Tributary of Fletcher's Creek Fluvial Geomorphological Assessment

DeZen Lands Development

7140 Hurontario Street, Mississauga

Prepared for:
DeZen Realty
128 Queen Street South
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1 Introduction

GEO Morphix Ltd. was retained to provide a geomorphological assessment for the proposed DeZen Lands Development located at 7140 Hurontario Street in the City of Mississauga, Ontario. Two watercourses are located within or adjacent to the subject lands, Fletcher's Creek and a small tributary of Fletcher's hereafter referred to as Tributary 1. The geomorphological assessment provides guidance in addressing and delineating erosion hazards and supporting erosion mitigation strategies for the stormwater management plan.

To fulfill erosion hazard delineation requirements, a toe erosion allowance was determined to support the slope stability assessment completed by Soil Engineers Ltd for Fletcher's Creek and Tributary 1. A short section of channel within Tributary 1 was identified as being unconfined as such, a meander belt width was also calculated for this reach. The meander belt width previously delineated for Fletchers Creek by Parish (2011) was also reviewed and further refined.

To support erosion mitigation, a crossing assessment and conceptual outfall design has been completed and integrated into this report. The location of the proposed outfall and crossing location were assessed in the field to support the assessment and conceptual design, respectively.

The following activities were completed as part of the geomorphological assessment in support of the development plan:

- Background review of reports and mapping for the subject lands (i.e., watershed/subwatershed studies, geology, topography, conceptual development plans, past environmental reports)
- Delineate watercourse reaches based on a desktop assessment of available data and confirmed through field reconnaissance
- Review of historical and recent aerial photographs to assess alterations in channel planform and location of the toe of slope over time
- Reach-level rapid geomorphological field assessments following standard protocols (e.g., RGA, RSAT) to evaluate instream and riparian conditions, and overall stability of the channel
- Delineate or refine limits of the meander belt width/erosion hazard on a reach basis using results of the desktop and field assessments
- A detailed geomorphic assessment including a longitudinal survey of the channel center line, 8 channel cross-section surveys, and Wolman pebble counts to determine grain size and material type for channel bed and banks
- Provide technical input and recommendations for the watercourse crossing. This includes input on watercourse crossing size and location as well as any setback limits in support of erosion mitigation
- Provide technical support for the assessment of any outlet locations to assess local erosion
- Provide support in development of a conceptual outfall design

2 Background Review

The subject lands are situated within the Fletchers Creek Subwatershed of the overall Credit River Watershed. The Fletchers Creek and associated tributary are present within or adjacent to the subject lands. Land use within the watershed is dominated by approximately 35% of natural land cover, 31% urban land cover, and 34 % agricultural and open space. The natural areas include forests, wetlands, meadows, and riparian areas (Credit Valley Conservation). The subject lands are generally comprised of agricultural lands with Tributary 1 flowing south through the subject lands and Fletchers Creek flowing in a southern direction south of the site. Fletchers Creek is also noted as occupied Redside dace habitat.

2.1 Background Reports

A detailed review of the documents below was conducted to understand relevant information associated with the watercourses for current or future assessments. The studies provide insight into past historical information, rapid assessment information and overall erosion potential information.

- DRAFT DeZen: Fletchers Creek Hazard Assessment – Parish Geomorphic (2011)

An erosion hazard assessment was completed to support the study area which consisted of background review, desktop assessment, rapid assessments, meander belt width delineation, and channel migration analysis for Fletchers Creek and its tributary. Reaches were assessed through field verified rapid assessments completed using RGA and RSAT tools and all reaches were reported to be in transition with the dominant process of widening.

A preliminary meander belt width was delineated along Reaches **FC-1, FC-2, FC-3, FCT-1**, and **FCT-2** (Tributary) using the Leopold and Wolman Method (1960). The method involves measuring the widest meander amplitudes along the reach to determine the meander belt width. Empirically modelling was also completed to estimate the meander belt widths including Williams (1986), Ward (2002), PARISH Geomorphic Ltd. (2004a) and Annable (1996). Ultimately, the meander belt widths determined by the Leopold & Wolman method was determined to be the most appropriate. An erosion analysis and channel migration rate was also completed along the main branch which studied rates at which the channel is migrating over time through historical aerial photograph review. The tributary was densely vegetated and as such, migration rates were not calculated. The 100-year erosion migration rate was determined to be 8 metres. Ultimately, the erosion hazard was determined by the meander belt width due to the inherent error in the migration rate measurements, field observations, and as a conservative approach given the meander belt width was equal to or slightly higher than the estimated 100-year erosion rate.

The results of the erosion hazard assessment are summarized as follows:

Table 1: Erosion Hazard Assessment results (Parish, 2011)

Reach Names	Preliminary Meander Belt Widths*	Erosion Migration Rate (m per 100 yrs)
FC-1	72	8
FC-2	108	8
FC-3	120	8
Tributary (FCT-1 & FCT-2)	22	n/a

**Including a FOS of 20%*

- Detailed Geomorphic Assessment – Fletchers Creek – Geomorphic Solutions (2012)

A detailed geomorphic survey was completed along a portion of Fletchers Creek downstream of the tributary in support of Redside Dace habitat delineation. The detailed geomorphic survey extended 278 m downstream of the tributary confluence with an average bankfull width and depth of 8.5 m and 0.7 m respectively. This assessment supported the assessment that the tributary is not contributing Redside Dace habitat as the average bankfull width downstream of the tributary confluence are more 7.5 m wide as discussed in the EIS (GEI, 2025).

- Environmental Impact Study (EIS) – 7140 Hurontario Street, Mississauga – GEI Consultants Canada Ltd. (February, 2025)

An EIS was completed and submitted as part of the resubmission for the draft plan of subdivision and zoning by-law amendment. The study was comprised of existing condition characterization of the natural environmental features, constraint delineation, identification of potential impacts of the development, and mitigation recommendations with the input of multiple disciplines and consultants.

With respect to fluvial geomorphology, the erosion hazard was one component of the constraint mapping which was based on the meander belt width previously delineated by Parish (2011) and the toe erosion

allowance recommended by GEO Morphix Ltd as discussed in **Section 4.2**. The classification of Redside Dace habitat was also discussed within EIS as previously noted.

- Functional Servicing Report (FSR) – 7140 Hurontario Street, Mississauga – Skira and Consultants Ltd. (February, 2025)

An FSR was completed and submitted as part of the resubmission for the draft plan of subdivision and zoning by-law amendment. The study was comprised of existing site condition characterization, grading plans, stormwater management plan, servicing requirements, and erosion and sediment controls.

The site will be developed in two Phases with the lands east of the tributary developed in Phase 1 and the lands west of the tributary will be developed in Phase 2. The Tributary to Fletchers Creek will continue to receive flows from approximately 12 ha of drainage area north of the subject lands in the post development scenarios. In Phase 1, flows will be conveyed to the existing storm sewer on Vicksburg Drive, which discharges to SWM Pond 4402B. In Phase 2 flows will generally be piped and conveyed to an outfall to the main branch of Fletchers Creek. A treatment train approach will be utilized to retain the first 5 mm of rainfall and for quality control.

- Geotechnical Investigation for Slope Stability Study – Soil Engineers Ltd. (2008)

  Supplementary Slope Stability Study Letter Report – Soil Engineers Ltd. (2016)

  Supplementary Slope Stability Study Letter Report – Soil Engineers Ltd. (2020)

A slope stability assessment was completed in 2008 and subsequently updated in 2016 and 2020 after receiving comments from agencies. The initial assessment provided characterization of the subsurface conditions and groundwater conditions, and slope stability analysis. It was determined that the site was generally comprised of silty clay till soils with a localized layer of very dense sandy silt till in the areas of the Fletchers Creek Tributary (BH1 and BH2). All boreholes remained dry upon completion of the investigation and the groundwater regime was inferred to lie in the grey saturated soils. A long-term stable slope was delineated which incorporated a 5 m development setback and an 8 m toe erosion setback.

In 2016, the cross sections were updated to reflect an updated topographic survey. In 2020, the tributary to Fletchers Creek was also added to the slope study. Additionally, the long-term stable slope was updated to incorporate the recommended toe erosion setbacks and meander belt widths determined by GEO Morphix Ltd. as discussed in **Section 4**.

2.2 Surficial Geology

Channel morphology and planform are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. Physiography, riparian vegetation, and land use also physically influence the channel. These factors provide insight into existing conditions and the potential future changes as they relate to a proposed activity.

Local surficial geology along the Tributary to Fletcher's Creek is fine-textured till composed of silt and clay derived from glaciolacustrine deposits (OGS, 2010). The study area is located within the Peel Plain physiographic region, a bevelled till plain which is characterized by gently undulating to rolling topography with layers of thick till deposits on bedrock (Chapman and Putnam, 1984). Understanding the surficial geology of the study area is important for determining the toe erosion allowance and assessing the erosion hazard, as stability of the channel banks and valley slope is dependent on soil composition and structure (MNRF, 2001).

2.3 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use/cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. For this exercise, the 1954, 1977 and 1989 photographs were retrieved from the National Air Photo Library, and the 2002, 2018, 2023 images were

retrieved from Google Earth Pro. Cropped aerial photographs, showing Fletcher's Creek, Tributary 1 and surrounding area are provided in **Appendix B**.

In 1954 land use within the vicinity of Fletcher's Creek and Tributary 1 was almost exclusively agricultural. A riparian buffer for the tributary was absent, while adjacent to Fletcher's Creek some patches of mature trees particularly along the west side of the channel within the valley were noted. Tributary 1 was observed to originate at a small agricultural pond located on the north side of an east-west road which transects the subject property. The tributary appears to have been straightened until reaching the valley corridor, at which point the channel follows the south westerly valley trend before forming a confluence with Fletcher's Creek. The planform of Fletcher's Creek nearby to the subject site is best described as irregular meanders within a confined valley. Nearby to the confluence of Tributary 1 with Fletcher's Creek, on the opposite bank, a cut-off channel can be observed, possible evidence of planform adjustments.

In 1977 land use nearby to the subject site has remained predominantly agricultural, with the exception of the lands south of Fletcher's Creek opposite to Tributary 1 which is now occupied by a golf course. The construction of the golf course included the removal of the cut off channel noted in the 1955 aerial photograph. The only significant change related to Tributary 1 is the removal of the east-west road noted to transect previously noted to cross the tributary.

The 1989 aerial photo indicates minimal changes to land use nearby to the subject site, although it is known that lands upstream in the Fletcher's Creek catchment have become significantly urbanized by this time. For Tributary 1, the watercourse appears to be recovering from previous channelization to have a small degree of sinuosity upstream of the confined segment. Within the confined segment, the channel has maintained its irregular meanders and more woody vegetation has become established. For the mainstem of Fletcher's Creek, a meander previously located upstream of the eastward valley trend turn is no longer present. As well, a historic channel is apparent north of the first meander bend located where Fletcher's Creek conveys flow eastward towards the tributary.

By 2002 land use in the vicinity of the DeZen Property has shifted to predominantly residential and commercial, although the property itself and the adjacent lands have remained agricultural. both channels, the presence of woody riparian vegetation has increased. The only notable change to Tributary 1 is that the pond located at the upstream extent no longer holds standing water but rather exists as a wetland feature.

In 2018 the trend towards residential and commercial development has persisted, with construction of commercial properties on the west side of Hurontario and the west side of Fletcher's Creek. Riparian conditions along both channels have continued to establish, with a dense canopy now apparent within the confined section of the tributary, and a significant quantity of mature trees within the corridor of the mainstem of Fletcher's Creek. For both channels, no planform changes were apparent.

Between 2018 and 2023, the subject lands east of Tributary 1 undergo some industrial development as well. Changes along Tributary 1 and Fletcher's Creek were not observed.

3 Watercourse Characteristics

3.1 Reach Delineation

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

Reaches are delineated based on changes in the following:

- Channel planform

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

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004) as well as others.

Reaches on and adjacent to the subject lands were delineated by a desktop exercise and were subsequently verified in the field. Reach **FC-2** was delineated along the main branch of Fletchers Creek and Reaches **FCT-1, FCT-2,** and **FCT-3** were delineated along the Fletcher's Creek tributary (Tributary 1) based on changes in gradient, land use, land cover, geology, and various flow or tributary inputs. Our reach delineation is graphically presented in **Appendix A.**

The upstream extent of Reach **FCT-1** was located at the northern edge of the forest patch within the subject property between two agricultural fields. The reach conveyed flow south for approximately 200 m towards Fletcher's Creek. Reach **FCT-1** was defined by deciduous trees in the riparian zone and valley confinement on both sides of the creek. Upstream of the forest patch, Reach **FCT-2** was a short, poorly defined channel which conveyed flows southwards through the vegetated corridor separating the two agricultural fields, upstream of Reach **FCT-1**. The channel was partially confined and generally had herbaceous vegetation and grasses occupying the riparian buffer. Reach **FCT1-3** was an undefined feature which conveyed flows from the old farm pond location to the top of **FCT-2**.

3.2 General Reach Observations

Field investigations were completed on November 1, 2018, and updated on July 18, 2025, and included the following reach-by-reach observations:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

These observations and measurements are summarized below. The descriptions are supplemented and supported with representative photographs, which are included in **Appendix C**. Field sheets, including reach summaries and rapid assessments, are provided in **Appendix D**.

Reach **FC-2** is a meandering channel within a well-defined confined valley system. The channel has a wide continuous riparian buffer zone consisting of predominately deciduous trees. The average bankfull width and depth were 8.04 m and 1.01 m, respectively. Erosion was observed throughout the reach with some areas of valley wall contact and with undercuts measured up to 0.86 m. Bed materials ranged from gravel to boulders in riffles, and clay, silt to cobbles in pools. A range of bank materials were observed due to the presence of a suspended armour layer. A high density of woody debris was also observed.

Reach **FCT-1** is a mixed-load sinuous channel with a steep gradient that occupies a confined valley. The channel was well defined but appeared to be slightly more incised in the upstream portion. The channel has a continuous riparian buffer zone that contained predominately deciduous trees with some encroached by vegetation. The average bankfull width and depth in Reach **FCT-1** were 1.21 m and 0.30 m. Erosion was noted along this reach with undercuts measured being up to 0.45 m. Bed and bank materials fairly uniform ranging from clay/silt to cobbles in riffles and in pools.

Reach **FCT-2** was a partially confined, sinuous channel with a continuous riparian buffer similar to the downstream extent. It was noted that the channel definition was observed to decrease further upstream.

The channel had no riffle-pool sequence, a moderate gradient and bed and bank material which was homogeneously composed of a range of materials from clay to cobbles. The channel was moderately encroached by riparian vegetation, and lots of woody debris was observed. Average bankfull width and depth for the reach were 1.06 m, and 0.19 m, respectively. Bank angles ranged from 30-90 degrees, and shallow undercuts were observed up to 0.14 m deep.

Reach **FCT-3** was a poorly defined feature which was predominately dry throughout. The majority of the channel was heavily encroached with herbaceous vegetation and grasses. Phragmites and cattails were observed in the upstream portion of the feature as well. The feature had no riffle-pool sequence, a low gradient and bed and bank material which was homogeneously composed of a clay-silt, sand, gravel mixture. Generally, the feature was poorly defined however bankfull measurements were collected in the portions that were defined. Average bankfull width and depth for the defined portion were 0.79 m, and 0.12 m, respectively.

3.3 Reconnaissance-level Assessments

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). 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 stressed 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 a modified Downs (1995) Channel Evolution Model and the River Styles Framework (Brierley and Fryirs, 2005). The Downs' 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 (Brierley and Fryirs, 2005) provides a geomorphological approach to examining river character, behaviour, condition, and recovery potential.

Reach **FC-2** was identified as primarily widening according to the RGA, as evidenced by the occurrence of fallen and leaning trees, large organic debris, exposed tree roots, and basal scour throughout more than 50% of the reach. Overall, the reach was assigned a stability index of 0.34 and classified as "in transition". The RSAT resulted in a *Good* ranking with a score of 27, with the limiting factor being channel stability, as evidenced by the frequently observed bank erosion also noted by the RGA. Using Downs' Model of Channel Evolution, the channel was determined to be U – undercutting, as evidenced by erosion and undercutting along the banks.

Reach **FCT-1** was identified as primarily widening with some degradation according to the RGA, as evidenced by the fallen and leaning trees, exposed tree roots, and suspended armour layer. Overall, the reach was assigned a stability index of 0.37 and classified as "in transition". The RSAT resulted in a *good* ranking with a score of 27, with the limiting factor being physical instream habitat and channel stability, as evidenced by the lack of diverse geomorphological units and bank erosion also noted by the RGA. Using Downs' Model of Channel Evolution, the channel was determined to be e - Enlarging, as evidenced by erosion along both banks and a scoured bed.

Reach **FCT-2** was identified by the RGA as being "In transition", with the score of 0.21, with the primary process being degradation and widening. This was evidenced by the suspended armour layer and leaning and fallen trees, and exposed roots. The RSAT resulted in a *fair* ranking with a score of 21, with the

limiting factor being physical instream habitat, as evidenced by the lack of diverse geomorphological units. Using Downs' Model of Channel Evolution, the channel was determined to be e - Enlarging, as evidenced by erosion along both banks.

Reach **FCT-3** was generally described as a poorly defined swale that vegetation controlled throughout the reach. As such, the RGA and RSAT tools are not applicable. According to Downs' model of Channel Evolution, the reach was classified as stable given there were almost no observations of ongoing geomorphic change.

3.4 Detailed Geomorphological Assessment

A detailed geomorphic assessment was completed within the downstream section of Reach **FCT-1**. The survey was completed on November 1, 2018. Activities completed for the detailed assessment included the following:

- Longitudinal profile of the channel bed to determine slope
- Eight representative cross-sectional surveys of the watercourse to determine average channel dimensions
- Detailed instream measurements at each cross-section including bankfull channel geometry, riparian conditions, bank materials, bank height/angle, and bank root density
- Bed material sampling at each cross-section
- Monumented geo-referenced photographs taken at each cross-section

The results of the detailed assessments are provided in **Table 2**, and a summary is included in **Appendix E**.

Table 2: Detailed geomorphic assessment results

Channel parameter	
Measured	
Average bankfull channel width (m)	2.25
Average bankfull channel depth (m)	0.50
Channel bed gradient (%)	2.55
D_{50} (mm)	3.2
D_{84} (mm)	15.0
Manning's n roughness coefficient	0.040
Computed	
Bankfull discharge (m^3/s)	3.29
Average bankfull velocity (m/s)	2.89
Unit stream power at bankfull (W/m^2)	474.20
Tractive force at bankfull (N/m^2)	164.37

4 Erosion Hazard Assessment

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width or erosion hazard assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a watercourse.

When defining the erosion hazard for a watercourse, Ministry of Natural Resources (MNR, 2002) guidelines treat unconfined and confined systems differently. Unconfined systems are those with poorly

defined valleys or slopes well outside where the channel could realistically migrate. Unconfined systems are generally found within glaciated plains with flat or gently rolling topography. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible.

In unconfined systems, at minimum, a meander belt width can be applied based on 20 times the bankfull channel width. Alternatively, the limit of the erosion hazard and migration potential can be delineated based on the meander amplitude through a detailed geomorphological study. Meander amplitude is defined by Leopold et al. (1964) as the lateral distance between tangential lines drawn to the center channel of two successive meander bends. This differs from meander belt, which is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends (TRCA, 2004). Both the meander belt width and amplitude quantify the lateral extent of a river's occupation on the floodplain (TRCA, 2004).

In confined systems, the MNR outlines an approach for establishing the erosion hazard where valley walls confine watercourses. The approach defines a toe erosion allowance or setback where the channel is within 15 m of the toe of slope. There are several ways to define the toe erosion allowance or setback: using an average annual recession rate; applying a generic and minimum 15 m toe erosion allowance in areas where the channel is within 15 m of the slope's toe; or using soil information and field observations of geomorphic processes (MNRF, 2002) for areas where average annual recession rates cannot be determined.

Based on field reconnaissance and desktop information, it was determined that Reach **FCT-2** was partially confined, requiring a meander belt width on the eastern bank. The main branch of Fletchers Creek (Reach **FC-2**) and Tributary 1 (Reach **FCT-1, FCT-2**) flow within a confined or partially valley systems requiring a toe erosion allowance to address the erosion hazard. Despite being a confined valley system, a meander belt width was also delineated for Reach **FC-2** to support Redside Dace habitat delineation.

4.1 Meander Belt Width Delineation

A review of recent and historical aerial imagery was completed but due to the low resolution and a densely vegetated riparian corridor, the watercourse in Reach **FCT-2** was not traceable for historical overlay analysis. As such, a suite of empirical equations was therefore used to delineate existing condition meander belt widths.

Meander belt widths were calculated using several empirical models for comparison purposes. The bankfull channel dimensions observed during field reconnaissance were used to inform both the Williams (1986) and Ward (2002) models outlined below.

The empirical relations from Williams (1986) were modified to include channel width, and applied using the bankfull channel dimensions such that:

$$B_w = 18A^{0.65} + W_b \quad \text{[Eq. 1]}$$

$$B_w = 4.3{W_b}^{1.12} + W_b \quad \text{[Eq. 2]}$$

where *Bw* is meander belt width (m), *A* is bankfull cross-sectional area (m^2), and W_b is bankfull channel width (m). An additional 20% buffer, or factor of safety, was applied to the computed belt width values. This addresses issues of under prediction.

The Ward et al. (2002) bankfull width model was also used to determine a meander belt width (ft), *Bw*:

$$B_w = 6{W_b}^{1.12} \quad \text{[Eq. 3]}$$

The resulting value was then converted to the metric system (m). An additional 20% buffer, or factor of safety, was applied to the computed belt width values.

Empirical modelling results are summarized in **Table 3,** below. The extents of all meander belt widths are illustrated in **Appendix A**. For **Reach FCT-2** the calculated meander belt widths range from 5 m to 10 m. The meander belt width of **10 m** was recommended for **Reach FCT-2** based on values determined

using the William Area model which includes a 20% factor of safety (FOS). The value is considered conservative given the recommended meander belt width is slightly larger than the modelled meander belt widths. Additionally, there is limited erosion potential along this reach, particularly given the feature has predominantly clay bed and banks mixed with coarse material due to a suspended armour layer present.

GEO Morphix Ltd. also reviewed and refined the meander belt width previously delineated by Parish (2011) to support the Redside Dace habitat delineation. Based on their assessment a meander belt width of **108 m** was delineated along Reach **FC-2** which was adjacent to the development. The meander belt width was defined by 90 m and an erosion setback of 9 m on each side. This meander belt width was delineated based on Leopold et al. (1964) method which measure the largest meander amplitudes. GEO Morphix Ltd. updated the meander belt width to be truncated along the delineated toe of valley slope in any areas where the reach is confined by adjacent valley slopes (i.e. the meander belt width crosses the toe of slope). This is shown in **Appendix A**, in these locations, the channel cannot realistically migrate further as it is restricted by the valley slope.

As such, the recommended meander belt width for both reaches is considered to appropriately address the potential erosion hazard and Redside Dace habitat delineation.

Table 3: Summary of modelled meander belt widths for watercourse reaches for existing conditions

Reach	Modelled Meander Belt Widths			Recommended Meander Belt Width (m)
	Modified Williams (1986) Area*	Modified Williams (1986) Width*	Ward Width (2002)*	
FCT-2	9	5	9	10

** Includes 20% factor of safety*

4.2 Toe Erosion Allowance

When defining an erosion hazard for a confined or partially confined valley system, a toe erosion allowance is provided where the channel is within 15 m of the toe of slope. Field observations indicated that **Reach FC-2** and **Reach FCT-1** was confined and **Reach FCT-2** was partially confined.

Generally, the watercourse occupied a confined valley, and the valley walls were often located further than 15 m from the channel in **Reach FC-2**. Average annual recession rates are determined through meander migration analysis using historic and recent aerial photographs. An annual recession rate of approximately 8 m per 100 years was previously determined by Parish (2011) however, due to inherent error in the migration rate measurements and updated field observations we have recommended a toe erosion allowance of 5 m. Additionally, some of the aerial photographs were densely vegetated and banks were poorly visible.

Reaches FCT-1 and **FCT-2** observed on-site were densely vegetated and poorly visible through aerial photograph interpretation. Given the poor aerial coverage and limited channel definition observed in the historical and recent aerials, meander migration analysis was not possible to determine an average annual recession rate.

As such, we have developed recommendations below for an appropriate toe erosion allowance based on a combination of reach-level observations of existing geomorphic conditions and guidance outlined by MNRF in the technical guide for defining riverine erosion hazards (MNR, 2002). The recommended toe erosion allowances for each confined reach are provided in **Table 4.**

Table 4: Summary of recommended toe erosion allowances for confined valley reaches

Reach	Range of Acceptable Toe Erosion Allowances (m)*	Final Recommended Toe Erosion Allowances (m)**
FC-2	5 – 8	5
FCT-1	5 – 8	5
FCT-2	5 – 8	5

** Range based on MNR, 2002 guidelines*
*** Final toe erosion allowance based on field observations and best judgement*

The valley slopes were investigated by Soil Engineers Ltd. (2016), which found the material to be predominantly hard silty clay till and very dense sandy silt till. In accordance with the MNRF's Erosion Hazard Technical Guidelines, a minimum toe erosion allowance of 5 m is required for the watercourse based on both the valley material and the presence of active erosion within the watercourse. The toe erosion allowance informed the long-term stable slope and is depicted in the Supplementary Slope Stability Study Letter Report – Soil Engineers Ltd. (2020).

Bank materials were consistent in all three of the confined reaches. It was observed to consist primarily of clay and silt; however, a suspended amour layer was present as well which resulted in coarse materials in the banks as well. All three reaches were well vegetated and had active erosion present. **Reach FCT-2** was classified as a partially confined small channel based on field observations, with a valley slope only present on the west side of the Fletcher's Creek Tributary. The upstream portion of the reach had limited definition. **Reach FCT-1** was a small channel that was confined and well defined however, the downstream portion of the channel was observed to be smaller than the upstream portion. **Reach FC-2** was a confined channel along the main branch of Fletchers Creek. Active erosion was observed; however, erosion was not exacerbated beyond how a watercourse of its size normally functions over time. Additionally, the majority of **Reach FC-2** was not within 15 metres of the toe of slope and as such, the toe erosion allowance was limited to the downstream portion of this reach.

5 Corridor Crossing Recommendations

One crossing over Tributary 1 (**Reach FCT-3)** associated with the extension of the proposed Vicksburgh Drive. The proposed crossing will require an opening to accommodate the current feature. To accommodate potential channel adjustments, the future crossing should generally span at least three times the bankfull channel width however, this is only one consideration when assessing future channel crossing sizes. Other requirements including flood conveyance or structural requirements may require a different opening and size requirement. Additionally, it should be noted that this feature is poorly defined, vegetation controlled and lacks erosion. As such, the minimum crossing widths provided below should be considered in conjunction with other requirements.

Bankfull channel widths were collected in the field while completing the rapid assessments. Bankfull widths and proposed crossing dimensions are provided in **Table 5.**

Table 5: Bankfull width and proposed crossing widths

	Average Bankfull Width (m)	*Minimum Recommended Crossing Width (m)
FCT-3 (Vicksburgh Street Extension)	0.79	2.37

A mix of river stone and granular 'B' is proposed throughout the crossing structures to provide for a stable bed and a level of sorting. A layer of native material is also proposed to cover the bed substrate. Hydraulic sizing of all materials should be completed as a part of detailed design activities to confirm that materials are stable under a range of conditions.

6 Outfall Erosion Assessment and Design

6.1 Outfall Erosion

According to the most recent draft plan, drainage from 7.75 ha located west of Tributary 1 is proposed to be discharged into Fletcher's Creek southwest of the DeZen Lands. At this location, the Ontario Flow Assessment Tool (OFAT) measures the drainage area of Fletcher's creek as approximately 3,328 ha (33.28 km^2). Given the minor drainage contributions from the site relative to the Fletcher's Creek watershed, no exacerbated rates of erosion are expected within the watercourse as a consequence of inputs from the development.

In order to address potential local erosion resulting from site discharge, survey mapping, historical imagery was reviewed and field verified to determine a suitable location for an outfall. This review identified a historic channel located southwest of the DeZen lands which currently exists as a shallow depression. This location is considered ideal given the proximity to Fletcher's Creek, a lack of mature wooded vegetation which could be disturbed during construction and its generally stable existing condition. Erosion was not observed along the historical channel or along the valley wall in the outfall location.

6.2 Stormwater Outfall Treatment Design

A stone core naturalized energy dissipater (SCONED) with a level spreader is proposed for the SWM outlet adjacent to Fletcher's Creek. The SCONED will receive flows from the outfall, dissipating energy and providing opportunities for retention, filtration, and infiltration before water disperses through the level spreader to the historic channel. In addition to mitigating any erosion between the outlet and the receiving feature, the treatment train will provide habitat and water quality benefits. The proposed design will act as a polishing feature to further improve water quality by capturing fine sediments at the outlet. Benefits of the SCONED and level spreader system include organic inputs, temperature regulation through shade from overhanging vegetation, polishing, energy dissipation, and dispersion of flows. Additionally, the feature would provide enhanced opportunities for stormwater infiltration, evapotranspiration, and detention.

The primary objectives of the design, therefore, are to:

- Mitigate any erosion between the outlet and receiving features by dissipating energy
- Enhance the function of the SWM by providing additional water polishing
- Provide opportunities for stormwater infiltration, evapotranspiration, and detention before water reaches the receiving features
- Provide additional habitat by installing woody and herbaceous plantings around the features

The proposed SCONED should be constructed as an over-excavated depression, lined with a mix of soil and granular materials to provide depressional and subsurface storage (within the interstitial space of the sediment and soil). A stone core will be installed in the SCONED consisting of hydraulically sized rounded stone to provide additional subsurface stability at the headwall. A layer of topsoil will cover the base layer and will be seeded with the proposed wet meadow seed mix.

The level spreader proposed in conjunction with the SCONED will consist of wattles (i.e., live cuttings) and a silt sock that will be live-staked and overlain with 100% biodegradable erosion control matting. The wattles and silt sock will provide additional protection by reducing velocities and spreading flow over a wider area, promoting sheet flow to minimize any potential erosion between the SCONED and Fletcher's Creek. Wattles can withstand velocities up to 2.5 m/s, which will likely be overly sufficient to

provide stability between the SCONED and receiving feature, as the SCONED will dissipate flows from the outlets before flows pass over the level spreader (Fischenich, 2001).

An aggressive landscape restoration plan is proposed around the SCONED to provide shading over the feature. Live staking around the periphery will provide thermal mitigation through shade, create additional stability in the feature and wattles, and will also provide a source of coarse organic matter. The incorporation of a native seed mix within the wetland will promote polishing of flows once the vegetation has established.

6.2.1 Hydraulic Substrate Sizing

The proposed SWM outlet treatment should provide long-term stability and be suitably robust to withstand the anticipated flow condition. As such, the anticipated 10-year flow of 0.323 m^3/s and associated velocity of 2.71 m/s as provided by SKIRA & ASSOCIATES LTD. (2025) was used to inform the design. The stone core is expected to be stable under the predicted flow conditions in the SCONED. A layer of topsoil will be installed over the stone core to improve vegetation establishment. A substrate mix of 60% 300 mm – 400 mm diameter riverstone with 20% granular 'b' and 20% native material is proposed for the stone core at the base of the outfall. Granular 'B' consists of a mix of stone where approximately 20% – 50% of the stone is greater than 0.005 m in diameter, but nothing larger than 0.15 m in diameter.

The stone core was hydraulically sized to limit entrainment. A range of techniques was utilized to determine the appropriate stone sizing, as summarized in the National Engineering Handbook (NRCS, 2007). These techniques are provided in **Table 6**. The anticipated peak flow velocity of 2.71 m/s, provided by SKIRA & ASSOCIATES LTD (2025) was used to determine the appropriate stone size for the material. The stone size includes a factor of safety to provide additional stability. The larger stone size offers stability while allowing storage and infiltration at lower flows.

Table 6: Substrate sizes for the stone core wetland stone lining, based on a range of techniques

Model	Formula	Velocity (m/s)	Stone Size* (mm)
SCONED Core Substrate			
Isbash Method (Isbash, 1936)	$D_{50} = \left(\frac{V_c}{C * \left(2 * g * \frac{\gamma_S - \gamma_w}{\gamma_w}\right)^{0.5}}\right)^2$	2.71	368
USBR Method (Peterka, 1958)	$D_{50} = 0.0122 * V^{2.06}$	2.71	402
Maynord's Method (Maynord, 1988)	$D_{50} = C_s * C_v * C_T * d * \left[\left(\frac{\gamma_w}{\gamma_S - \gamma_w}\right)^{0.5} * \frac{V}{\sqrt{K_1 * g * d}}\right]^{2.5}$	2.71	300

*Includes 20% factor of safety

The Isbash method (Isbash, 1936) was developed for the construction of dams by placing rock into moving water. This model predicts the median stone size (D_{50}; ft) under the given flow conditions, given by:

$$D_{50} = \left(\frac{V_c}{C*\left(2*g*\frac{\gamma_S-\gamma_w}{\gamma_w}\right)^{0.5}}\right)^2 \quad \text{[Eq.1]}$$

Where:

V_c = critical velocity (ft/s)

C = Isbash constant (dimensionless)
g = gravity (ft/s)
γ_s = stone density (lb/ft^3)
γ_w = water density (lb/ft^3)

The USBR Method (Peterka, 1958) was developed for sizing riprap below a stilling basin. This model predicts the median stone size (D_{50}; ft) under the given flow conditions, given by:

$$D_{50} = 0.0122 * V^{2.06} \quad \text{[Eq.2]}$$

Where:

V = average channel velocity (ft/s)

Maynord's Method (Maynord, 1988) was developed for sizing riprap in open channel flows. This model predicts the largest stone size (D_{100}; ft) under the given flow conditions, given by:

$$D_{100} = C_s * C_v * C_T * d * [(\frac{\gamma_w}{\gamma_s - \gamma_w})^{0.5} * \frac{V}{\sqrt{K_1 * g * d}}]^{2.5} \quad \text{[Eq.3]}$$

Where:

d = water depth (ft)
C_s = stability coefficient
C_v = velocity distribution coefficient
C_T = thickness coefficient
γ_s = stone density (lb/ft^3)
γ_w = water density (lb/ft^3)
V = velocity (ft/s)
g = gravity (ft/s)
K_1 = side slope correction, calculated by:

$$K_1 = \sqrt{1 - \frac{sin^2\theta}{sin^2\emptyset}} \quad \text{[Eq.4]}$$

Where:

θ= angle of rock from the horizontal
∅ = angle of repose (typically 40°)

The values used for each variable in the Isbash method, USBR method, and Maynord's method are provided in **Table 7.**

Table 7: Variables and values associated with the stone core wetland stone sizing

Variable	HW 1
Isbash Method	
Critical velocity (V_c) (ft/s)	8.89
Isbash constant (C) (unitless)	0.86
Gravity (g) (ft/s^2)	32.2
Stone density (γ_s) (lb/ft^3)	165.43
Water density (γ_w) (lb/ft^3)	62.43

Variable	HW 1
USBR Method	
Velocity (V) (ft/s)	8.89
Maynord Method	
Water depth (d) (ft)	1.64
Stability coefficient (C_s) (unitless)	0.3
Velocity distribution coefficient (C_v) (unitless)	1
Thickness coefficient (C_T) (unitless)	1.5
Stone density (γ_s) (lb/ft^3)	165.43
Water density (γ_w) (lb/ft^3)	62.43
Velocity (V) (ft/s)	8.89
Gravity (g) (ft/s^2)	32.2
Side slope correction (K_1) (unitless)	1
Θ (°)	20
ø (°)	40

Newly constructed features can be vulnerable to erosion. This is particularly true before vegetation has been established. While low-flow events should not intensify erosion, the concern for erosion occurs when high flows or precipitation events occur during construction or prior to vegetation establishment. A 100% biodegradable erosion control blanket, native seed, and live stakes are to be installed along the level spreader and wetland perimeter for immediate erosion protection. Over time, the blanket will biodegrade, while the live stakes and native seed species will establish to provide long-term soil stability.

6.2.2 Construction Timing

Based on resident fish species and their respective life cycles, in-stream work will be regulated by the fisheries warmwater timing window (July 15th to March 15th), unless otherwise directed by the Ministry of Natural Resources (MNR).

Vegetation removals associated with clearing, site access and staging should occur outside the key breeding bird period identified by Environment Canada for migratory birds to ensure compliance with the *Migratory Birds Convention Act, 1994* (MBCA) and *Migratory Bird Regulations*. The breeding season for migratory birds in this part of the country typically extends from as early as March 1st to as late as September 15th. Should tree removals be required during key breeding bird season, a qualified biologist should inspect those trees to ensure they do not contain nesting birds. It is understood that the MBCA is not limited to cutting woody vegetation, but also applies to topsoil stripping and grubbing activities, as there are ground nesting bird species that are protected under the Act.

6.2.3 Best Management Practices

The design elements are unique and as such, the designer or representative should be part of construction supervision to ensure proper installation and function of the design elements. The designer should confirm materials are appropriate prior to installation. This will ensure the feature functions as

intended. On-site supervision will ensure a rapid response to construction issues. The constructed feature should be deemed stable by the designer, prior to flow introduction.

All works should be isolated from the surrounding natural areas in order to mitigate potential impacts, such as sediment loading. The perimeter of the constructed feature should be stabilized using the prescribed combination of biodegradable erosion control blankets, live staking, and seed. If required, unwatering discharge should be pumped at least 30 m from the existing feature through a filter bag prior to release. The water should be dispersed across the area through straw bales or Filtrexx® SiltSoxx™.

All materials and equipment will be stored and operated in such a manner that prevents any deleterious substances from entering the water. Vehicle and equipment refuelling and/or maintenance will be conducted away from the watercourse and be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances. Machinery should arrive on site in a clean condition (including free of mud/soil/dirt from other locations; including clean wheels/tires/tracks) and should be maintained free of fluid leaks. To reduce the spread of invasive species, equipment should be cleaned before being brought onsite and before leaving site. For guidance in this regard, please refer to the Clean Equipment Protocol for Industry available online: (https://www.ontarioinvasiveplants.ca/wp-content/uploads/2016/07/Clean-Equipment-Protocol_June2016_D3_WEB-1.pdf).

6.2.4 Post-construction Monitoring

A post-construction monitoring program is recommended to assess the performance of the implemented design. Monitoring observations can also be used to determine the need for remedial works, if required. Inspections and monitoring should take place for three full calendar years post-construction. The following monitoring and reporting activities are suggested for the outfall treatment:

- General observations of the outlet treatment should be documented after construction and after the first large flow event to identify any potential areas of erosion concern
- Collect a detailed photographic record of site conditions, including monumented and georeferenced photographs at the treatment location
- A general vegetation survey at the outfall locations in the spring of each year
- A yearly report for the first two years, with a final report at the end of the three-year period
- Monitoring activities should be undertaken by a qualified fluvial geomorphologist
- Sites should be reviewed annually to identify natural variability of the system. Reporting should be provided annually, with a summary report at the end of each year

7 Summary and Recommendations

A hazard assessment completed for both Tributary 1 of Fletcher's Creek and Fletcher's Creek itself determined that a 5 m toe erosion allowance was appropriate given the findings of Soil Engineering Ltd.'s 2020 study and our field observations. This toe erosion allowance was applied wherever the watercourses were within 15 m of the valley wall, in accordance with MOE (2003) guidelines. The final erosion hazard linework for the confined systems is based on the results of a geotechnical slope stability study by Soil Engineers Ltd.

For the short section of channel at the upstream extent of Tributary 1, **Reach FCT-2**, which lacked a valley wall, a meander belt width of 10 m was calculated using a Modified Williams Area Model (1986). Additionally, the meander belt width previously delineated by Parish (2011) along the main branch of Fletcher's Creek (**Reach FC-2**) was refined to be truncated at the toe of slope for Redside Dace habitat delineation. These hazard limits are graphically displayed in **Appendix A**.

For Fletcher's Creek, a desktop assessment identified the ideal location for an outfall location, and an outfall design was provided to mitigate the potential for localized erosion at this site. In terms of potential systemic erosion impacts to Fletcher's Creek resulting from the proposed development, it was determined that given the drainage area of the watercourse relative to the contributing drainage that no exacerbated erosion is expected.

Additionally, the crossing location was also assessed through field verification. The location of the crossing (**Reach FCT-3**) is proposed to cross a poorly defined and vegetation-controlled feature that lacks erosion. A crossing requirement of 2.37 m was recommended however, the minimum crossing width provided below should be considered in conjunction with other requirements.

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

Rachel Abbott, B.Sc., G.I.T
Environmental Scientist, Project Lead

Rachel Sun, M.Sc.
Restoration Design Technician

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Appendix A:
Erosion Hazard Mapping

Legend

- Reach Break and ID
- 0.25 m Contour
- Proposed Outfall
- Meander Belt Width
- Meander Belt Width Truncated to Toe of Slope
- 30 m Setback from Meander Belt
- Watercourse
- Drainage Feature
- Crossing Location

Erosion Hazard Assessment

Fletcher's Creek

Mississauga, Ontario

GEO MORPHIX™

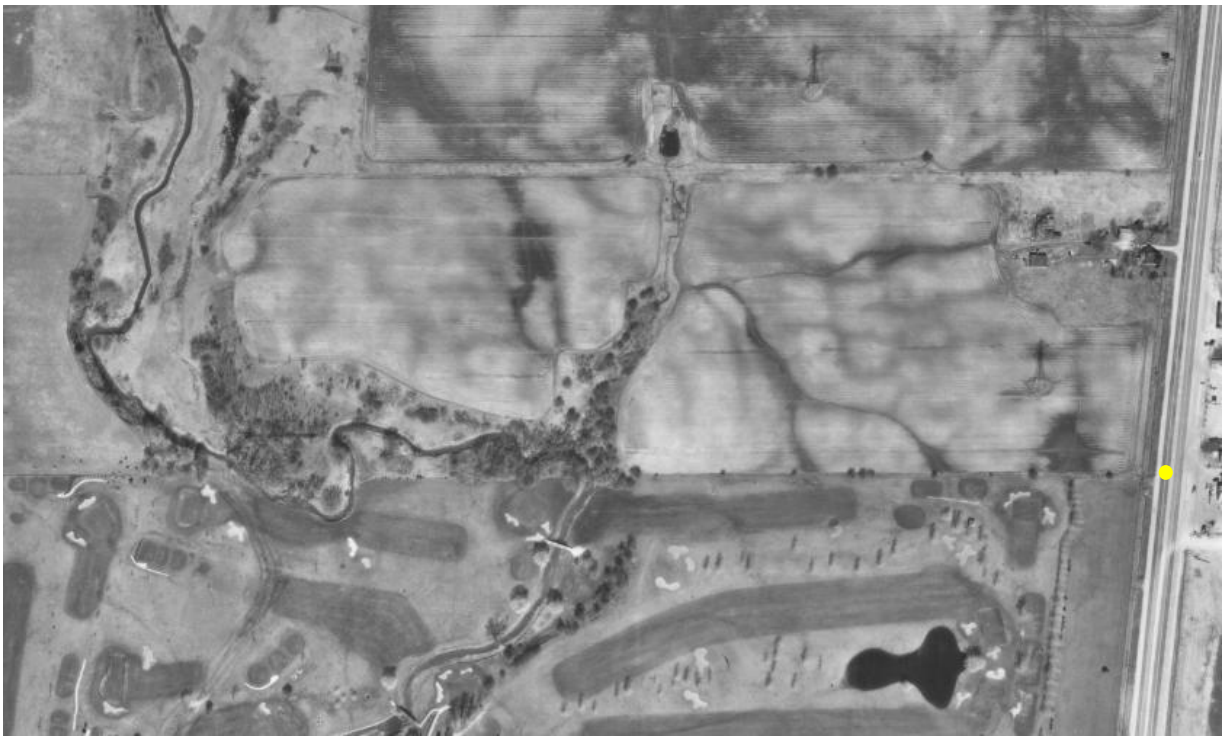
0 40 80
Metres

Imagery: Google Earth. Watercourse: CVC, 2022.
Reach Break and ID: GEO Morphix Ltd., 2018/2025.
0.25 m Contour: Skira & Associates Ltd., 2025. PN25102.
Print Date: September 2025. Drawn By: M.O., R.A., G. U.

Appendix B:
Historical Aerial Imagery

Location: Hurontario Street, Mississauga, Ontario
Year: 1954
Source: National Air Photo Library
Yellow Point: Hurontario Street

Location: Hurontario Street, Mississauga, Ontario
Year: 1977
Source: National Air Photo Library
Yellow Point: Hurontario Street



Location: Hurontario Street, Mississauga, Ontario
Year: 1989
Source: National Air Photo Library
Yellow Point: Hurontario Street

Location: Hurontario Street, Mississauga, Ontario
Year: 2002
Source: Google Earth Pro
Yellow Point: Hurontario Street

Location: Hurontario Street, Mississauga, Ontario
Year: 2002
Source: Google Earth Pro
Yellow Point: Hurontario Street

Location: Hurontario Street, Mississauga, Ontario
Year: 2018
Source: Google Earth Pro
Yellow Point: Hurontario Street

Location: Hurontario Street, Mississauga, Ontario
Year: 2023
Source: Google Earth Pro
Yellow Point: Hurontario Street

Appendix C:
Photographic Field Record

Photo 1 **Outlet Headwall Location,** 7140 Hurontario Street, Mississauga, ON	
	Photograph of staked headwall location facing the direction of the tie-in location.
Photo 2 **Outlet Headwall Location,** 7140 Hurontario Street, Mississauga, ON	
	Photograph of the valley wall behind the headwall location. The slope is well vegetated and showed a lack of erosion at the time of assessment.

Photo 3 **Reach FC-2,** 7140 Hurontario Street, Mississauga, ON	
	Photograph showing the confluence between the historic channel and **Reach FC-2.** The confluence was located at an outer meander bend along **Reach FC-2**.
Photo 4 **Reach FC-2,** 7140 Hurontario Street, Mississauga, ON	
	Photograph of **Reach FC-2** facing upstream. Leaning trees and woody debris jams that impacted flow were common throughout the reach.

Photo 5
Reach FC-2, 7140 Hurontario Street, Mississauga, ON

Coarse material was commonly observed along the channel bed. A suspended armour layer was observed in the channel banks as well. The bank materials consisted of clay, silt materials with some coarse materials due to the suspended armour layer.

Photo 6
Reach FCT-1, 7140 Hurontario Street, Mississauga, ON

Photograph of **Reach FCT-1** facing upstream. The channel was confined and had low flow conditions at the time of assessment. Exposed roots and undercutting were commonly observed. The bed was also eroded into parent material (till) in a localized portion of the reach upstream.

Photo 7
Reach FCT-1, 7140 Hurontario Street, Mississauga, ON

Photograph of **Reach FCT-1**. Active erosion was noted along this reach however; the channel banks were observed to be well vegetated. Some fallen and leaning trees were also observed, indicating some widening along the reach.

Photo 8
Reach FCT-2, 7140 Hurontario Street, Mississauga, ON

Photograph of **Reach FCT-2** facing upstream. The reach was partially confined and had a high density of woody debris and exposed roots.

Photo 9
Reach FCT-2, 7140 Hurontario Street, Mississauga, ON

Photograph of **Reach FCT-2** located at the upstream extent. Note that banks are less defined as the channel moved upstream towards **FCT-3**.

Photo 10
Reach FCT-3, 7140 Hurontario Street, Mississauga, ON

Photograph of **Reach FCT-3** facing upstream towards the pond. Though dry at the time of assessment, much of the reach was comprised of an online wetland containing cattails and phragmites.

Photo 11
FCT-3 Approx. Crossing Location, 7140 Hurontario Street, Mississauga, ON

The proposed water crossing location is situated across **Reach FCT-3.** The location's topography was unconfined, flat, and the feature was poorly defined. Herbaceous plants and tall grasses dominated the area.

Appendix D:
Field Observations

GEO MORPHIX™

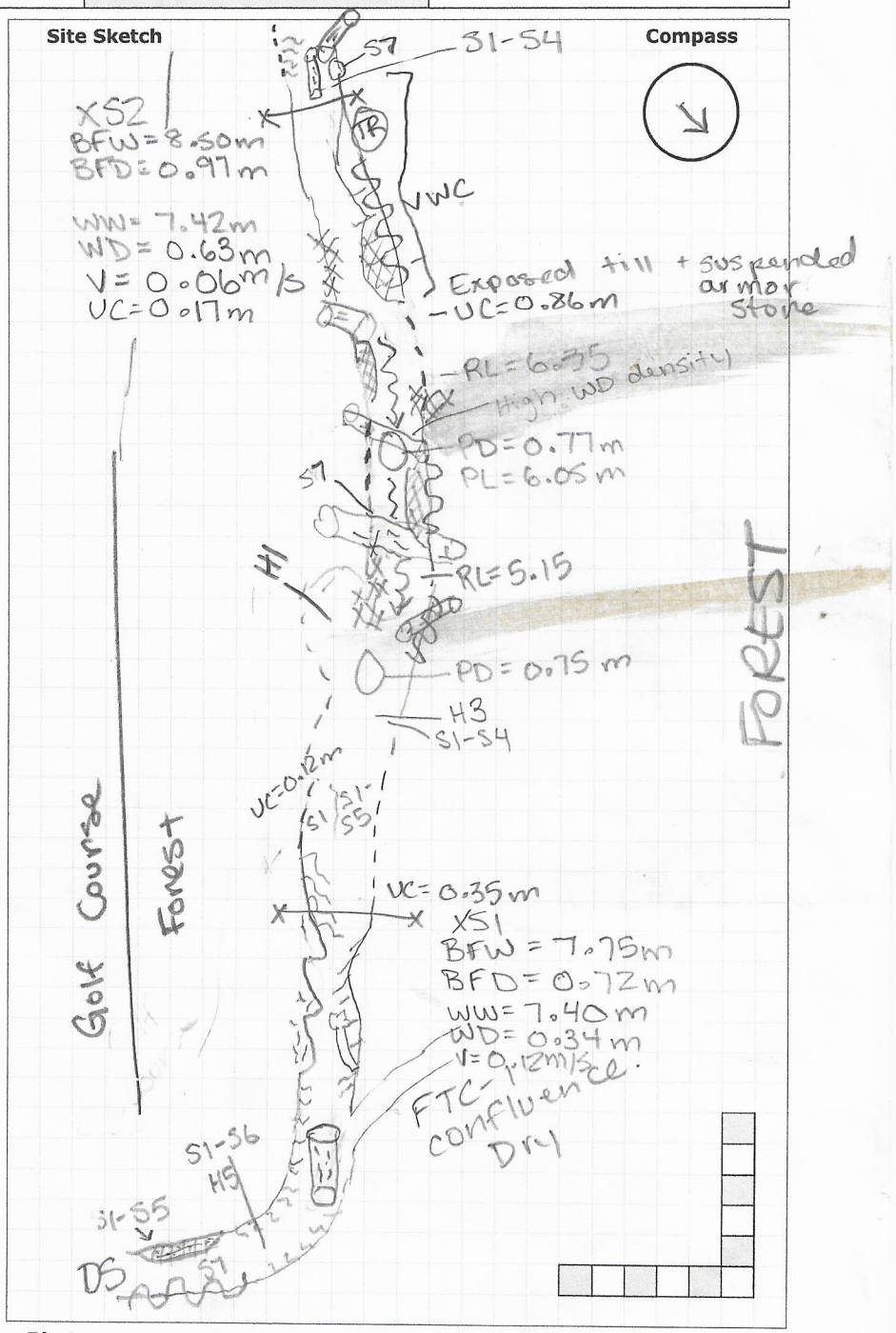
General Site Characteristics

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	9:00	**Reach:**	FC-2
Weather:	24°C, Sunny	**Location:**	Derry Crest Rd.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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		mass wst. slump
	Bank stabilization		exposed roots
	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:

Bank Materials = Clay, silt, sand, cobbles

GEO MORPHIX

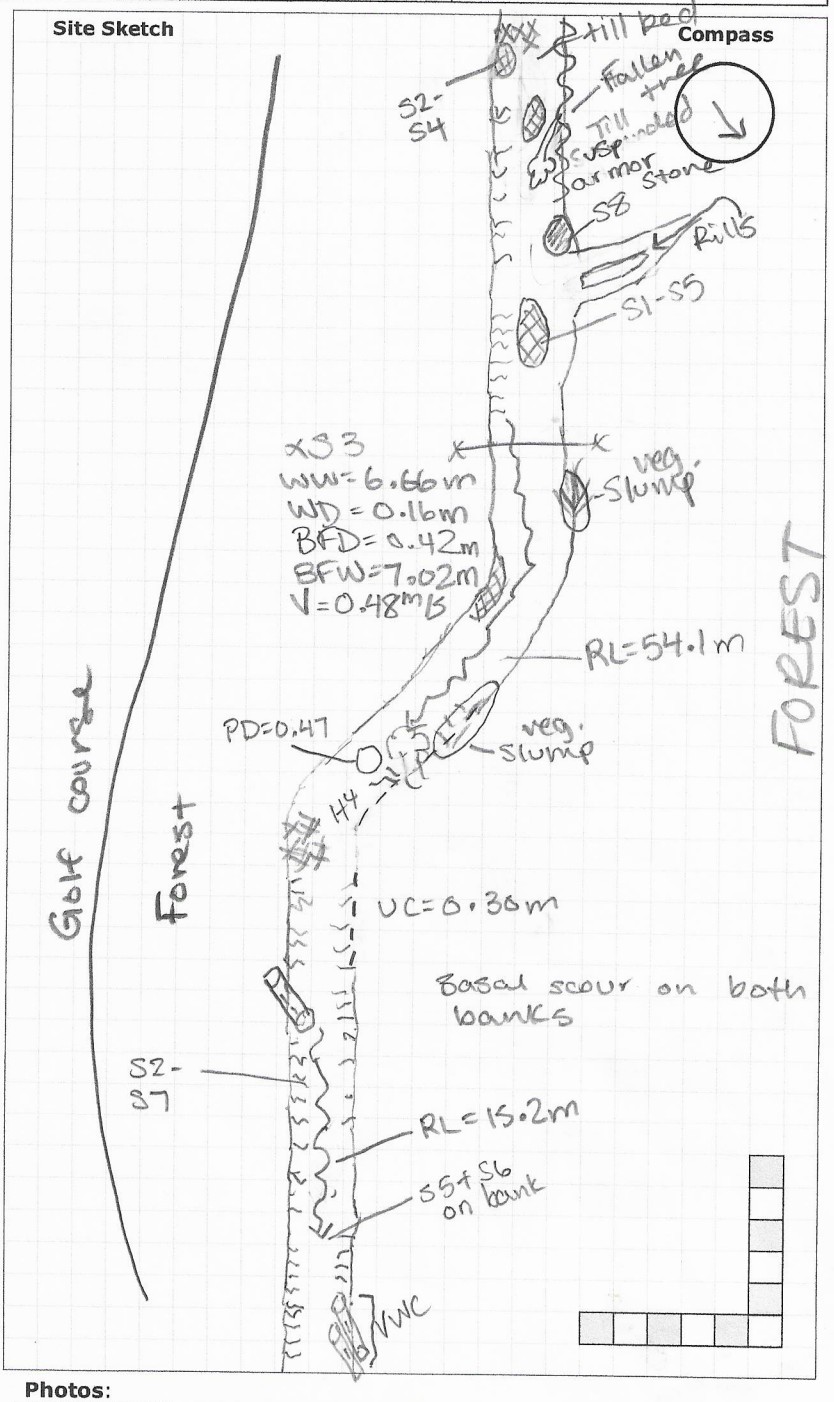
General Site Characteristics

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	9.30	**Reach:**	FC-2
Weather:	24°C, Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH, CM	**Watershed/Subwatershed:**	

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™

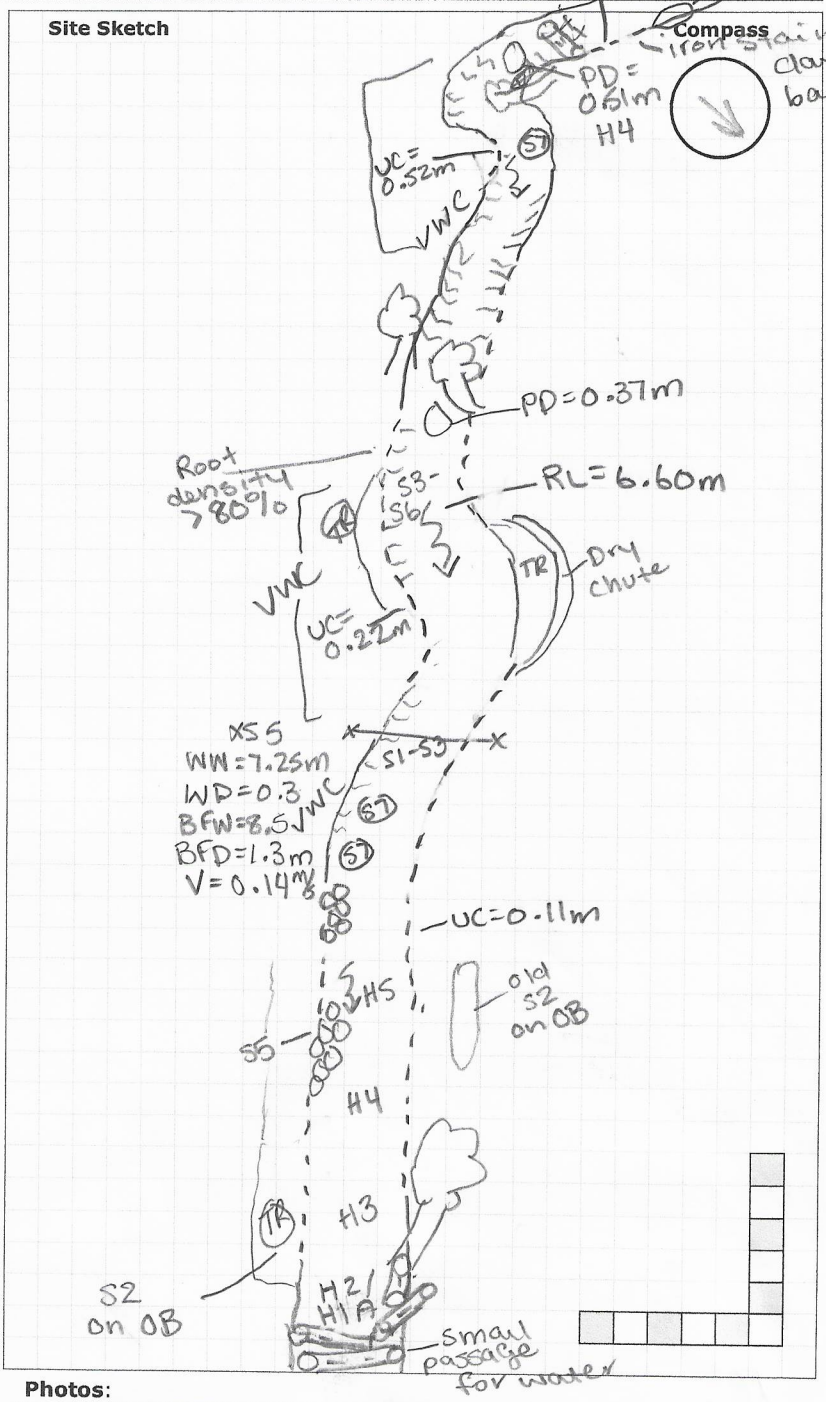
General Site Characteristics

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	10:00	**Reach:**	FC-2
Weather:	24°C, Sunny	**Location:**	Dreamy UC=0.82m St Dr.
Field Staff:	NH, CM	**Watershed/Subwatershed:**	

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™

General Site Characteristics

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	10:30	**Reach:**	FC-2
Weather:	24°C, Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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		
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H6	Unbroken standing wave		
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H9	Free fall	**H9A**	Dissipates below free fall

Substrate

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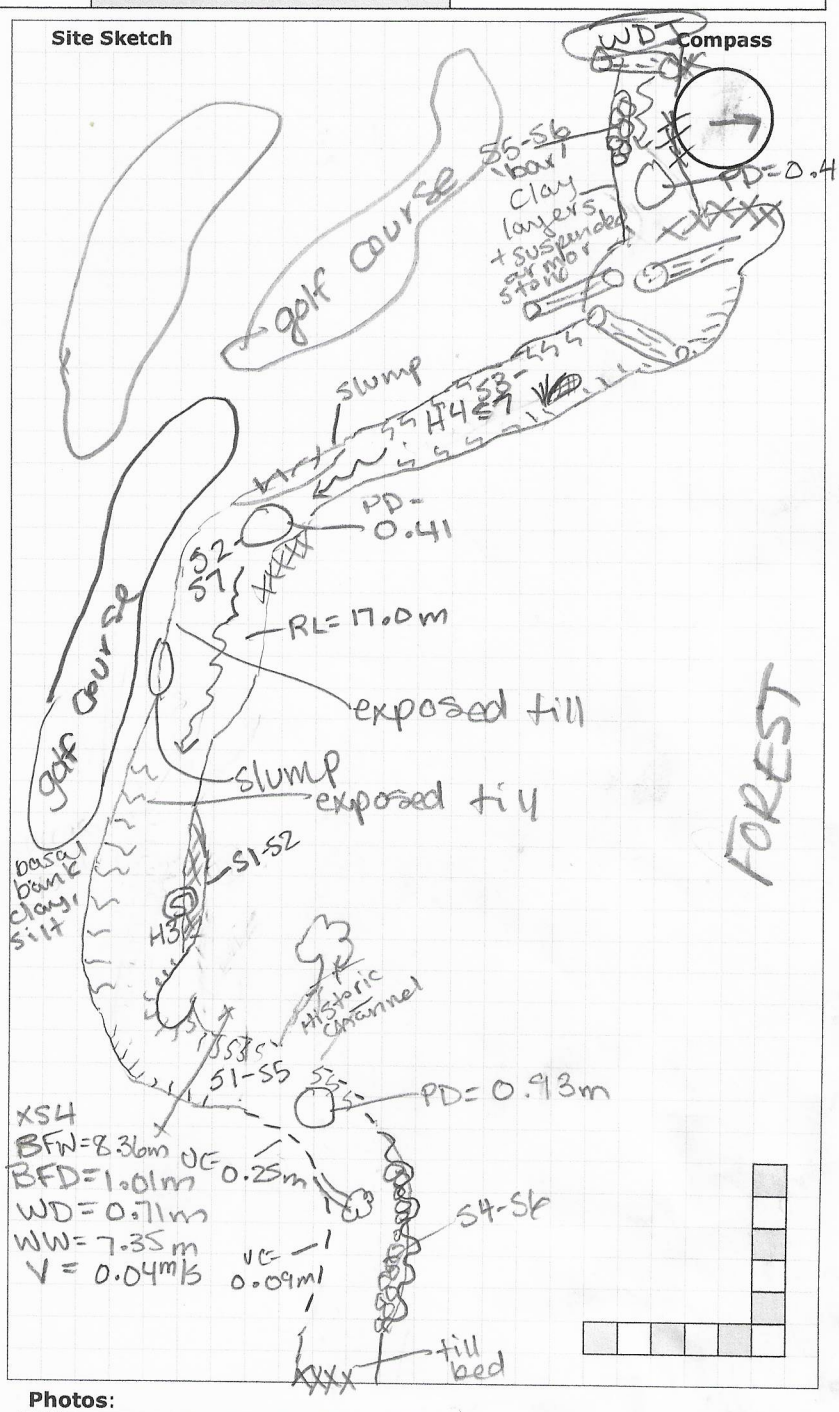
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

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:

GEO MORPHIX™

General Site Characteristics

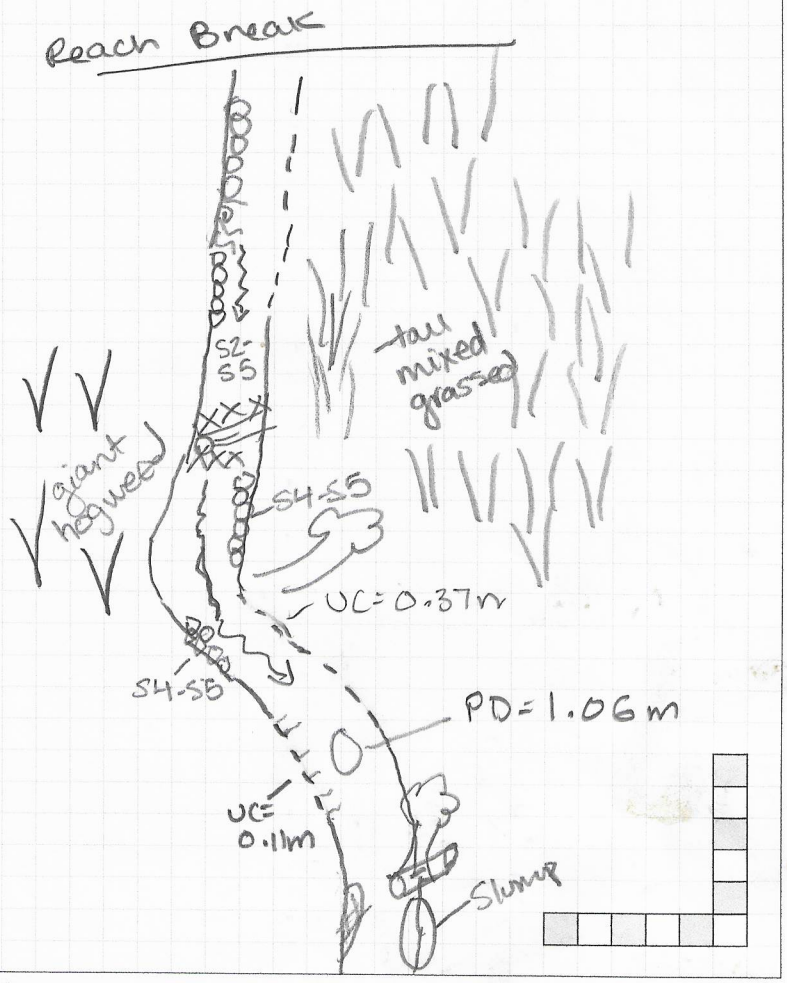
Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletchers Creek
Time:	11:00	**Reach:**	FC-2
Weather:	24°C, Sunny	**Location:**	Derry/Crest Dr.
Field Staff:	NH, CM	**Watershed/Subwatershed:**	

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

Compass



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		
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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:

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 2502

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	11:18	**Reach:**	FC-2
Weather:	Sun 25	**Location:**	Derrycrest Rd
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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 - clay/silt	• 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: CM Completed by: NH

GEO MORPHIX™

Date:	2025-07-18	PN:	25102	Location:	

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) = 27	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: MH

GEO MORPHIX

Reach Characteristics Project Number: 25102

Date:	2025-07-18	**Field Staff:**	CM NH	**Watershed/Subwatershed:**	
Time:	9:00	**Stream:**	Fletcher's Creek	**UTM (Upstream):**	
Weather:	Sun 25°	**Reach:**	FC-2	**UTM (Downstream):**	

Land Use (Table 1): 1,8 | **Valley Type** (Table 2): 3 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 1 | **Encroachment** (Table 7): 1

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 %**: 0.5

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

WDJ/50m: 2

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 | **# of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Bank Failure** (Table 14): 2,5,6

Down's Model (Table 15): E/U | **Bankfull Indicators** (Table 18): 1,3,5 7

Sed Sorting (Table 20): MoD | **Sediment Transport Observed?** ☐ Yes ☒ No ☐ Not Visible

Transport Mode (Table 21): 1 | **% of Bed Active**: 0

Geomorphic Units (Table 22): 4-8 | **Mass Movement** (Table 23): 1,3

Riffle-Pool Spacing (m): | **% 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)	7.25	8.5	8.36	**Wetted Width (m)**	7.40	7.25	7.35
Bankfull Depth (m)	0.72	1.3	1.01	**Wetted Depth (m)**	0.34	0.3	0.71
Undercuts (m)	0.35	0.86	0.11	**Velocity (m/s)**	0.12	0.14	0.04
Pool Depth (m)	0.75	0.93	0.42	**Velocity Estimate Method**	WB	WB	WB
Riffle Length (m)	6.35	15.2	17.0	**Meander Amplitude (m)**	/	/	/

Notes:

- Channel flows through forest/golf course landscape. Buffer width varies. Trees + shrubs dominant
- VWC observed on both banks throughout reach
- Irregular meanders present but infrequent. Meander amplitude could not be accurately measured
- Cobbles dominant bed substrate. Scattered boulders present.
- Undercutting/basal scour present on both banks. Inside of bend undercut.
- Fallen trees common but most were dead and likely not recent falls
- Mass rotational slides/slumps observed on both banks.
- Minnows observed throughout reach

Photos:

- Large WDJ observed causing back watering US of golf course
- Extensive undercuts on both banks at tie in confluence
- Till bed observed US and DS on tie in confluence

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	11:28	**Reach:**	FC-2
Weather:	Sun 24	**Location:**	Derrycrest Dr, On
Field Staff:	NH CM	**Watershed/Subwatershed:**	

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	2/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars – 2 @ course materials, 1 @ vfg	✓		
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone – 1 area US of WDJ		✓	
		Sum of indices =	2	5	0.29
Evidence of Degradation (DI)	1	Exposed bridge footing(s) N/A	—	—	2/6
	2	Exposed sanitary / storm sewer / pipeline / etc.		✓	
	3	Elevated storm sewer outfall(s) N/A	—		
	4	Undermined gabion baskets / concrete aprons / etc. N/A	—	—	
	5	Scour pools downstream of culverts / storm sewer outlets N/A	—	—	
	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 – 1 area		✓	
		Sum of indices =	2	4	0.33
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		6/8
	2	Occurrence of large organic debris	✓		
	3	Exposed tree roots	✓		
	4	Basal scour on inside meander bends	✓		
	5	Basal scour on both sides of channel through riffle	✓		
	6	Outflanked gabion baskets / concrete walls / etc. N/A	—		
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc. – tile @ golf course		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation N/A	—	—	
		Sum of indices =	6	2	0.75
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s) – 1 chute, dry		✓	0/7
	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 =	0	0	0

Notes: High density of fallen trees + exposed roots
VWC on both banks
Slumping more common in US extent

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.34

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: CM Completed by: NH

GEO MORPHIX™

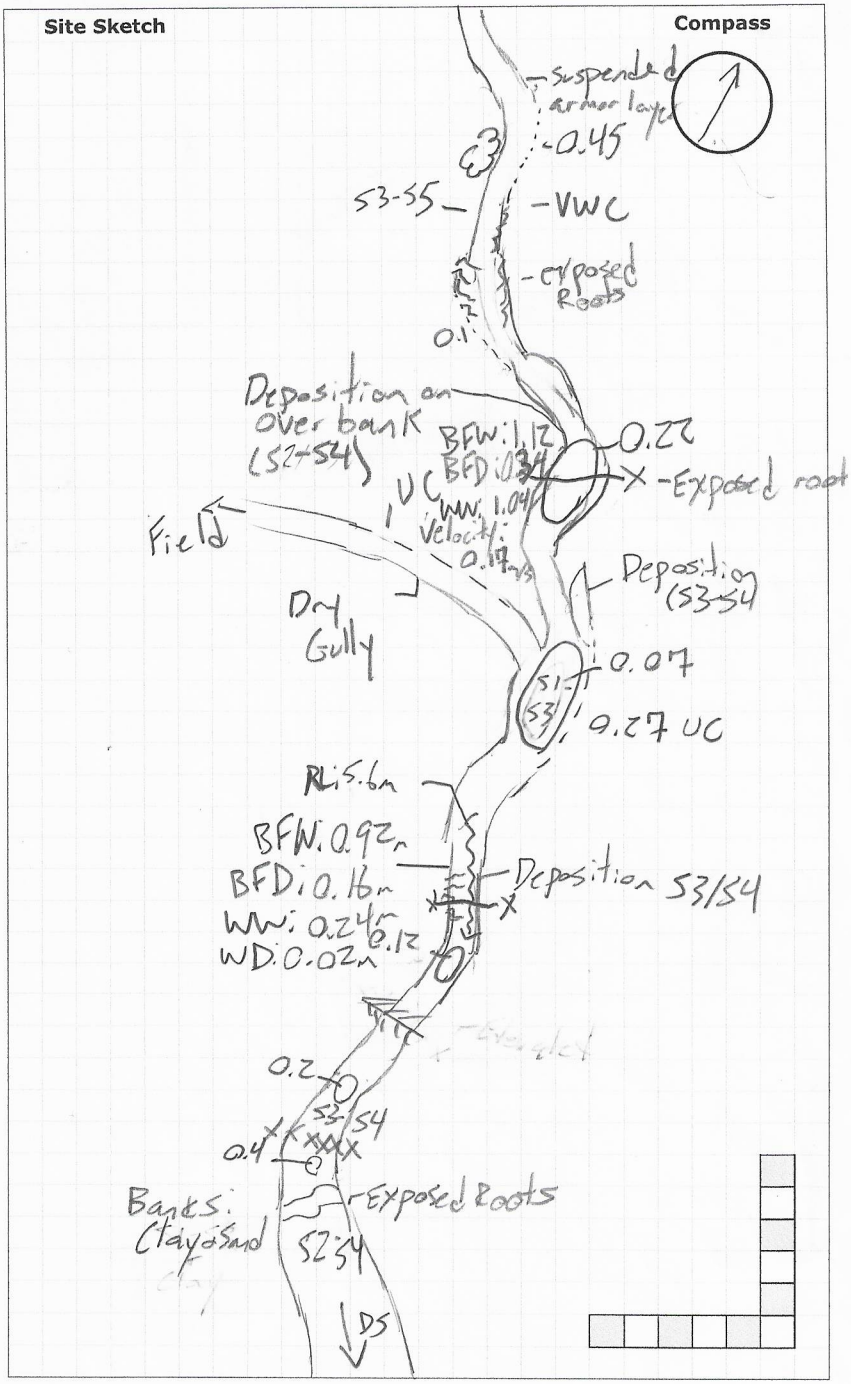
General Site Characteristics

Project Number: 25102

Date:	2025-07-16	**Stream:**	Fletcher's Creek
Time:	12:45	**Reach:**	FTC-1
Weather:	24°C, Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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
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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:

GEO MORPHIX™

General Site Characteristics

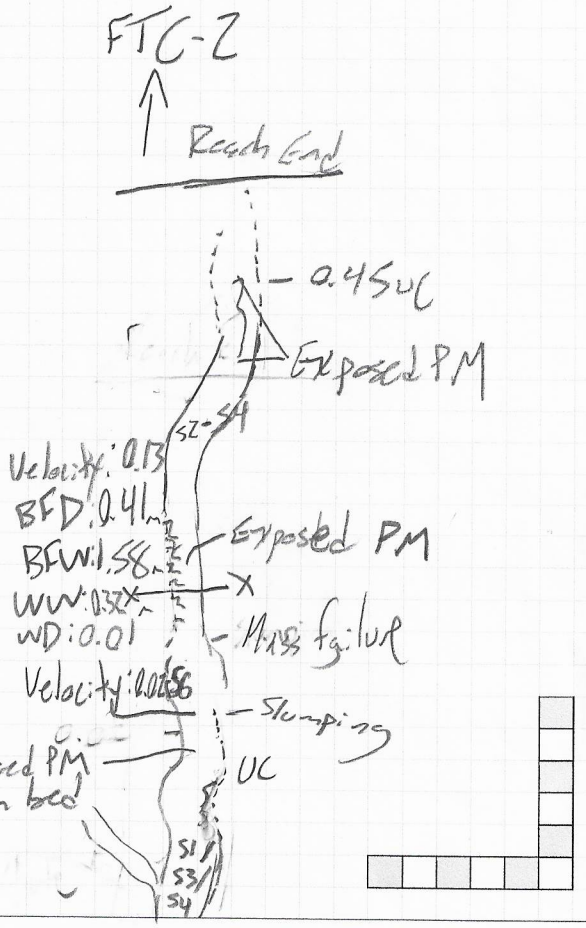
Project Number: 25102

Date:	2025-07-16	**Stream:**	Fletcher's Creek
Time:	13:55	**Reach:**	FTC-1
Weather:	24°C, Sunny	**Location:**	Deery Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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

Compass



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:

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	12:45	**Reach:**	FTC-1
Weather:	Sun 25°	**Location:**	Derrycrest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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: CM Completed by: NH

GEO MORPHIX™

Date:	2025-07-18	PN:	25102	Location:	

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) = 27	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: CM

GEO MORPHIX

Reach Characteristics Project Number: 25102

Date:	2025-07-18	**Field Staff:**	NH CM	**Watershed/Subwatershed:**	
Time:	12:45	**Stream:**	Fletcher's Creek	**UTM (Upstream):**	
Weather:	Sun 25	**Reach:**	FCT-1	**UTM (Downstream):**	

Land Use (Table 1): 1,3,6 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 6 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ 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): N/A
Reach Coverage %: 0

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

WDJ/50m: 1

Water Quality

Odour (Table 16): 1
Turbidity (Table 17):

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 2
Entrenchment (Table 13): 1
Down's Model (Table 15): e
Sed Sorting (Table 20): Poor
Transport Mode (Table 21): 2,3
Geomorphic Units (Table 22): 5,6,9
Riffle-Pool Spacing (m): NA

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): 2,6
Bankfull Indicators (Table 18): 1,3,7,5
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23): 4
% Riffles: /
% Pools: /

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)	0.92	1.12	1.58	**Wetted Width (m)**	0.24	1.04	0.32
Bankfull Depth (m)	0.16	0.34	0.41	**Wetted Depth (m)**	0.02	0.22	0.01
Undercuts (m)	0.27	0.45	0.10	**Velocity (m/s)**	0.17	0.13	0.02
Pool Depth (m)	0.20	0.07	0.40	**Velocity Estimate Method**	WB	WB	WB
Riffle Length (m)	5.6	/	/	**Meander Amplitude (m)**	N/A	NA	NA

Notes:

- Low water levels. Small wetted perimeter
- Till exposed on bed in US extent, near reach break
- Dry gully leading from field on RB undercut. Sed. deposition observed DS of confluence
- Exposed roots + undercutting on <50% of reach. Suspend armor stone observed
- Exposed roots young and old
- Till + suspended armor stone observed on LB
- Meander amplitude not measured due to irregular/weak meanders
- Valley wall contact on left bank

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	12:45	**Reach:**	FTC-1
Weather:	Sun 25°	**Location:**	Derrycrest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		/	2/7
	2	Coarse materials in riffles embedded		/	
	3	Siltation in pools		/	
	4	Medial bars – Single occurance		/	
	5	Accretion on point bars		/	
	6	Poor longitudinal sorting of bed materials	/		
	7	Deposition in the overbank zone – NOT FRESH	/		
		Sum of indices =	2	5	0.29
Evidence of Degradation (DI)	1	Exposed bridge footing(s) NA	—	—	3/5
	2	Exposed sanitary / storm sewer / pipeline / etc. NA	—	—	
	3	Elevated storm sewer outfall(s) NA	—	—	
	4	Undermined gabion baskets / concrete aprons / etc. NA	—	—	
	5	Scour pools downstream of culverts / storm sewer outlets NA	—	—	
	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 – Near FTC-2 reach break	/		
		Sum of indices =	3	2	0.6
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	/		4/7
	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. NA	—	—	
	7	Length of basal scour >50% through subject reach	/		
	8	Exposed length of previously buried pipe / cable / etc. NA	—	—	
	9	Fracture lines along top of bank		/	
	10	Exposed building foundation NA	—	—	
		Sum of indices =	4	3	0.57
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		/	0/7
	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 =			0

Notes:

→ Undercuts + exposed roots
→ Low flow conditions
→ Gully from farm field feeds into trib

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.37

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: CM Completed by: NH

GEO MORPHIX™

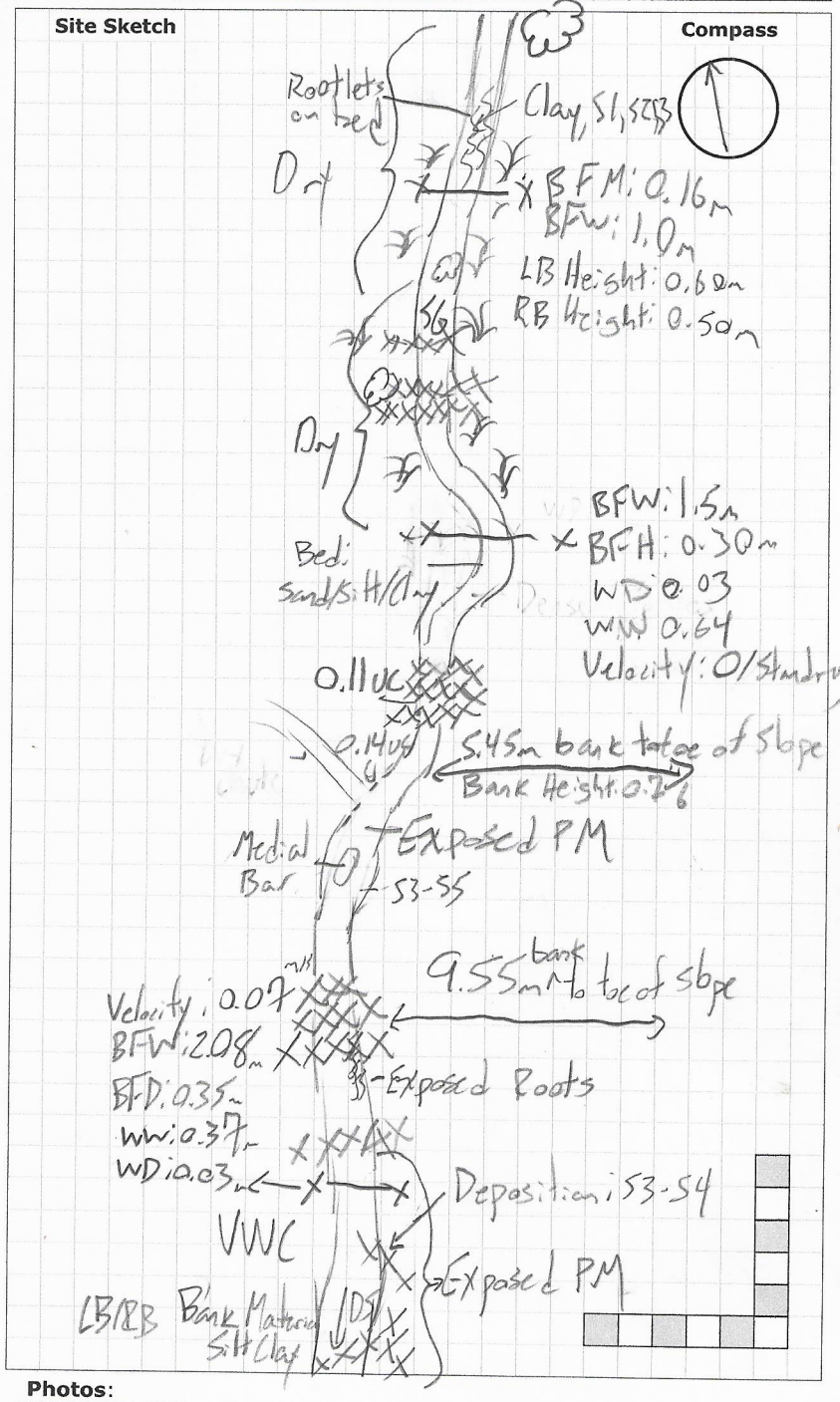
General Site Characteristics

Project Number:

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	8:09	**Reach:**	FTC-2
Weather:	24°C, Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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™

General Site Characteristics

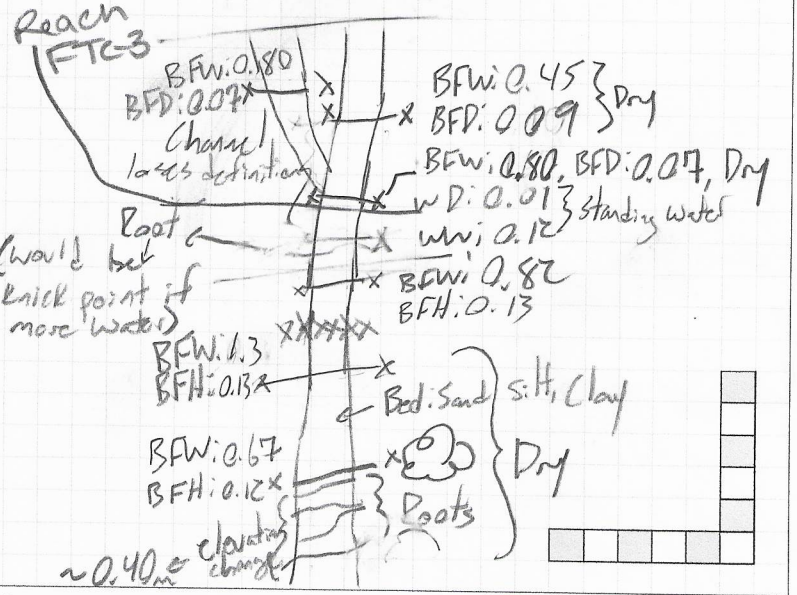
Project Number: 25102

Date:	2025-07-15	**Stream:**	Fletcher's Creek
Time:	1:45	**Reach:**	FTC-2
Weather:	Sunny 24°C	**Location:**	Derry Crest Dr.
Field Staff:	NH, CM	**Watershed/Subwatershed:**	

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

Compass



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 Stream Assessment Technique Project Number: 25107

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	13:10	**Reach:**	FTC-2
Weather:	24°C, Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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: CM Completed by: NH

GEO MORPHIX™

Date:		PN:		Location:	

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) = 21	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: NH

GEO MORPHIX™

Reach Characteristics Project Number: 25102

Date:	2025-07-18	**Field Staff:**	NH CM	**Watershed/Subwatershed:**	
Time:	13:09	**Stream:**	Fletcher's Creek	**UTM (Upstream):**	
Weather:	Sun 25	**Reach:**	FCT-2	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 1
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): NA
Reach Coverage %:

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

WDJ/50m: 2

Water Quality

Odour (Table 16): 1
Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 2
Entrenchment (Table 13): 1
Down's Model (Table 15): e
Sed Sorting (Table 20): Poor
Transport Mode (Table 21): 2,3
Geomorphic Units (Table 22): 9,10,5
Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): 2,6
Bankfull Indicators (Table 18): 3,5,7
Sediment Transport Observed? ☐ Yes ☐ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23): 4
% Riffles: / **% Pools:** /

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)	1.0	1.50	0.67	**Wetted Width (m)**	0	0.64	0.37
Bankfull Depth (m)	0.16	0.30	0.12	**Wetted Depth (m)**	0	0.03	0.03
Undercuts (m)	0.11	0.14	/	**Velocity (m/s)**	0	0.07	0
Pool Depth (m)	/	/	/	**Velocity Estimate Method**	WB		
Riffle Length (m)				**Meander Amplitude (m)**			

Notes:

→ Left bank @ reach break w FCT-1 is ~15m from toe of slope (partially confined)
→ Dry during assessment in US extent
→ Roots growing through channel bed
→ Exposed till in bed
→ Banks become shallow + less defined moving US

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:		**Reach:**	FTC-2
Weather:	Sun 25°	**Location:**	Derrycrest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	1/6
	2	Coarse materials in riffles embedded		X	
	3	Siltation in pools NA			
	4	Medial bars - one occurance DS of confluence		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 =	1	5	0.17
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	NA		2/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	NA		
	3	Elevated storm sewer outfall(s)	NA		
	4	Undermined gabion baskets / concrete aprons / etc.	NA		
	5	Scour pools downstream of culverts / storm sewer outlets	NA		
	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 =	2	3	0.4
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	/		3/7
	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.	NA		
	7	Length of basal scour >50% through subject reach		/	
	8	Exposed length of previously buried pipe / cable / etc.	NA		
	9	Fracture lines along top of bank		/	
	10	Exposed building foundation	NA		
		Sum of indices =	3	4	0.43
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		/	0/7
	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 =	0	7	0

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.21

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: CM Completed by: NH

GEO MORPHIX™

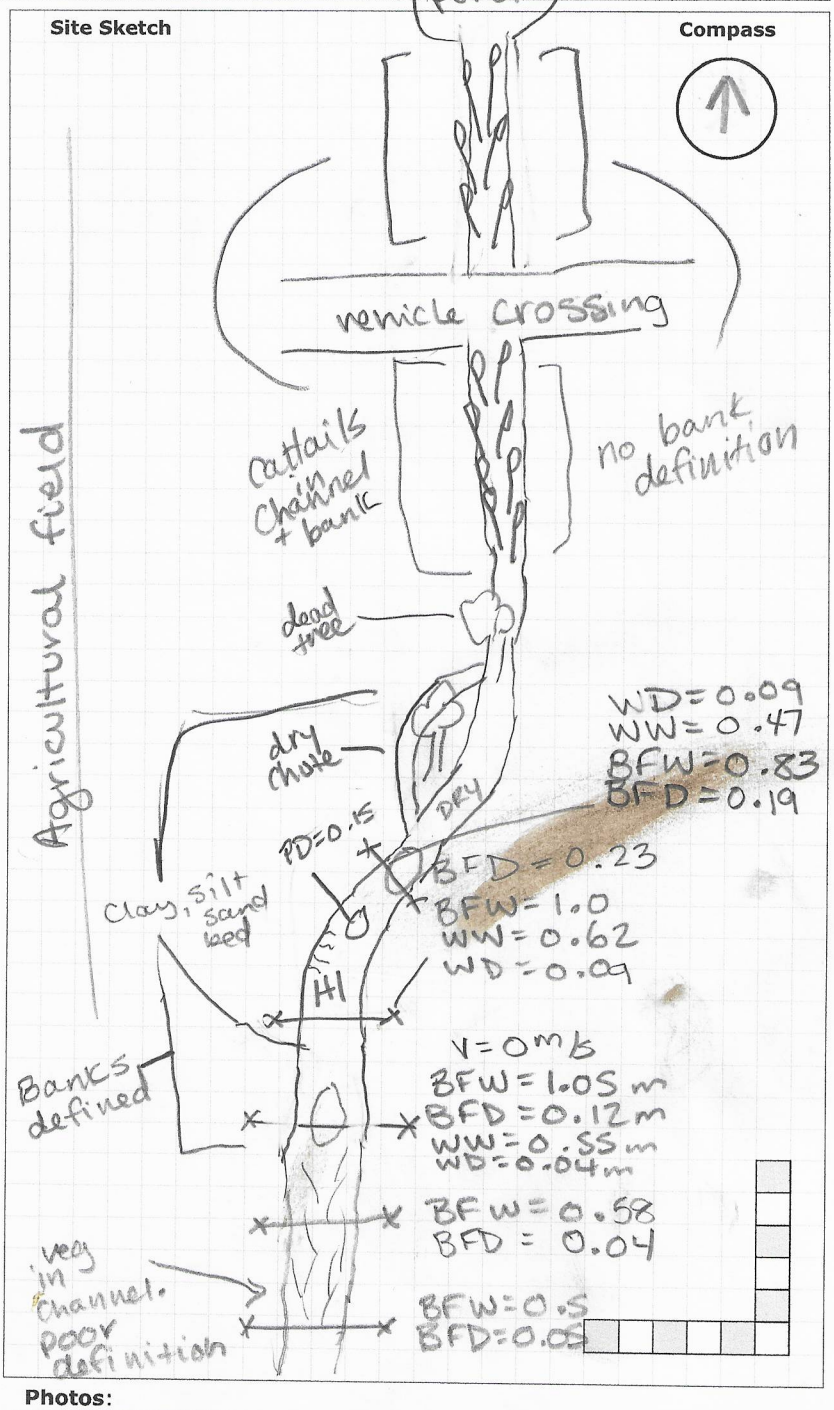
General Site Characteristics

Project Number: 25102

Date:	2025-07-18	**Stream:**	Fletcher's Creek
Time:	14:15	**Reach:**	FTC-3
Weather:	24°C Sunny	**Location:**	Derry Crest Dr.
Field Staff:	NH CM	**Watershed/Subwatershed:**	

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	cattails/phrag	
	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:

→ Small extent of reach has defined banks, but is otherwise grassy swale (DS) or cattail/phrag encroached wetland (US)

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

Reach Characteristics Project Number: 25102

Date:	2025-07-18	**Field Staff:**	CM NH	**Watershed/Subwatershed:**	
Time:	14:15	**Stream:**	Fletcher's Creek	**UTM (Upstream):**	
Weather:	24° Sunny	**Reach:**	FCT-3	**UTM (Downstream):**	

Land Use (Table 1): 3,9 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 3
Encroachment (Table 7): 90

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 %: 60

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

WDJ/50m: 0.25

Water Quality

Odour (Table 16): 1
Turbidity (Table 17): 3

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 4
Down's Model (Table 15): 5
Sed Sorting (Table 20): well
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 5
Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): 1
Bankfull Indicators (Table 18): 1,3,5
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23): /
% Riffles: 0
% Pools: 15

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)	0.5	1.05	0.83	**Wetted Width (m)**	0.55	0.62	0.47
Bankfull Depth (m)	0.05	0.12	0.19	**Wetted Depth (m)**	0	0	0.04
Undercuts (m)	/	/	/	**Velocity (m/s)**	0	0	0
Pool Depth (m)	0.15	0.09	0.04	**Velocity Estimate Method**	WB →		
Riffle Length (m)	/	/	/	**Meander Amplitude (m)**	/	/	/

Notes:

→ Sporadic stagnant puddles but predominantly dry channel
→ Banks have little to no definition DS at FCT-2 reach break or in US extent that is dominated by cattails and phragmites
→ Small section of reach that was not swale/wetland had exposed roots
→ 1 dry chute present

Photos:

Version #4
Last edited: 04/04/2023

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

Appendix E:
Detailed Assessment Summaries

Detailed Geomorphological Assessment Summary

Reach FCT-1

Project Number:	PN 18129	**Date:**	Nov 1, 2018
Client:	DeZen Realty	**Length Surveyed (m):**	82.6
Location:	Hurontario Street and Derry Road West	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	0.672 km^2	**Dominant Riparian Vegetation Type:**	Herbaceous, trees
Geology/Soils:	Till	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Agricultural, commerical	**Width of Riparian Cover:**	4 to 10 times channel width
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Established (5-10 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Heavy
Portion of Reach with Vegetation:	0	**Density of Woody Debris:**	High

Hydrology

Measured Discharge (m^3/s):	0.01	**Calculated Bankfull Discharge (m^3/s):**	3.27
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	2.89
Modelled 2-year Velocity (m/s):	Not modelled		

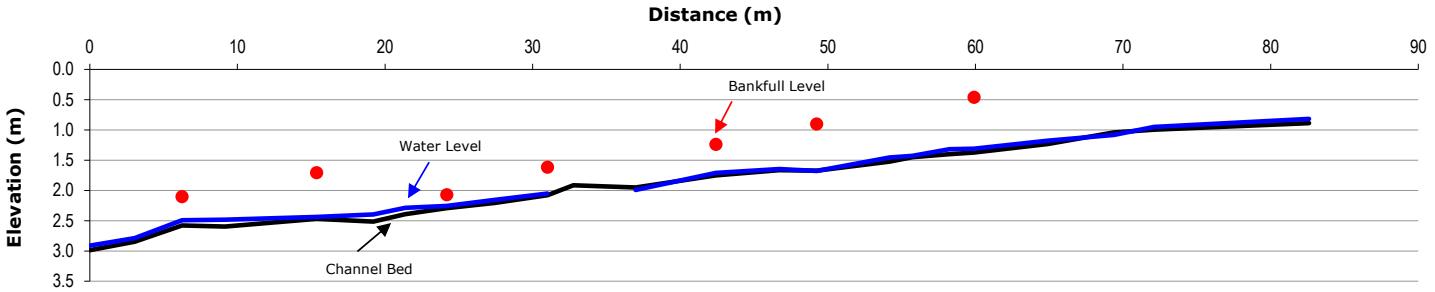
Profile Characteristics

Bankfull Gradient (%):	3.33
Channel Bed Gradient (%):	2.55
Riffle Gradient (%):	Not measured
Riffle Length (m):	Not measured
Riffle-Pool Spacing (m):	Not measured

Planform Characteristics

Sinuosity:	1.10
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):	0.2	1.30	0.91
Bank Angle (deg):	25	90	72
Root Depth (m):	0.00	0.45	0.22
Root Density (%):	0	10	6
Bank Undercut (m):	0	0.4	0.10

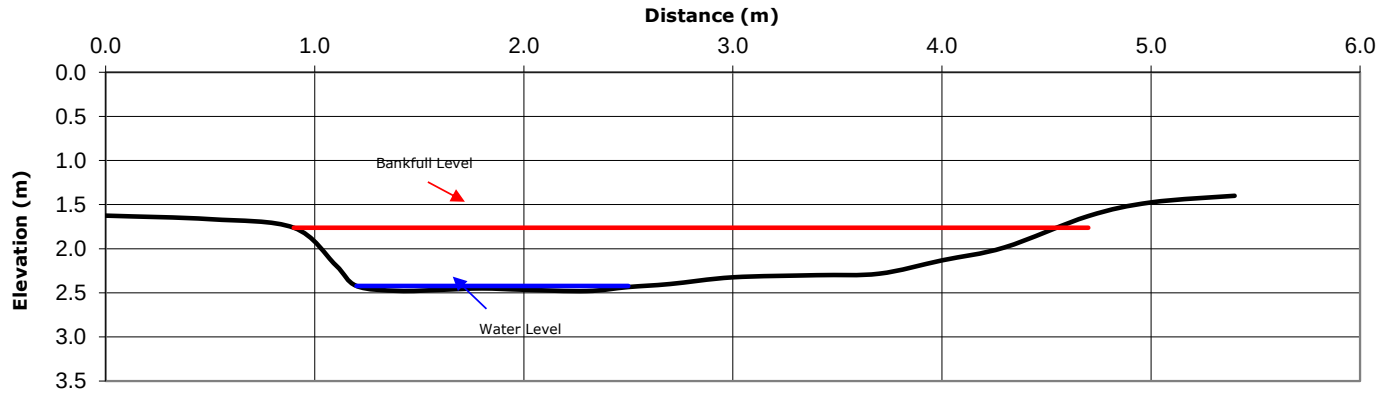
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to silt	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.30	3.40	2.25
Average Bankfull Depth (m):	0.16	0.90	0.50
Bankfull Width/Depth (m/m):	2	8	5
Wetted Width (m):	0.55	1.30	0.93
Average Water Depth (m):	0.00	0.08	0.05
Wetted Width/Depth (m/m):	8	68	26
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.03	0.14	0.07
Manning's *n* :		0.040	

Photograph at cross section 4 (looking downstream)

Representative Cross-Section 2



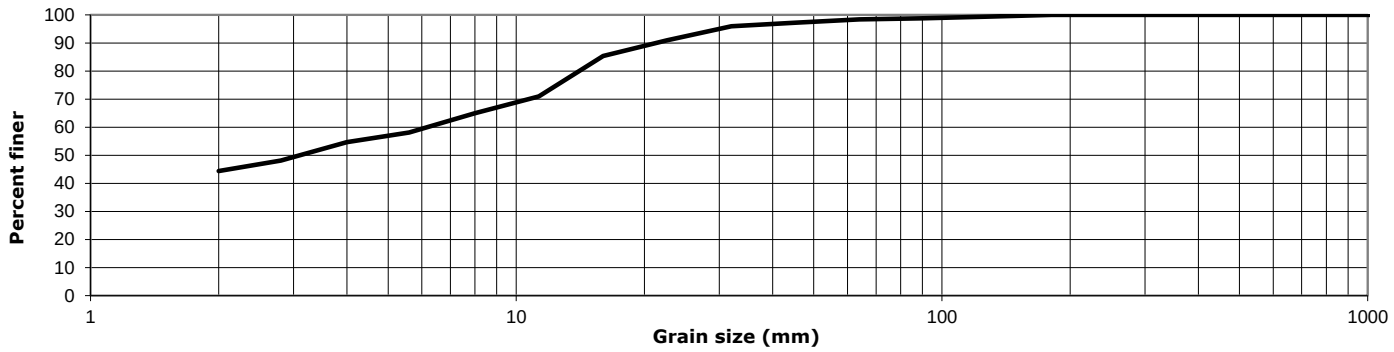
Substrate Characteristics

Particle Size (mm)

D_{10} :	2.0
D_{50} :	3.2
D_{84} :	15.0

Subpavement:	Till
Particle shape:	Platy
Embeddedness (%):	10 to 50
Particle range (riffle):	Clay to cobble
Particle Range (pool):	Clay to gravel

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	164.37
for D_{50}:	0.34	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.69	**Critical Shear Stress (D_{50}) (N/m^2):**	2.33
Unit Stream Power at Bankfull (W/m^2):	474.20		

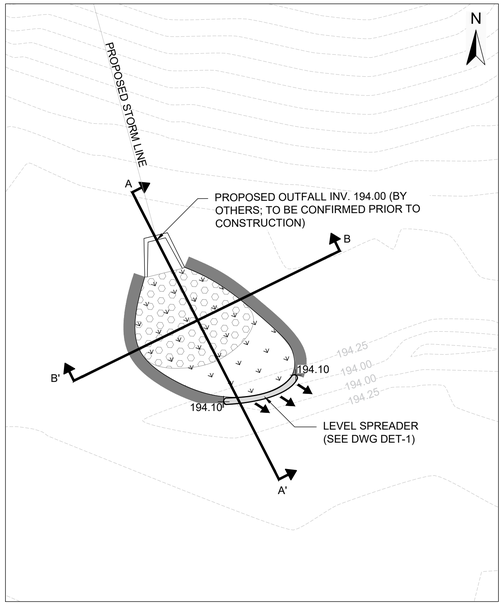
General Field Observations

Channel Description

Reach FCT-1 was a mixed-load meandering channel, with a moderate gradient that sits within a confined valley. The channel flowed through a continuous riparian buffer zone that extended 4 to 10 times the channel width and contained predominately trees and herbaceous vegetation. The channel was heavily encroached by vegetation. High density of woody debris was observed in the channel. The average bankfull width and depth were 2.44 m and 0.50 m. The average wetted width and depth were 0.93 m and 0.05 m. Bank angles ranged from 25 to 90 degrees, with undercutting measured up to 0.4 m. Bed materials ranged from clay to cobbles in riffles, and clay to gravel in pools. Bank material consisted of clay and silt.

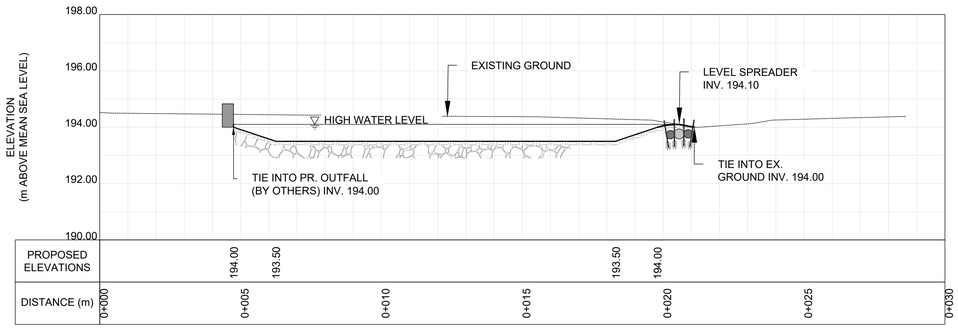
Cross Section 6 - Facing Upstream

Appendix F:
Outfall Design Drawings

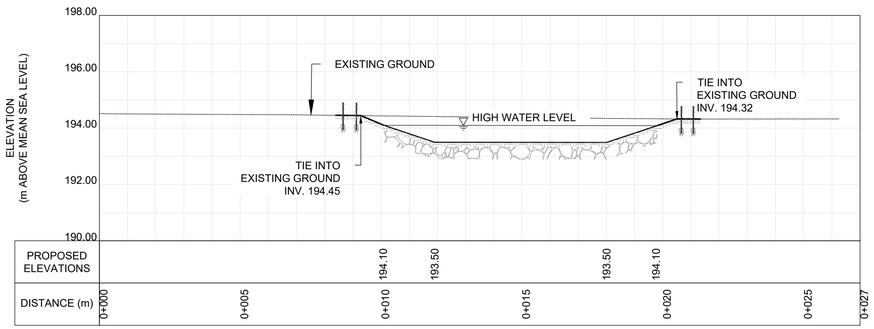


PLANFORM
1:250

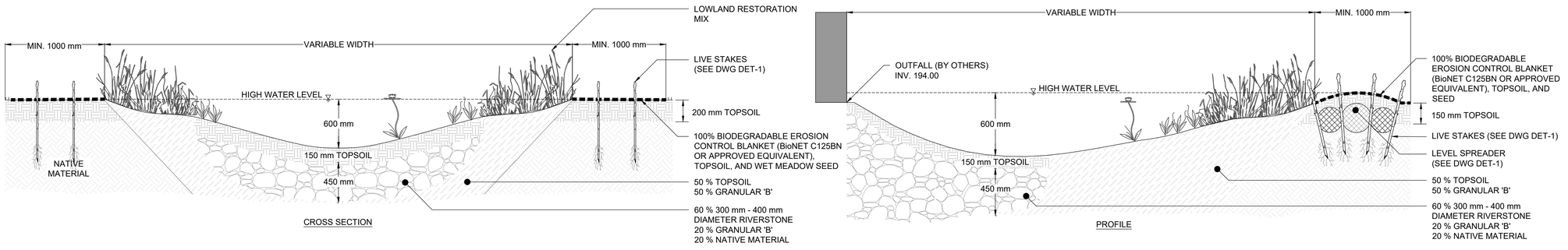
LEGEND
- SCONED (SEE DWG GEO-1)
- SCONED (SEE DWG GEO-1)
- 100% BIODEGRADABLE EROSION CONTROL BLANKET AND LIVE STAKES (SEE DWG DET-1)
- LEVEL SPREADER (SEE DWG DET-1)



CROSS SECTION A-A'
1:100

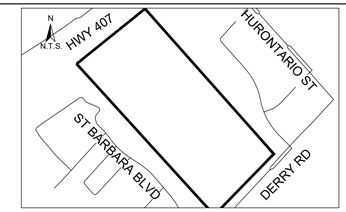


CROSS SECTION B-B'
1:100



STONE CORE NATURALIZED ENERGY DISSIPATER
N.T.S

LEGEND
- TOPSOIL
- STONE CORE (SEE DWG GEO-1)
- 100% BIODEGRADABLE EROSION CONTROL BLANKET, WET MEADOW SEED AND LIVE STAKES (SEE DWG DET-1)
- LEVEL SPREADER (SEE DWG DET-1)



KEY MAP
N.T.S.

GENERAL NOTES

1. THE ACCOMPANYING CHANNEL REALIGNMENT TECHNICAL DESIGN BRIEF PREPARED BY GEO MORPHIX LTD. (2025) PROVIDES ADDITIONAL DESIGN DETAILS AND DIRECTION FOR IMPLEMENTATION AND IS TO BE REVIEWED IN CONJUNCTION WITH THIS DRAWING SET.
2. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
3. THE CONTRACTOR MUST NOTIFY THE DESIGNER AND CONTRACT ADMINISTRATOR OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
4. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
5. LAYOUT MUST BE REVIEWED AND APPROVED BY THE DESIGNER / DESIGNER REPRESENTATIVE, DESIGNATED ENGINEER, AND THE CONTRACT ADMINISTRATOR.
6. CONSTRUCTION OBSERVATION IS TO BE PERFORMED BY A CERTIFIED FLUVIAL GEOMORPHOLOGIST OR EXPERIENCED ENVIRONMENTAL INSPECTOR UNDER DIRECTION FROM THE DESIGNER.
7. ON-SITE SUPPORT FROM PROJECT ENGINEER (E.G., GEOTECHNICAL, HYDROGEOLOGICAL, AND/OR WATER RESOURCES ENGINEER) REQUIRED TO ASSESS AND ENSURE FAVOURABLE SURFICIAL AND SUBSURFACE CONDITIONS TO SUPPORT CHANNEL REALIGNMENT CONSTRUCTION.
8. BE ADVISED THAT THE LOCAL REGULATORY BODY MAY, AT ANY TIME, WITHDRAW THIS PERMISSION, IF, IN THE OPINION OF THE AUTHORITY, THE CONDITIONS OF THE PERMIT ARE NOT BEING COMPLIED WITH. THIS APPROVAL DOES NOT EXEMPT THE PROPERTY OWNER/APPLICANT/AGENT FROM THE PROVISIONS OF ANY OTHER FEDERAL, PROVINCIAL OR MUNICIPAL STATUTES, REGULATIONS OR BY-LAWS, OR ANY RIGHTS UNDER COMMON LAW.

TIMING OF WORKS

1. WORKS SHALL BE COMPLETED DURING THE DESIGNATED IN-WATER WORKS WINDOW SET OUT BY MNR/DFO.
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4. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW.
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1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
2. FOLLOWING INSTALLATION OF THE PROPOSED ESC MEASURES, A QUALIFIED AGENT OF THE PROPONENT (E.G. CAN-CISEC CERTIFIED MONITOR) WILL CONDUCT REGULAR SITE VISITS TO MONITOR ALL WORKS, PARTICULARLY THE CONDITION OF THE ESC MEASURES, DEWATERING, AND IN- OR NEAR-WATER WORKS. SHOULD CONCERNS ARISE; THE ENVIRONMENTAL MONITOR WILL CONTACT THE PROPONENT, THE CONSERVATION AUTHORITY, AND ANY OTHER APPROPRIATE PARTIES.
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9. IF EXCESSIVE SILTATION RESULTS FROM THE CONSTRUCTION ACTIVITIES, THE ONSITE SUPERVISOR/INSPECTOR AND/OR THE LOCAL REGULATORY BODY RESERVE THE RIGHT TO REQUEST ADDITIONAL ESC MEASURES WHICH WOULD BE INSTALLED PRIOR TO FURTHER CONSTRUCTION ACTIVITIES.

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2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
4. A SPILL CONTAINMENT KIT MUST BE READILY ACCESSIBLE ON SITE IN THE EVENT OF A RELEASE OF A DELETERIOUS SUBSTANCE TO THE ENVIRONMENT. ONSITE STAFF MUST BE TRAINED IN ITS USE.
5. THE CONTRACT ADMINISTRATOR MUST BE NOTIFIED IMMEDIATELY IN THE EVENT OF A SPILL OF DELETERIOUS SUBSTANCE, ANY SEDIMENT SPILL FROM THE SITE SHOULD BE REPORTED TO MINISTRY OF ENVIRONMENT (SPILL ACTION CENTER) AT 1-800-268-6060.

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1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
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1.0	08/15/2025	AS	FIRST DETAILED DESIGN SUBMISSION TO CLIENT
	DATE	BY	REVISIONS

DESIGNED BY: AS | CHECKED BY: PV

DRAWN BY: RS | DATE: AUGUST 2025

DRAFT FOR INTERNAL DISCUSSION

NOT FOR CONSTRUCTION

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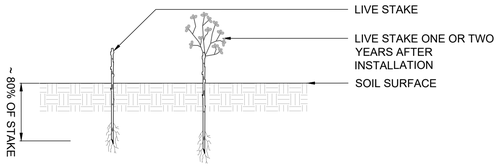
DEZEN REALTY DEVELOPMENT
7140 HURONTARIO STREET
CITY OF MISSISSAUGA

FLETCHERS CREEK
SWM OUTFALL DESIGN SUPPORT
PLANFORM AND PROFILE

PROJECT No.: PN25102 | DRAWING No.: GEO-1

SCALE: AS NOTED | SHEET 1 OF 2

SCALED FOR PLOT ON 'ARCH D'



SCIENTIFIC NAME	COMMON NAME	QTY	CONDITION
CORNUS STOLONIFERA	RED OSIER DOGWOOD	34	1 m, LIVE STAKE
SALIX BEBBIANA	BEBB'S WILLOW	34	1 m, LIVE STAKE
SALIX DISCOLOR	PUSSY WILLOW	34	1 m, LIVE STAKE
SALIX INTERIOR	SANDBAR WILLOW	34	1 m, LIVE STAKE
SALIX LUCIDA	SHINING WILLOW	34	1 m, LIVE STAKE

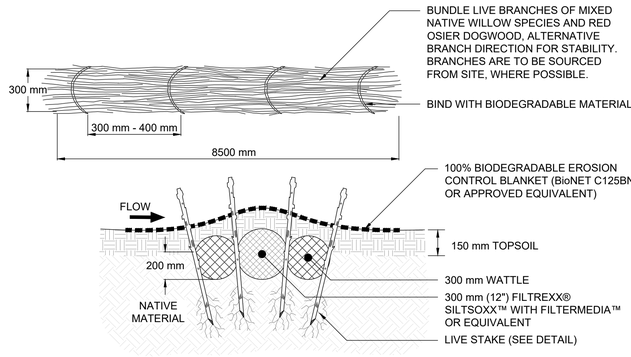
NOTES

1. QUANTITY TO BE DETERMINED BASED ON AREA OF DISTURBANCE TO BE RESTORED
2. LIVE STAKES SHOULD BE FROM AT MINIMUM 2-YEAR OLD STOCK.
3. LIVE STAKES ARE TO BE INSTALLED AT A DENSITY OF 3 STAKES PER SQUARE METRE.
4. LIVE STAKES SHOULD BE PRE-SOAKED (SUBMERGED IN WATER) FOR AT LEAST 24 HOURS AFTER HARVESTING AND IMMEDIATELY BEFORE INSTALLATION.
5. LIVE STAKES SHOULD NOT BE STORED FOR A PERIOD LONGER THAN 2 DAYS, UNLESS THEY ARE BEING SOAKED.
6. THE CONTRACTOR SHALL PROTECT PLANT MATERIALS FROM DRYING FROM THE TIME OF HARVEST UNTIL INSTALLED.
7. LIVE STAKES ARE TO BE A MINIMUM OF 25 mm IN DIAMETER AND CUT TO A LENGTH OF 1000 mm.
8. CUT ANGLE AT THE BOTTOM OF THE STAKE AND FLAT ON THE TOP.
9. TRIM ALL SIDE BRANCHES WHILE TAKING CARE NOT TO DAMAGE THE BARK.
10. INSTALL STAKES WITH BUDS POINTING UPWARDS AND THICKER STEM IN THE BED.
11. LIVE STAKES SHOULD BE INSTALLED USING A LARGE RUBBER MALLET.
14. IN COMPACT SOIL A PILOT HOLE MUST BE USED TO LIMIT DAMAGE TO THE STAKES. PILOT HOLES SHOULD BE MAX. 25 mm DIAMETER.
15. IF USING A PILOT HOLE REPACK SOIL AROUND THE LIVE STAKE.
16. 80% OF THE STAKE IS TO BE BELOW SURFACE.
17. TAMP THE LIVE STAKE INTO THE GROUND AT RIGHT ANGLE TO THE SURFACE.
18. LIVE STAKES SHOULD STAND FIRM FROM THE SOIL FOLLOWING INSTALLATION.
19. ALL STAKES NOT PLANTED TO THE SPECIFICATIONS ABOVE WILL BE REPLACED AT THE CONTRACTOR'S EXPENSE.

LIVE STAKING
N.T.S.

EROSION CONTROL BLANKET SPECIFICATIONS

1. A BIODEGRADABLE EROSION CONTROL BLANKET (ECB) SHALL BE INSTALLED ON ALL DISTURBED/NATURAL SURFACES FOLLOWING THE PLACEMENT OF TOPSOIL AND APPLICATION OF THE NATIVE SEED MIX.
2. THE ECB MUST BE CONSTRUCTED OF 100% WOVEN COCONUT FIBRE (E.G., COIR) OR STRAW MAT WITHIN A GEOJUTE NETTING (TOP AND BOTTOM) WITH BIODEGRADABLE THREAD. NON-BIODEGRADABLE MATERIAL INCLUDING POLYPROPELENE OR PLASTICS WITH A BIODEGRADABLE RATING ARE NOT ACCEPTABLE. THE MINIMUM WEIGHT OF THE ECB MUST BE 400 g/m^2 (12 oz./yd^2).
3. TO INSTALL, THE ECB MUST BE UNROLLED DOWNSLOPE OR IN DIRECTION OF WATER FLOW. ADJACENT ECBS SHOULD OVERLAP A MINIMUM OF 150 mm ALONG THE EDGES. AT THE END OF EACH ROLL, FOLD BACK 100 mm TO 200 mm OF THE ECB. OVERLAP THIS 100 mm TO 200 mm OVER THE START OF THE NEXT ROLL. SECURE THE TWO LAYERS TO THE GROUND SECURELY.
4. BIODEGRADABLE OR TAPERED WOODEN STAKES SHALL BE USED TO SECURE THE BLANKET. STAKES SHALL BE INSTALLED AT THE SPACING RECOMMENDED BY THE ECB MANUFACTURER TO PREVENT SURFACE RUNOFF FROM ERODING THE UNDERLYING SOIL.



NOTES

1. WATTLE AND SILTSOXX TO BE INSTALLED IN A 200 mm WIDE TRENCH AND STAKED EVERY METER.
2. WATTLE, SILTSOXX AND GRADING INSTALLATION TO RESULT IN A LEVEL BERM WITHOUT BREAKS.

WATTLE AND FILTREXX® SILTSOXX™ (OR EQUIVALENT) DETAIL
N.T.S.

CVC 3 – LOWLAND RESTORATION MIX

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
ANEMONE CANADENSIS	CANADA ANEMONE	1
BIDENS CERNUA	NODDING BEAGGARTICKS	1
CAREX VULPINOIDEA	FOX SEDGE	25
ELYMUS VIRGINICUS VAR. VIRGINICUS	VIRGINIA WILD RYE	25
EUTROCHIUM MACULATUM VAR. MACULATUM	SPOTTED JOE PYE WEED	1
JUNCUS EFFUSUS SUBSP. SOLUTUS	EASTERN SOFT RUSH	5
JUNCUS TENUIS	PATH RUSH	5
POA PALUSTRIS	FOWL BLUEGRASS	25
SCIRPUS ATROVIRENS	DARK GREEN BULRUSH	5
SYMPHYOTRICHUM NOVAE-ANGLIAE	NEW ENGLAND ASTER	1
SYMPHYOTRICHUM PUNICEUM	SWAMP ASTER	1
VERBENA HASTATA	BLUE VERVAIN	5

NOTES:

1. APPLY SEED MIX AT A RATE OF 25 kg PER HECTARE.
2. SEEDING SHALL OVERLAP ADJACENT GROUND COVER BY 300 mm.
3. SIMULTANEOUSLY APPLY THE SPECIED NURSE CROP MIX AT A RATE OF 15 kg PER HECTARE.
4. WATER SOIL AFTER SEED APPLICATION.

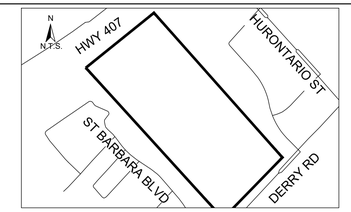
CVC RESTORATION NURSE CROP MIX

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
AVENA SATIVA	ANNUAL OATS	40
ELYMUS CANADENSIS	CANADA WILD RYE	15
HORDEUM VULGARE	BARLEY	45

NOTES:

1. APPLY SEED MIX AT A RATE OF 15 kg PER HECTARE.
2. SEEDING SHALL OVERLAP ADJACENT GROUND COVER BY 300 mm.
3. SIMULTANEOUSLY APPLY THE SPECIFIED NATIVE SEED MIX AT A RATE OF 25 kg PER HECTARE.
4. WATER SOIL AFTER SEED APPLICATION.
5. IF SEEDING IN FALL (OCTOBER-NOVEMBER), 100% WINTER WHEAT (TRITICUM AESTIVUM) SHOULD BE SUBSTITUTED FOR THE SPECIES LISTED ABOVE.

SCALED FOR PLOT ON 'ARCH D'



KEY MAP
N.T.S.

GENERAL NOTES

1. THE ACCOMPANYING CHANNEL REALIGNMENT TECHNICAL DESIGN BRIEF PREPARED BY GEO MORPHIX LTD. (2025) PROVIDES ADDITIONAL DESIGN DETAILS AND DIRECTION FOR IMPLEMENTATION AND IS TO BE REVIEWED IN CONJUNCTION WITH THIS DRAWING SET.
2. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
3. THE CONTRACTOR MUST NOTIFY THE DESIGNER AND CONTRACT ADMINISTRATOR OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
4. THE CONTRACTOR IS RESPONSIBLE FOR ALL UTILITY LOCATES.
5. LAYOUT MUST BE REVIEWED AND APPROVED BY THE DESIGNER / DESIGNER REPRESENTATIVE, DESIGNATED ENGINEER, AND THE CONTRACT ADMINISTRATOR.
6. CONSTRUCTION OBSERVATION IS TO BE PERFORMED BY A CERTIFIED FLUVIAL GEOMORPHOLOGIST OR EXPERIENCED ENVIRONMENTAL INSPECTOR UNDER DIRECTION FROM THE DESIGNER.
7. ON-SITE SUPPORT FROM PROJECT ENGINEER (E.G., GEOTECHNICAL, HYDROGEOLOGICAL, AND/OR WATER RESOURCES ENGINEER) REQUIRED TO ASSESS AND ENSURE FAVOURABLE SURFICIAL AND SUBSURFACE CONDITIONS TO SUPPORT CHANNEL REALIGNMENT CONSTRUCTION.
8. BE ADVISED THAT THE LOCAL REGULATORY BODY MAY, AT ANY TIME, WITHDRAW THIS PERMISSION, IF, IN THE OPINION OF THE AUTHORITY, THE CONDITIONS OF THE PERMIT ARE NOT BEING COMPLIED WITH. THIS APPROVAL DOES NOT EXEMPT THE PROPERTY OWNER/APPLICANT/AGENT FROM THE PROVISIONS OF ANY OTHER FEDERAL, PROVINCIAL OR MUNICIPAL STATUTES, REGULATIONS OR BY-LAWS, OR ANY RIGHTS UNDER COMMON LAW.

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FLETCHERS CREEK SWM OUTFALL DESIGN SUPPORT PLANFORM AND PROFILE

PROJECT No.: PN25102	DRAWING No.: DET-1
SCALE: AS NOTED	SHEET 2 OF 2