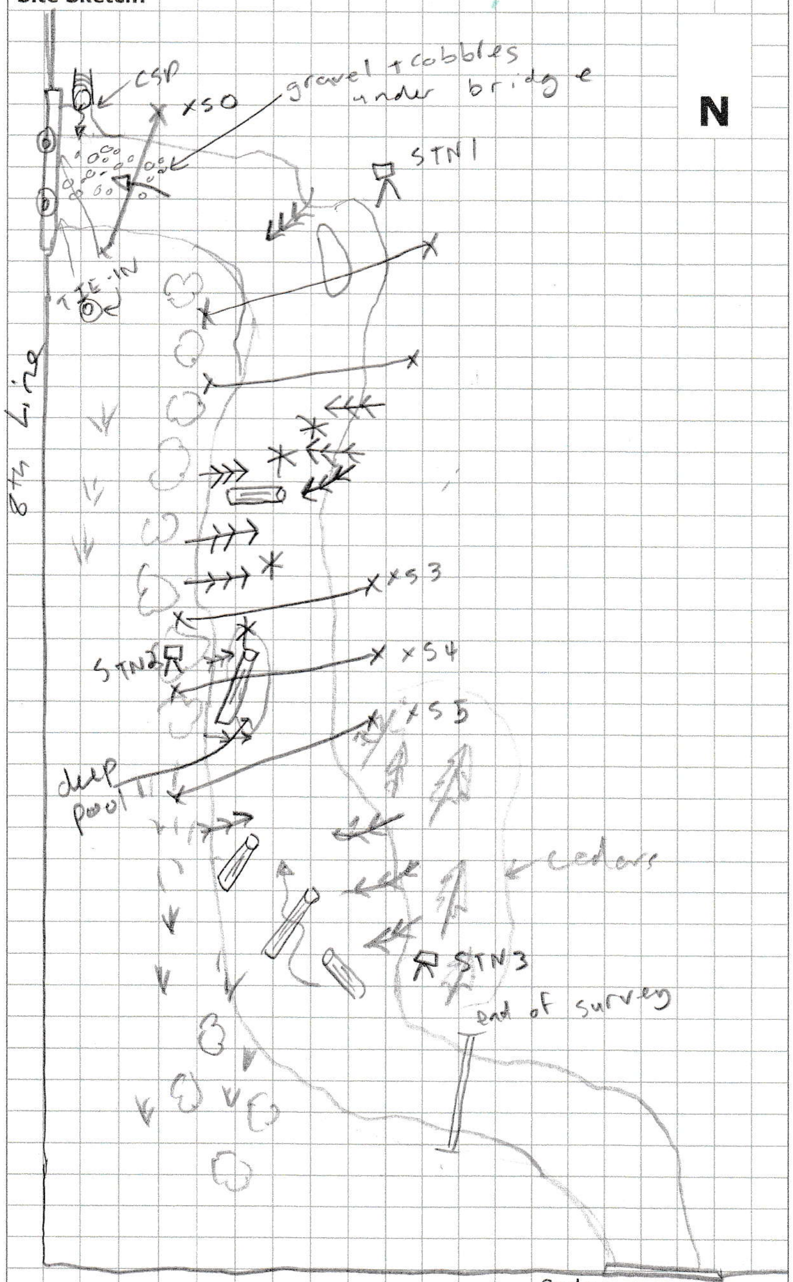
Substrate

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:



Scale:

Additional Notes: - sand bed
- silty banks with trace sand/clay

Completed by: ________ Checked by: ________

GEO | MORPHIX
Geomorphology
Earth Science
Observations

Reach Characteristics

Project Code/Phase: PN 21060

Date:	2021-10-18	**Stream/Reach:**	ECR1
Weather:	Sunny 12°C	**Location:**	17th Sideroad & 8th Line
Field staff:	JV JT	**Watershed/Subwatershed:**	Credit River
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: ____________

Riparian Vegetation

Dominant Type: (Table 6) 1/2

Species: eastern cedar, tamarack, spruce, red osier, speckled, buckthorn, alder

Coverage:
- ☐ None
- ☐ Fragmented
- ☒ Continuous

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

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

Encroachment: (Table 7) 3

Aquatic/Instream Vegetation

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

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

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

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9): 2 | **Sinuosity (Degree)** (Table 10): 2 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): 1/2 | **Downs's Classification** (Table 15): 5

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

Bankfull Width (m): see detailed data
Bankfull Depth (m): see detailed data
Wetted Width (m): see detailed data
Wetted Depth (m): see detailed data

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

Pool Depth (m): | **Riffle Length (m)**: | **Undercuts (m)**: 0.05, 0.18

Velocity (m/s): 0.294 | 0.287 | 0.180 | Wiffle ball / ADV / Estimated

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

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

Comments: - Scour associated with LWD in channel

Notes: - Sandy bed
- low gradient, slow velocity
- little ongoing erosion

- only coarse substate observed adjacent to brigde
  → likely not naturally occurring

Completed by: __________ Checked by: __________

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: PN 21060

Date:	2021-10-18	**Stream/Reach:**	ECR1
Weather:	Sunny 12°C	**Location:**	17th Sideroad & 8th Line
Field Staff:	JV JT	**Watershed/Subwatershed:**	Credit River

Process	No.	Geomorphic Indicator Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	3/7
	2	Coarse materials in riffles embedded		X	
	3	Siltation in pools	X		
	4	Medial bars	X		
	5	Accretion on point bars		X	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone	X		
		Sum of indices =	3	4	0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		X	0
	2	Exposed sanitary / storm sewer / pipeline / etc.	—	—	
	3	Elevated storm sewer outfall(s)	—	—	
	4	Undermined gabion baskets / concrete aprons / etc.		X	
	5	Scour pools downstream of culverts / storm sewer outlets	—	—	
	6	Cut face on bar forms		X	
	7	Head cutting due to knick point migration		X	
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		3/8
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle		X	
	6	Outflanked gabion baskets / concrete walls / etc.		X	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		—	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation		—	
		Sum of indices =	3	5	0.38
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	1/7
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		X	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)	X		
	6	Thalweg alignment out of phase with meander form		X	
	7	Bar forms poorly formed / reworked / removed		X	
		Sum of indices =	1	6	0.14

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =			
Condition	**In Regime**	**In Transition/Stress**	**In Adjustment**
SI score =	☐ **0.00 - 0.20**	☐ **0.21 - 0.40**	☐ **0.41**

Completed by: ________ Checked by: ________

Rapid Stream Assessment Technique **Project Code:** PN 21060

Date:	2021-10-18	**Stream/Reach:**	ECR1
Weather:	Sunny 12°C	**Location:**	17th Sideroad & 8th Line
Field Staff:	JT JV	**Watershed/Subwatershed:**	Credit River

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

Date: 2021-10-18		Reach: ECR1	Project Code: PN 21060
Evaluation Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• 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) = 33	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: ________ Checked by: ________

Appendix E
Detailed Assessment Summary

Detailed Geomorphological Assessment Summary

Reach WC-1

Project Number:	PN21060	**Date:**	2021-10-18
Client:	Mattamy Erin Development	**Length Surveyed (m):**	94.5
Location:	Erin, Ontario	**# of Cross-Sections:**	6

Reach Characteristics

Drainage Area:	3571 ha	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Organic deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forested, residential	**Width of Riparian Cover:**	4-10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Mature
Dominant Instream Vegetation Type:	Rooted Submergent	**Extent of Encroachment into Channel:**	Moderate
Portion of Reach with Vegetation:	<5%	**Density of Woody Debris:**	High

Hydrology

Measured Discharge (m^3/s):	0.38	**Calculated Bankfull Discharge (m^3/s):**	2.12
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.52
Modelled 2-year Velocity (m/s):	Not modelled		

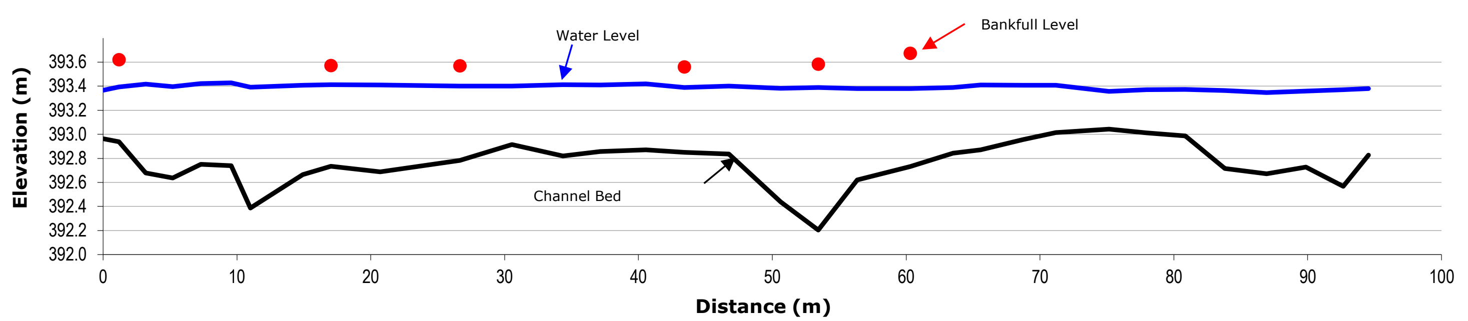
Profile Characteristics

Bankfull Gradient (%):	0.05
Channel Bed Gradient (%):	0.09
Riffle Gradient (%):	2.25
Riffle Length (m):	18.82
Riffle-Pool Spacing (m):	Not Measured

Planform Characteristics

Sinuosity:	1.07
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.63	1.45	0.97
Bank Angle (deg):	60	90	83
Root Depth (m):	0.05	0.20	0.13
Root Density (%):	10	30	18
Bank Undercut (m):	0.05	0.18	0.13

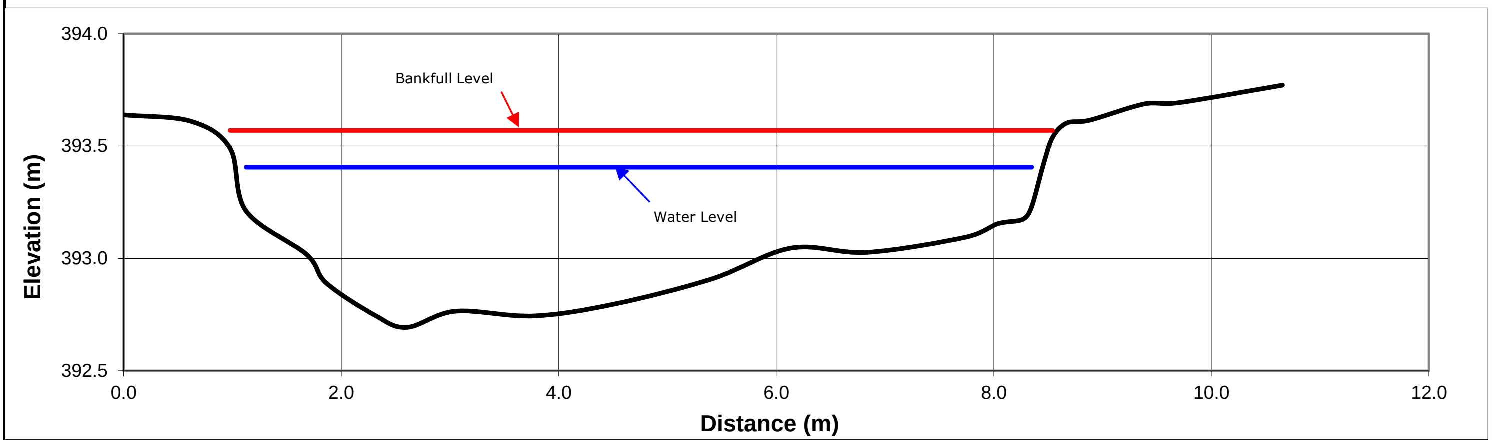
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):			

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	6.05	7.76	6.94
Average Bankfull Depth (m):	0.45	0.80	0.58
Bankfull Width/Depth (m/m):	8	17	12
Wetted Width (m):	5.78	7.22	6.50
Average Water Depth (m):	0.43	0.72	0.50
Wetted Width/Depth (m/m):	8	17	13
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.61	1.31	0.80
Manning's *n*:		0.040	

Photograph at cross section 3 (looking downstream)

Representative Cross-Section #3

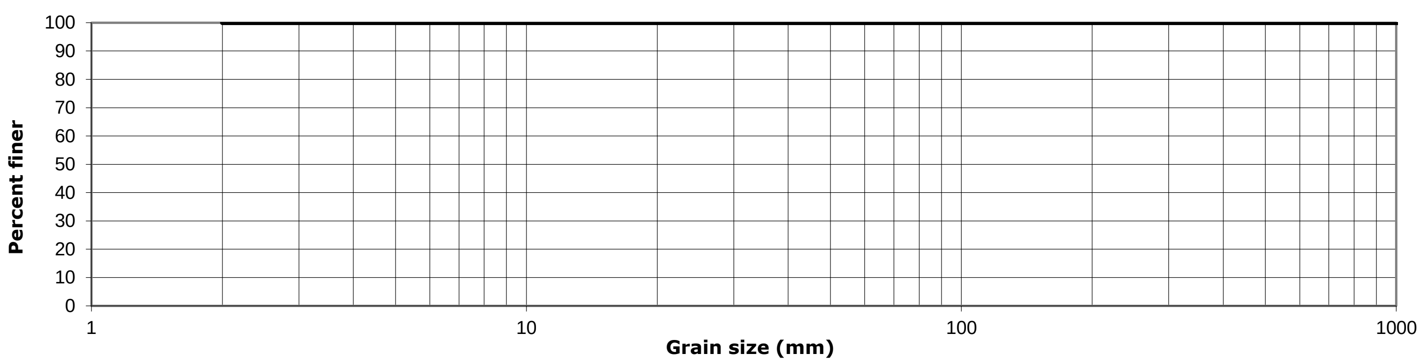


Substrate Characteristics

Particle Size (mm)	
D_{10} :	2.0
D_{50} :	2.0
D_{84} :	2.0

Subpavement:	Sand
Particle shape:	n/a
Embeddedness (%):	n/a
Particle range (riffle):	Sand
Particle Range (pool):	Silt to sand

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	5.15
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.27	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	2.70		

General Field Observations

Channel Description

Reach **TCR-1** is a meandering channel with a low gradient conveying flows within an unconfined valley. The channel's riparian buffer is composed of trees and shrubs, with moderate encroachment along the margins of the bankfull channel. The reach has fairly defined riffle-pool sequences with several instances of deep, slow-velocity pools. The bed substrate is primarily composed of sand with isolated pockets of loose silt deposits. Gravel and cobbles were observed within the channel adjacent to the bridge crossing. The average width of the bankfull channel is 6.94 m, and the average maximum bankfull depth is 0.98 m. On the day of the assessment the average wetted width was 6.50 m and the average wetted depth was 0.44 m.

Cross Section 4 - Facing Upstream