GEO MORPHIX™

West Humber River
Fluvial Geomorphological Assessment

12489 and 12861 Dixie Road
Caledon, Ontario

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1 Introduction

GEO Morphix Ltd. ("GEO Morphix") was retained to complete a fluvial geomorphological assessment for tributaries of the West Humber River in support of a development application for 12861 and 12489 Dixie Road ("Subject Lands"). The subject lands are generally situated east of Dixie Road and south of Old School Road in the Town of Caledon and fall within the jurisdictional area of the Toronto Region Conservation Authority (TRCA).

To support planning and development activities for the subject lands, a fluvial geomorphological assessment was completed to characterize watercourses on site and delineate the meander belt width associated with each watercourse feature. The meander belt width extent is used, in part, to support constraint delineation and the overall limit of development. Preliminary erosion threshold estimates were also completed to support initial stormwater management and erosion mitigation strategies for the site.

To complete the fluvial geomorphological assessment for watercourses on site, the following activities were completed:

- Review of available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Watercourse reach delineation by desktop assessment and confirmed through field reconnaissance
- Review of recent and historical aerial photographs to understand historical changes in land use and channel form and function and to inform meander belt width delineation
- Complete field reconnaissance to understand general property and watercourse characteristics
- Delineate the erosion hazard (i.e., meander belt width) on a reach-by-reach basis based on results of the desktop and field assessments
- Complete detailed geomorphic field assessments to inform preliminary erosion threshold calculations
- Estimate preliminary erosion thresholds for watercourses potentially receiving stormwater discharge through field and desktop data analysis
- Provide recommendations and guidance to address erosion mitigation requirements for future design phases

2 Background Review and Desktop Assessment

2.1 Background Information

The subject section of West Humber River is situated within the Toronto and Region Conservation Authority (TRCA) jurisdiction as part of the Humber River watershed. The Humber River watershed originates in the Oak Ridges Moraine, outlets to Lake Ontario, and encompasses approximately 911 square kilometers (TRCA, 2021). The West Humber River specifically originates in Caledon (South Slope) and flows over 45 km (crossing Peel Plain) in Brampton prior to its confluence with the Main Humber River in Toronto (TRCA, 2021).

A small tributary of the West Humber River originates west of Dixie Road and flows roughly northwest to southeast along the eastern margin of Dixie Road through 12861 Dixie Road. The tributary drains to a larger branch of the West Humber River which bisects the central portion of the Subject Lands between 12861 and 12489 Dixie Road. The larger tributary is situated within the Greenbelt Plan Area.

A small section of Kilamanagh Creek (tributary to the West Humber River) also flows southwest to northeast through the southeastern corner of the subject lands through 12489 Dixie Road. Kilamanagh Creek is also situated within the Greenbelt Plan Area and is designated by the Ministry of the Environment, Conservation and Parks (MECP) as redside dace (*Clinostomus elongatus*) habitat. This has implications with respect to the limit of development in proximity to the creek, as redside dace and its

habitat are regulated under the provincial *Endangered Species Act, 2007 (ESA)* and the *Species at Risk Act, 2002 (SARA)*.

Additional drainage features on-site were observed through a desktop assessment of recent aerial imagery from Google Earth Pro. Recent aerial photographs indicate that there are small headwater drainage features on site that extend through existing agricultural fields. It should be noted that these features are only visible through aerial photograph interpretation and are not included in any available stream layer datasets reviewed through the desktop assessment. A headwater drainage feature assessment was completed by Stantec and is summarized in the Environmental Impact Study (EIS) for the subject lands (*12489 & 12861 Dixie Road, Caledon, Ontario – Draft Environmental Impact Study – Stantec File No. 160623114, 160623115 – November 2023*). A map of the subject lands and various drainage features is provided under **Appendix A**, for reference.

Based on plans developed by Stantec Consulting (2024), we understand that two stormwater management (SWM) ponds are proposed within the subject lands. One SWM pond is located east of the West Humber River tributary that runs north to south, parallel and east of Dixie Road. The Pond will ultimately discharge to the north-south tributary. The second SWM pond is further south on the east side of Dixie Road and will ultimately outlet to the Kilamanagh Creek branch in the southwest portion of the lands.

2.2 Surficial Geology and Physiology

Surficial geology and physiography act as constraints to channel development and tendency. These factors determine the nature and quantity of the availability and type of sediment. Secondary variables that affect the channel include land use and riparian vegetation. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

Within the subject property, the West Humber River and associated tributaries are dominated by the Till Plains (drumlinized) physiographic region of Ontario (Chapman and Putnam, 2007). In terms of surficial geology, the subject lands are characterized by till (OGS, 2010). Soils within these areas include clay to silt-textured clay derived from glaciolacustrine deposits or shale (OGS, 2010). Additionally, along the downstream extent of the northern tributary, soils were characterized by modern alluvial deposits, including clay, silt, sand, gravel, and organic remains (OGS, 2010).

2.3 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. Specifically, an aerial photograph from 1974 (1:25,000) was obtained from the National Air Photo Library (NAPL), and recent Google Earth Pro imagery for the years 2004, 2009, 2015 and 2019 were reviewed to understand site history and inform the erosion hazard assessment. All aerial images are provided in **Appendix B** for reference. **Table 1** below summarizes historical changes in land use and land cover based on year and subwatershed.

Table 1: Historical assessment summary

	Tributaries of the West Humber River	Kilamanagh Creek
1974	• Land use was predominantly agricultural and rural residential • Two tributaries of the West Humber River were visible, one flowing parallel to Dixie Road and into the larger main tributary that flows southwest to northeast	• Land use was predominantly agricultural and rural residential • Upstream of the subject lands the channel may have been straightened to facilitate agricultural practices • Within the subject lands Kilamanagh Creek had a low sinuosity planform with few meanders

	Tributaries of the West Humber River	Kilamanagh Creek
	• Channel planform of the smaller tributary appeared to be previously straightened for agricultural purposes • Large offline pond present adjacent to upstream extent of the small tributary • Limited natural riparian vegetation present along the smaller tributary • Channel planform of the main tributary appeared to be previously straightened for agricultural purposes along the upstream extent, meandering planform initiating near the downstream forested extent • Natural riparian vegetation was limited to the section of channel in the northern portion of the subject lands for the main tributary • Both tributaries likely received fine sediment inputs due to lack of riparian vegetation and adjacent farming activities • Low order tributaries faintly visible but appeared cultivated	• Limited natural riparian vegetation apparent along the channel • Channel likely received fine sediment inputs due to lack natural of riparian vegetation along some sections of channel and adjacent farming activities
2004	• No significant changes to land use within the subject lands, a golf course was constructed northeast of the subject property • Straightened channel planform of tributary parallel to Dixie Road readily apparent in imagery, a small headwater feature is visible flowing into the middle section of the small tributary • Natural riparian vegetation was retained and matured along the main tributary within the subject lands • Rural development had expanded when compared to 1974	• Two large offline ponds were constructed adjacent to Kilamanagh Creek, one was located upstream of Dixie Road and the other was situated on the north side of the channel within the subject lands, during high water levels it is likely that the ponds overtop into the channel • Channel planform had been modified to accommodate the pond and larger meanders observed in 1974 imagery are no longer apparent • Riparian zone along the upstream portion of Kilamanagh Creek had naturalized with few mature trees, obscuring the channel planform • Riparian vegetation along the downstream portion of the channel remained generally sparse, and the meandering planform appeared more sinuous when compared to 1974 • Rural development had expanded when compared to 1974
2009	• No significant changes to land use or channel planform within and upstream of the subject lands • Naturalization of woody vegetation along the main tributary channel banks within subject lands, which may have improved channel stability, coarse organic matter inputs and shade to the larger tributary	• No significant changes to land use or channel planform within the subject lands • Narrow band of vegetation permitted to naturalize along the channel, which likely improved channel stability, coarse organic matter inputs and shade to the channel

	Tributaries of the West Humber River	Kilamanagh Creek
2019	• No significant changes to land use or channel planform within and upstream of the subject lands • Woody riparian vegetation along the downstream portion of the main tributary was able to mature and obscures the channel planform	• A large industrial building was constructed with two stormwater management ponds on the west side of Dixie Road, across from the channel. • No significant changes to channel planform within the subject lands were observed • Woody riparian buffer along Kilamanagh Creek has further naturalized and matured

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are divided as such because they are expected to have similar inputs and outputs in terms of sediment and discharge. They are also expected to react similarly 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 channel modifications by humans

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field.

Five (5) watercourse reaches were delineated within the subject property. **Reach 4a** and **Reach 4b** are situated along Kilamanagh Creek: **Reach 4b** extends from Dixie Road to the downstream extent of an offline pond and **Reach 4a** extends from the downstream extent of the offline pond to the eastern property boundary. **Reaches 7**, **8** and **8a** are associated with tributaries of the West Humber River through the central portion of the subject lands. **Reaches 7** and **8** flow northeast to southwest within the centre of the subject property. **Reach 8a** flows west to east parallel to Dixie Road and flows into **Reach 8**. The extent of each reach is shown in **Appendix A**.

3.2 General Reach Observations

Field investigations were completed along the reaches within the subject lands on June 13, 2023 and November 12, 2024. The following data were collected for all reaches assessed in the field:

- 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 field descriptions are supplemented with representative photographs, which are included in **Appendix C**. Field sheets, including those completed for rapid assessments, are provided in **Appendix D**. A summary of the general observations characterizing the delineated reach is presented in **Table 2**.

Table 2: Reach characteristics summary

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed Substrate	Riffle Substrate	Dominant Riparian Condition	Notes
Reach 4a	3.36	0.65	Clay/silt, sand, gravel, and cobbles*		Continuous coverage of grasses	Partially confined system;
Reach 4b	3.25	0.66	Clay/silt, sand, gravel, and cobbles*		Continuous coverage of grasses and mature trees	Partially confined system, moderate bank erosion with valley wall contacts
Reach 7	7.17	0.85	Clay/silt, sand, and exposed parent material	Sand, gravel, and cobbles	Continuous coverage of mature trees and grasses	Partially confined system; valley wall contacts, fallen trees common throughout channel
Reach 8	4.10	0.67	Clay/silt, sand	Sand, gravel, and cobbles	Herbaceous species, with scattered shrubs and trees	Partially confined system, moderate density of woody debris
Reach 8a	4.59	0.79	Clay/silt, sand and gravel	Gravel and cobble	Continuous coverage of grasses	Partially confined system, evidence of erosion throughout the reach

**Uniform bed morphology*

Reach 4a was characterized as an irregularly meandering, moderate gradient channel situated within a partially confined valley. The riparian zone was dominated by a continuous coverage of grasses that heavily encroached the channel. The channel was dominated by runs with few pools; riffles were not observed along the reach. Bed substrate was comprised of clay/silt, sand, gravel, and cobbles. Bank angles ranged from 30° to 60° with undercuts measuring up to 0.80 m. Average bankfull width and depth were 3.36 m and 0.65 m, respectively.

Reach 4b was situated in a partially confined valley, adjacent to a large offline pond. The reach was characterized as irregularly meandering with a moderate gradient and perennial flow regime. The riparian zone was comprised of a continuous coverage of grasses and mature trees. Like **Reach 4a**, the channel was dominated by runs with few deep pools and no riffles present. Bed substrate was comprised of clay/silt, sand, gravel, and cobbles; bank substrate was composed of clay, silt, and sand. Average bankfull width and depth were 3.25 m and 0.66 m, respectively. Bank angles ranged from 30° to 60° with a moderate amount of bank erosion observed through undercutting, valley wall contacts and basal scour. A low density of woody debris was observed in the channel and cutbanks.

Reach 7 was characterized as an irregularly meandering, moderate gradient channel situated within a partially confined valley. The riparian zone was wide spanning greater than 10 channel widths and was dominated by a continuous coverage of mature trees and grasses. Riffle-pool morphology was present with bed substrate ranging from clay/silt to cobbles and exposed parent material (till). Average bankfull width and depth were 7.17 m and 0.85 m, respectively. Bank angles ranged from 60° to 90° and bank erosion was observed along 60% to 100% of the reach. Erosion was evident as undercutting, exposed tree roots and valley wall contacts. A low density of woody debris was present in the channel and cutbanks.

Reach 8 had an irregularly meandering planform and was a low gradient channel situated in a partially confined valley. The riparian zone was wide and dense, dominated by a continuous coverage of trees and shrubs. Riffle-pool morphology was observed with riffle substrate ranging from sand to cobbles and pool substrate ranging from clay/silt to sand. Rooted emergent aquatic vegetation was observed through 25% of the reach. Average bankfull width and depth were 4.10 m and 0.67 m, respectively. Bank angles ranged from 30° to 60° and the banks were moderately eroded. Evidence of erosion included exposed tree roots, undercuts and valley wall contacts. A moderate density of woody debris was present in the channel and cutbank.

Reach 8a was slightly sinuous and historically straightened to facilitate agricultural practices. The channel had a low gradient and was situated within a partially confined valley with valley walls at a significant distance from the centre of the channel. The floodplain adjacent to the channel is primarily used as pastured land. At the time of assessment, high flows were observed following a storm event, and much of the floodplain adjacent to the channel was inundated with water. Riparian vegetation in the corridor consisted of immature grasses with several mature trees. The riparian zone was greater than 10 channel widths wide with minimal encroachment on the channel. Aquatic vegetation including rooted emergent plants and attached algae covered approximately 45% of the reach. Riffle-pool geomorphic units were observed throughout the reach. The bed was noted to be predominantly sand and gravel with finer silts noted in pools and coarser cobbles noted in riffles. The banks of the stream consisted of clay, silt, and sand. Bank erosion was noted along 60% to 100% of the reach and was observed as bank slumps and undercutting. Bank angles were observed to be undercut or approximately 60° to 90° bank angle. Average bankfull width and depth was 4.59 m and 0.79 m, respectively.

3.3 Rapid Geomorphological Assessment Tools

Rapid assessments were completed to identify dominant geomorphic processes, document stream health, and to identify any areas of concern regarding erosion or instability. Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function 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.

Reaches were also classified according to a modified Downs (1995) Channel Evolution Model. The Downs model describes successional stages of a channel because 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 results of these assessments are summarized below.

The River Styles Framework (Brierley and Fryirs, 2005) provides a geomorphic approach to examining river character, behaviour, condition and recovery potential through the identification of the Geomorphic Process Zone. Geomorphic attributes are assessed, larger scale interactions between zones are analyzed, and historical data are studied to understand the historical evolution and future trajectories of those reaches. This ultimately provides a physical template for river management. A modified classification approach was applied to the study reaches. A summary of the reach classifications and rapid assessment scores is provided in Error! Reference source not found.**3**.

Table 3: Summary of rapid assessment results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995) Channel Evolution Model	River Styles Framework (Bierley and Fyris, 2005)
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)		
Reach 4a	0.21	In Transition/Stress	Evidence of Widening	23	Fair	Riparian Habitat Condition	E - Enlarging	Mixed load meandering
Reach 4b	0.24	In Transition/Stress	Evidence of Widening	22	Fair	Riparian Habitat Condition	E - Enlarging	Mixed load meandering
Reach 7	0.37	In Transition/Stress	Evidence of Widening	30	Good	Channel Stability	U - Undercutting	Mixed load meandering
Reach 8	0.25	In Transition/Stress	Evidence of Planimetric Form Adjustment	25	Good	Riparian Habitat Condition	E - Enlarging	Mixed load meandering
Reach 8a	0.17	In Regime	Evidence of Aggregation	23	Fair	Riparian Habitat Condition	E - Enlarging	Suspended load sinuous

Reach 4a was evaluated to be in transition/stress, with an RGA score of 0.21. The dominant systematic adjustment was evidence of widening. The channel contained basal scour on the inside of meander bends and both sides through the riffles. The reach was assigned an RSAT score of 23, indicating it was in fair condition. The limiting factor was riparian conditions. The Downs (1995) classification indicated that this reach was enlarging (E). The reach was a mixed load meandering channel under the River Styles Framework.

The RGA results for **Reach 4b** indicated that the reach was in transition/stress, with a score of 0.24. The dominant mode of systematic adjustment was evidence of widening. This was shown by occurrence of large organic debris, exposed tree roots, and basal scour. The RSAT indicated the reach was in fair condition with a score of 22. The limiting factor was riparian habitat condition. The riparian corridor was narrow with limited canopy coverage. Similar to **Reach 4b,** the Downs (2005) channel evolution model classified this reach as enlarging (E). The reach was a mixed load meandering channel under the River Styles Framework.

Reach 7 was assigned an RGA score of 0.37, indicating the reach was in transition/stress. The dominant systematic adjustment was evidence of widening. The channel had fallen/leaning trees, occurrence of organic debris and exposed tree roots. The RSAT resulted in a score of 30, or good. The limiting factor was channel stability due to undercutting, bank slumps, and valley wall contacts. **Reach 7** was characterized as an undercutting (U) channel under the Downs (1995) classification and a mixed load meandering channel under the River Style Framework.

The RGA results for **Reach 8** indicated the reach was in transition/stress, with a score of 0.25. The dominate mode of systematic adjustment was evidence of planimetric form adjustment. Formation of chutes, single thread to multiple channels and cut-off channels were observed. The RSAT indicated the reach was in good condition with a score of 25. The limiting factor was riparian habitat condition. The reach had a riparian zone consisting of grasses and herbaceous vegetation with few trees and limited canopy cover. The Downs (1995) classification indicated that the channel was enlarging (E), and the River Style Framework characterized the channel as mixed load meandering.

Reach 8a was evaluated to be in regime with an RGA score of 0.17. The dominant systematic adjustment was evidence of aggregation. Siltation in pools, coarse material embedded in riffles and poor longitudinal sorting of bed materials indicate aggradation of the channel. The RSAT resulted in a score of 23, or fair condition. The limiting factor was riparian habitat condition due to the lack of woody vegetation and limited canopy cover in the riparian buffer. The Downs (1995) classification indicated

that the channel was enlarging (E). The reach was a suspended load-dominated sinuous channel under the River Styles Framework.

3.4 Detailed Geomorphological Assessments

Detailed geomorphological assessments were completed in Fall 2024. These assessments provide bankfull channel characteristics, cross-sectional geometry, sediment characterization, and hydraulic information for use in defining appropriate erosion thresholds. Reaches were selected for assessment based on proximity to the zone of impact associated with their respective pond outlet. . **Reaches 7**, **8a**, and **4a** were selected for detailed geomorphic assessments. A map with the locations of these assessments is provided in **Appendix A**.

Representative cross-sections were surveyed along each reach to characterize channel geometry, and a longitudinal bed survey was completed to measure the channel gradient. Detailed observations of bank conditions were collected at each cross section. A modified Wolman (1954) pebble count was completed, where applicable, to characterize the bed materials. Sediments sampled from bank and fine bed materials were collected for further review and laboratory grain size analysis to provide additional details regarding substrate composition and erosion sensitivity. For each assessed reach, a summary of measured and computed values is presented in **Table 4**.

4 Erosion Threshold Analysis

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia, 2008; Villard and Parish, 2003). As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Erosion thresholds were modelled from detailed field observations of **Reaches 7**, **8a**, and **4a**. These reaches were selected for the assessment, as they were determined to be the most erosion-sensitive reaches immediately downstream of the SWM outlets for the proposed development.

The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the morphology of the channel and characteristics of the bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate of erosion potential.

A theoretical erosion threshold is an inherently conservative value, as it represents the force required to initiate sediment motion rather than the force needed for systemic erosion. The methods applied also make assumptions necessary to adopt when the variability of a natural channel is reduced to variables in an equation, adding to the inherent conservatism. The shear acting on the bed material is assumed to be representative of the total shear in the hypothetical representative cross-section. At the same time, in a natural channel, there is additional resistance to erosion provided by vegetation and non-uniform channel bed geometry that dissipates a portion of the force. Subtracting the resistance from the total shear gives the effective shear, which is the force acting on the bed in a natural channel.

Erosion thresholds are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach can also be applied. For cohesive materials, a method such as that described by Komar (1987), or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994), can be applied.

An erosion threshold, defined in terms of a critical discharge, is quantified based on the bed and bank materials and local channel geometry. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, U, or Shear Stress, t, is calculated at various depths for a representative cross section until the average velocity or shear stress in slightly exceeds the critical threshold of the bed material. The velocity is determined using a Manning's approach, where the Manning's n value is visually estimated through a method described by Acrement

and Schneider (1989) or calculated using the Limerino (1970) approach. The velocity is mathematically represented as:

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

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

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

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

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

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

The Ontario Soil Survey Complex identifies five soil types within the drainage areas upstream of and within the reaches: Chingacousy Clay Loam, Jeddo Clay Loam, Oneida Clay Loam, Bookton sandy loam, and Fox sandy loam (OMAFRA, 2024). The former three soils are calcareous fine-grained soils derived from Till diamicton parent materials, while the latter two soils are calcareous medium-grained sandy soils derived from sandy glacial moraine deposits overlying local clay till (Gillespie, Wicklund, and Miller, 1967). The banks within **Reaches 7** and **8a** were characterized as predominantly consisting of silt loam, based on the criteria of Fischenich (2001) as this soil type most closely matches observations made during field assessments. The banks within **Reach 4a** were characterized as predominantly consisting of sand loam, based on the criteria of Julien (1998) as this soil type most closely matches observations made during field assessments and the results of particle size analysis conducted on samples taken during the field assessment.

A critical velocity approach was taken using the criteria of Julien (1998) for the silt loam bank material in **Reaches 7** and **8a**, and for the sand loam bank materials in **Reach 4a**. These materials are estimated to have critical velocities of 0.53 m/s and 0.50 m/s, respectively, which were used to determine the threshold discharges for these reaches. Threshold discharge is an estimate of the discharge at which sediment entrainment begins to occur. Manning's roughness values were adopted for the critical discharge calculations for each reach, based on the framework described by Acrement and Schneider (1989). A value of n = 0.045 was adopted for **Reach 7**, a value of n = 0.040 was adopted for **Reach 8a**, and a value of n = 0.045 was adopted for **Reach 4a**.

Based on a critical velocity of 0.53 m/s, the critical discharge for the bank materials within **Reach 7** was predicted to be 0.998 m^3/s. Using the same critical velocity, the critical discharge for the bank materials within **Reach 8a** was predicted to be 0.946 m^3/s. Based on a critical velocity of 0.50 m/s, the critical discharge for the bank materials within **Reach 4a** was predicted to be 0.599 m^3/s.

The beds within **Reaches 7**, **8a** and **4a** were characterized as predominantly consisting of sediments ranging in size from silt to cobble. Angular, sub-angular, and platy gravel to cobble sized sediments were observed at all cross-sections surveyed within these reaches during field assessments. These bed sediments were classified as graded silt to cobbles, based on the criteria of Julien (1994), as this most closely matches observations made during field assessments. This material is estimated to have a critical velocity of 1.14 m/s, which was used to determine the threshold discharges for these reaches. The same Manning's n values listed above were adopted for bed material calculations for the respective reaches.

Based on critical velocity of 1.14 m/s, the critical discharge for the bed materials within **Reach 7** was predicted to be 4.675 m^3/s. Using the same critical velocity, the critical discharge for the bed materials within **Reach 8a** was predicted to be 6.772 m^3/s. Based on critical velocity of 1.14 m/s, the critical discharge for the bed materials within **Reach 4a** was predicted to be 6.331 m^3/s.

The results of the erosion threshold assessment are provided in **Table 4** below.

Table 4: Detailed field assessment and erosion threshold analysis results

Channel Parameter	R4a		R8a		R7	
Channel Characteristics						
Average bankfull width (m)	4.32		4.37		7.07	
Average bankfull depth (m)	0.35		0.30		0.32	
Channel gradient (%)	0.55		0.36		0.66	
D_{50} (mm)	14.6		2.8		11.0	
D_{84} (mm)	64.0		19.0		65.0	
Manning's n roughness coefficient	0.045		0.040		0.045	
Average bankfull discharge (m^3/s)	1.21		1.34		1.65	
Average bankfull velocity (m/s)	0.76		0.77		0.82	
Drainage area* (h)	1194		847.20		970.05	
Erosion Threshold Analysis						
	Bed	**Banks**	**Bed**	**Banks**	**Bed**	**Banks**
Material	Silt to cobbles	Sandy loam	Graded loam to cobbles	Silty loam	Graded loam to cobbles	Silty loam
Reference	Julien (1994)	Julien (1994)	Julien (1994)	Fischenich (2001)	Julien (1994)	Fischenich (2001)
Critical velocity (m/s)	1.14	0.50	1.14	0.53	1.14	0.53
Apparent shear stress (N/m^2)	35.18	15.59	19.08	9.46	24.57	11.68
Critical depth (m)	0.65	0.29	0.71	0.36	0.50	0.24
Critical discharge (m^3/s)	6.331	0.599	6.772	0.946	4.675	0.998
Unitary threshold ($m^3/s/ha$)	0.0053	0.0005	0.0080	0.0013	0.0048	0.0010
Limiting critical discharge (m^3/s)	**0.599**		**0.946**		**0.998**	
Unitary threshold ($m^3/s/ha$)	**0.0005**		**0.0013**		**0.0010**	

* *Drainage areas estimated using combination of the Ontario Watershed Information Tool (OWIT)*

Drainage areas were estimated for **the above reaches** using the Ontario Watershed Information Tool (OWIT) to derive preliminary unitary erosion thresholds for comparison across similar watersheds. The drainage area of 1194 ha for **Reach 4a** resulted in a preliminary unitary erosion threshold of 0.0005 $m^3/s/ha$. A drainage area of approximately 847 ha was estimated for **Reach 8a**, resulting in a preliminary unitary erosion threshold of 0.0013 $m^3/s/ha$. A drainage area of approximately 970 ha was estimated for **Reach 7**, resulting in a preliminary unitary erosion threshold of 0.0010 $m^3/s/ha$.

These values are comparable to unitary erosion thresholds accepted for watercourses with similar characteristics, including other watercourses in the Humber River watershed and nearby watersheds within the TRCA as well as neighbouring conservation authority jurisdictions. Stormwater management and erosion mitigation strategies, such as low-impact development (LID), water detention, and water retention, for example, applied in similar and nearby watersheds are thus likely to be sufficient to

address downstream impacts associated with the proposed development. We recommend that the pond release rates be refined through detailed design and that a combination of onsite SWM detention and retention through LIDs be implemented.

5 Erosion Hazard Delineation

5.1 Meander Belt Width

Most watercourses in Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width 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 erosion hazard to proposed activities adjacent to a given watercourse.

In unconfined systems, a meander belt width can be applied, at minimum, based on 20 times the bankfull channel width. Alternatively, the meander belt width can be determined through a detailed geomorphological study that examines the largest channel meanders observed through historical and recent aerial photograph interpretation. The meander belt width can then be graphically defined using orthorectified aerial imagery by determining the channel centerline and the channel's central tendency (i.e., meander belt axis). In cases where the channel is not discernible in aerial photographs or the channel has been substantially modified, empirical models can be used to estimate the meander belt width.

Partially confined systems are those where meander bends are adjacent to only one valley wall and the watercourse is therefore restricted in migration and floodplain occupation on one side of the valley system. Confined systems are those where the watercourse position is such that meander bends are adjacent to both valley walls and meander migration is restricted on both sides of the valley. The Ontario Ministry of Natural Resources (MNR) outlines an approach for establishing the erosion hazard where watercourses are confined by valley walls. This approach defines an appropriate erosion setback or toe erosion allowance from a channel bank where the creek is within 15 m of the toe of the valley slope. The toe erosion allowance is combined with a stable slope allowance to form the overall long-term stable slope (i.e., erosion hazard for confined valleys).

Based on field observations and available topographic data, **Reaches 4a**, **4b**, **7**, **8** and **8a** are partially confined. In this case, a meander belt width has been defined for each reach. In areas where the meander belt width extends beyond the valley wall, it has been truncated along the estimated toe of slope, which is the point where channel migration is impeded. If delineation of a long-term stable slope is required for any of the valley features on site, geomorphic confirmation will be required to define an appropriate toe erosion allowance. It should be noted that any stable slope allowance and final long-term stable slope line should be completed and delineated by a geotechnical engineer.

As meanders within the subject lands were not readily visible in aerial imagery due to the presence of woody vegetation and channel form, meander belt widths were calculated using an empirical modelling approach. The series of empirical models used to estimate meander belt widths are scientifically defensible and have been verified in past projects as suitable for use in southern Ontario.

A meander belt width was calculated based on TRCA's (2004) empirical model [Eq.1]:

$$B_w = -14.827 + 8.319\ln(\rho g Q S * DA) \quad \text{[Eq. 3]}$$

where ρ is water density (1000 kg/m^3), g is acceleration due to gravity (9.8 m/s^2), Q is discharge (m^3/s), S is channel slope (m/m), and DA is drainage area (km^2). Drainage area values are based on information available through the Ontario Watershed Information Tool (OWIT).

In addition to the TRCA (2004) model described above, empirical relations such as those modified from Williams (1986) [Eqs. 3 and 4] were used to delineate the meander belt width, and includes the width of the channel as follows:

$$B_w = 18A^{0.65} + W_b \quad \text{[Eq. 4]}$$

$$B_w = 4.3W_b{}^{1.12} + W_b \quad \text{[Eq. 5]}$$

where *A* is bankfull cross-sectional area (m^2) and W_b is average bankfull channel width (m). An additional 20% buffer was applied to the computed results as a factor of safety.

The Ward et al. (2002) model [Eq.5] was also used to determine meander belt widths (ft), B_w:

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

A 20% factor of safety was not applied to this value due to the approach used in the modelling (i.e., hazard envelope rather than a linear relationship). The results of the meander belt width assessment are provided in **Table 4.** Refer to **Appendix A** for the extent of the meander belt width along each reach.

Table 5: Summary of meander belt widths

Reach	Valley Form	Meander Belt Width (m)				Recommended Meander Belt Width (m)*
		Williams (1986) Area*	Williams (1986) Width *	Ward et al. (2002) Width	TRCA (2004)**	
Reach 4a	Partially Confined	40	24	27	60	40
Reach 4b	Partially Confined	40	23	26	58	40
Reach 7	Partially Confined	78	56	63	59	78
Reach 8	Partially Confined	46	30	34	55	46
Reach 8a	Partially Confined	55	34	38	59	55

** A 20% factor of safety is included*
*** 1 standard error (8.63 m) is included*

The range of meander belt widths derived from the empirical modelling ranged from 30 m to 78 m for the reaches along the tributaries of the West Humber River. Meander belt width estimates were selected based on the Williams Area (1986) model. **Reach 7** was recommended as 78 m, **Reach 8** was recommended as 46 m, and **Reach 8a** was recommended at 55 m. These meander belt widths include a 20% factor of safety. Using the Williams Area (1986) model is considered a conservative estimate as it is slightly larger than meander belt width values for most of the reaches, it is also based on bankfull channel dimensions and is comparable to meander belt width values calculated using drainage area and 2-year discharge. The meander belt widths also generally fall within the extent of the valley bottom width, where the channel can realistically migrate.

The meander belt widths derived from the empirical modelling range from 24 m to 60 m for the reaches along Kilamanagh Creek. A meander belt width of 40 m is recommended based on the Willams Area (1986) model. A greater meander belt width such as 60 m would extend beyond the extent of defined slopes adjacent to the creek. The channel can not realistically migrate beyond the valley toe. The 40 m meander belt width is generally situated within the width of the valley floor, and as such, it is more appropriate and realistic.

Refer to **Appendix A** for mapping of the meander belt width extent along each reach. It should be noted that in areas where the meander belt width extended beyond the valley walls, the meander belt width has been truncated along the estimated valley toe of slope given that the valley will act to limit channel migration. As noted previously, if future long-term stable slope analysis is required, additional geomorphic analysis should be completed to confirm appropriate toe erosion allowance requirements. However, the final long-term stable slope would need to be completed and confirmed by a geotechnical engineer.

6 Redside Dace Habitat Delineation

Kilamanagh Creek within the subject lands is considered Redside Dace (*Clinostomus elongatus*) habitat by the Ontario Ministry of the Environment, Conservation and Parks (MECP). This has implications with respect to the limit of development in proximity to the creek, as Redside Dace and its habitat are regulated under the provincial *Endangered Species Act, 2007* (ESA) and the *Species at Risk Act, 2002*.

Ontario Regulation 832/21 under the ESA defines occupied and recovery Redside Dace habitat as the meander belt width and 30 m of vegetated riparian habitat along both sides of the meander belt. As the habitat regulation does not account for differences in valley setting, where the channel is confined or partially confined, the 30 m riparian area is applied from the toe of slope. This represents the extent that the channel can physically or effectively migrate. This approach has been accepted by the MECP elsewhere in the Greater Toronto Area. The extent of regulated habitat for Redside Dace is presented graphically in **Appendix A** along **Reach 4a** and **4b** in association with Kilamanagh Creek.

7 Summary and Recommendations

A fluvial geomorphological assessment was completed for the properties located at 12489 and 12861 Dixie Road to support development applications for future industrial properties. Several watercourses flow through the subject lands, including two tributaries of the West Humber River and a third tributary of the West Humber River named Kilamanagh Creek. The assessment included a review of historical aerial imagery, rapid and detailed field reconnaissance, meander belt width delineation, and preliminary erosion threshold analysis to support SWM and erosion mitigation strategies.

The meander belt widths were determined to be 40 m for **Reaches 4a** and **4b** along Kilamanagh Creek and 78 m for **Reach 7**, 46 m for **Reach 8** and 55 m for **Reach 8a** along the tributaries of the West Humber River. These meander belt width values include a 20% factor of safety. The reaches observed were also confined or partially confined by defined valley walls. Note that if delineation of a long-term stable slope is required in the future for any of the valley features on site, this work would need to be completed by a qualified geotechnical engineer. Although, it is recommended that geomorphic input be included in this type of study to define an appropriate toe erosion allowance.

Lastly, Kilamanagh Creek is considered redside dace habitat by the MECP. Occupied and recovery Redside Dace habitat is typically defined based on the meander belt width and a 30 m vegetated riparian habitat along both sides of the meander belt. As such, a 30 m buffer has been established beyond the meander belt width extent delineated here.

A preliminary erosion threshold, expressed as a critical discharge, was determined for both the bed and bank materials for each detailed geomorphic assessment field site. The more conservative of the two values was used to calculate unitary erosion thresholds using estimated drainage areas for each of the subject reaches. The unitary values were compared to those accepted for nearby watercourses to determine whether stormwater management and erosion mitigation strategies are likely to be sufficient to mitigate downstream impacts associated with the development. The unitary erosion thresholds outlined here are within the range of those successfully applied elsewhere in combination with Low Impact Development (LID) measures and stormwater management. We recommend that the pond release rates be refined through detailed design and that a combination of onsite SWM detention and retention through LIDs be implemented.

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

Respectfully submitted,

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Kat Woodrow, M.Sc.
Manager of Watershed Studies

Jan Franssen, Ph.D.
Senior Watershed Scientist

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Appendix A
Study Area Mapping

GEO MORPHIX™

12489 and 12861 Dixie Road

Fluvial Geomorphic Assessment

Caledon, Ontario

Legend

- Reach Break and ID
- Watercourse
- Headwater Drainage Feature
- Detailed Assessment Location
- 0.25 m Contour
- 1 m Contour
- Estimated Toe of Slope
- Meander Belt Width
- Meander Belt Width Truncated at Toe of Slope
- Redside Dace Habitat Extent
- Staked Top of Slope
- Approximte Study Area
- Approximate SWM Pond Location
- OHN Waterbody

0 100 200

Metres

Imagery: Google Earth, 2023. Watercourse: Peel Region, 2021 / J.D. Barnes, 2022. 0.25 m Contour: J.D. Barnes, 2022. 1.0 m Region of Peel: 2020. Waterbody: MNR, 2020. Detailed Assessment Location: GEO Morphix Ltd., 2024. Staked Top of Bank: J.D. Barnes, 2023. Reach Break and ID, Approximate Study Area, Meander Belt Width, Redside Dace Habitat: GEO Morphix Ltd., 2023. Toe of Slope: GEO Morphix Ltd., 2023 (derived from J.D. Barnes Contour and Peel Region Contours). Headwater Drainage Features: Stantec, 2023. PN23012. Print Date: December 2024. Drawn By: M.O., K.W.

Old School Road

Dixie Road

Tributary of West Humber River

Kilamanagh Creek

Reach 7

78 m

46 m

Reach 8

Reach 8a

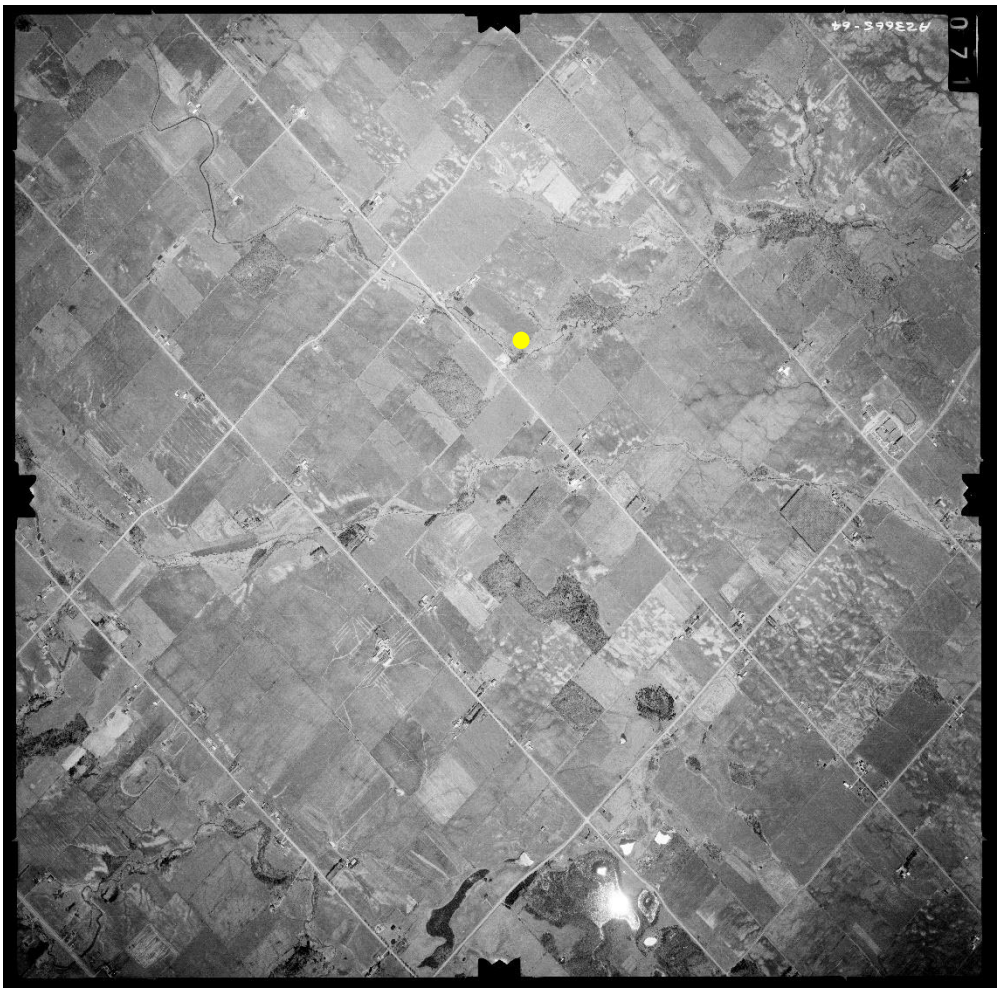
55 m

Reach 4a

40 m

Reach 4b

Appendix B
Historical Aerial Photographs

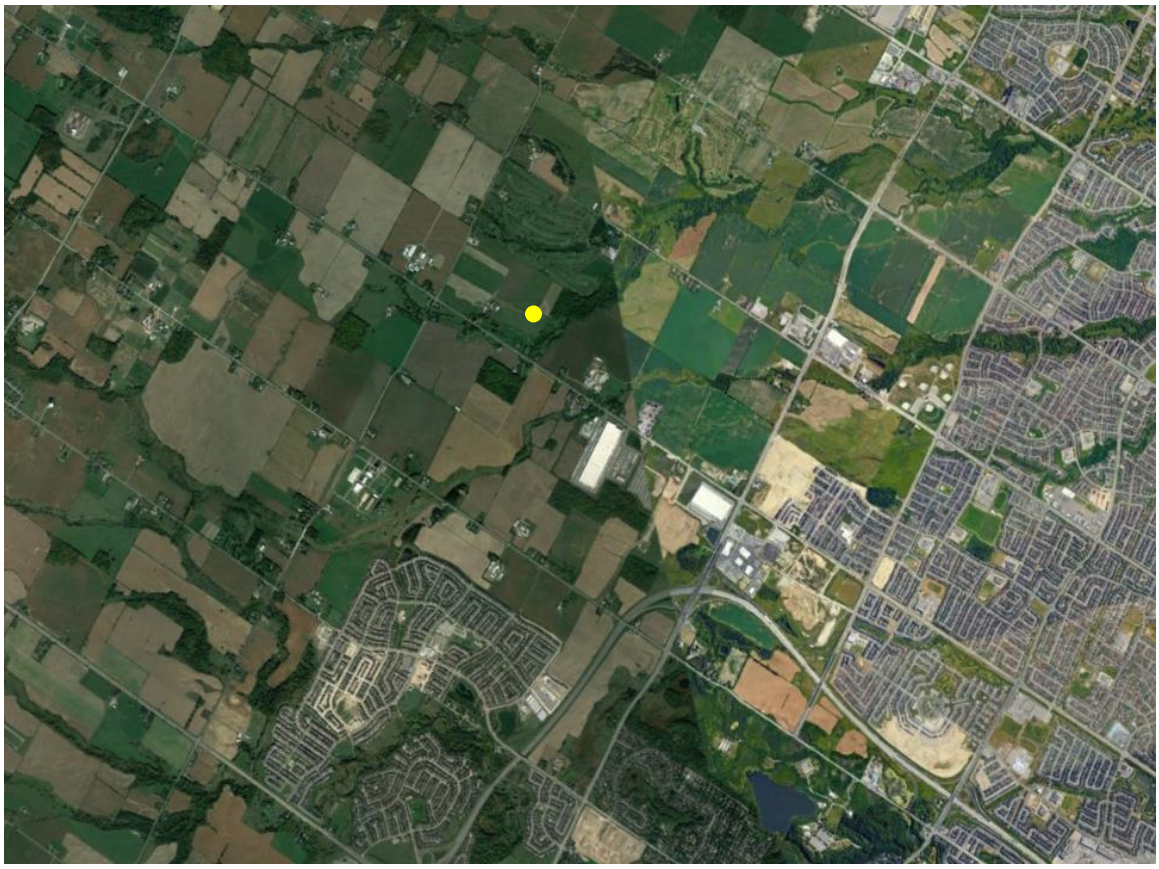


Location: Caledon, ON. (Yellow dot denotes the subject lands)
Year: 1974
Scale: 25,000
Source: National Air Photo Library

Location: Caledon, ON
Year: 2004
Scale: Digital Orthoimagery
Source: Google Earth Pro

Location: Caledon, ON
Year: 2009
Scale: Digital Orthoimagery
Source: Google Earth Pro

Location: Caledon, ON
Year: 2015
Scale: Digital Orthoimagery
Source: Google Earth Pro



Location: Caledon, ON
Year: 2019
Scale: Digital Orthoimagery
Source: Google Earth Pro

Appendix C
Photographic Record

Photo 1 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
	Photograph taken at the upstream extent of **Reach 4b.** The reach enters the subject property through a culvert along Dixie Road (yellow arrow indicates flow direction).
Photo 2 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
	The reach flows through a partially confined valley, with multiple valley wall contacts. The riparian area consists primarily of grasses with few mature trees.

Photo 3 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
Average bankfull width and depth were 3.25 m and 0.66 m, respectively. At the time of assessment, high flows were noted, and the channel was near bankfull capacity.	
Photo 4 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
A large offline pond was present adjacent to the channel, separated by a tall berm. During high flows a small flow path connects the pond to the channel.	

Photo 5 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
	Bank erosion was observed throughout the channel as undercuts, basal scour, exposed tree roots, and fallen or leaning trees.
Photo 6 Kilamanagh Creek - Reach 4b, Caledon, Ontario	
	Photograph taken near the downstream extent of the reach. A low density of woody debris was present in the channel and cutbanks.

Photo 7 Kilamanagh Creek - Reach 4a, Caledon, Ontario	
Photograph taken at the upstream extent of **Reach 4a**. The reach was characterized as irregularly meandering through a partially confined valley.	
Photo 8 Kilamanagh Creek - Reach 4a, Caledon, Ontario	
The riparian zone was dominated by a continuous coverage of herbaceous vegetation and grasses, with few mature trees present.	

Photo 9 Kilamanagh Creek - Reach 4a, Caledon, Ontario	
A degraded tractor crossing was present within the reach. The concrete culvert was separated through the middle and flows were undermining the feature.	
Photo 10 Kilamanagh Creek - Reach 4a, Caledon, Ontario	
Bank angles ranged from 30° to 60° with minor undercutting observed. Average bankfull width and depth was 3.36 m and 0.65 m, respectively.	

Photo 11 Kilamanagh Creek - Reach 4a, Caledon, Ontario	 The reach was dominated by runs with few deep pools observed. Bed substrate was comprised of clay/silt, sand, gravel and cobbles.
Photo 12 Kilamanagh Creek - Reach 4a, Caledon, Ontario	 Photograph taken at the downstream extent of the reach. Canopy cover was limited, and bank slumping was frequently observed in this section.

Photo 13 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	 Photograph taken at the upstream extent of **Reach 8a.** The reach enters the subject property through a culvert along Dixie Road (yellow arrow indicates flow direction).
Photo 14 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	 The reach flows through a pasture in a partially confined valley. The riparian area consists primarily of grasses with few mature trees.

Photo 15 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	
	Riffle-pool morphology was observed. Bed substrate consisted primarily of clay/silt, sand, and gravel in pools and gravel and cobbles in riffles.
Photo 16 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	
	Bank slumps and undercutting were noted throughout the reach. Bank material was primarily silt, sand, and some clay.

Photo 17 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	 Bank erosion was high in the channel ranging from 60% to 100% of the banks eroded. Large bank slumps, undercutting, and basal scour were most frequently observed.
Photo 18 Tributary of the West Humber River- Reach 8a, Caledon, Ontario	 Photograph taken near the downstream extent of the reach. Average bankfull width and depth were 4.59 m and 0.79 m, respectively.

Photo 19 Tributary of the West Humber River- Reach 8, Caledon, Ontario	 Photograph taken at the upstream extent of **Reach 8**. The reach was characterized as an irregularly meandering, low gradient channel within a partially confined valley.
Photo 20 Tributary of the West Humber River- Reach 8 Caledon, Ontario	 At the upstream extent the riparian zone was dominated by grasses that heavily encroached the channel.

Photo 21 Tributary of the West Humber River- Reach 8, Caledon, Ontario	 Bank angles ranged from 30° to 60° and bank material was comprised of clay/silt, and sand. Average bankfull width and depth was 4.10 m and 0.67 m, respectively.
Photo 22 Tributary of the West Humber River- Reach 8, Caledon, Ontario	 Bank erosion was observed through 30% to 60% of the reach. Undercuts, exposed tree roots, and fallen/leaning trees were observed indicating the channel is widening.

Photo 23 Tributary of the West Humber River- Reach 8, Caledon, Ontario	 A moderate density of large woody debris jams were present within the channel and the cutbank.
Photo 24 Tributary of the West Humber River- Reach 8, Caledon, Ontario	 Photograph taken at the downstream extent of **Reach 8**. The reach was dominated by runs with few deep pools and bed substrate ranged from clay/silt, and sand to cobbles.

Photo 25 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 Photograph taken at the upstream extent of the **Reach 7**. Riparian vegetation was dominated by a continuous, dense coverage of mature trees.
Photo 26 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 The reach was characterized as irregularly meandering situated in a partially confined valley with valley wall contacts frequently observed.

Photo 27 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 Riffle-pool sequencing was well developed with bed substrate ranging from clay/silt, sand, and exposed parent material (till) in pools and sand, gravel, and cobbles in riffles.
Photo 28 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 Evidence of bank erosion was observed throughout 60% to 100% of the reach. Undercuts measured up to 0.82 m and exposed till, fallen/leaning trees, and exposed tree roots were common.

Photo 29 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 Bank angles ranged from 0° to 30° at the inside of bends and 60° to 90° along the rest of the reach. Average bankfull width and depth were 7.17 m and 0.85 m, respectively.
Photo 30 Tributary of the West Humber River- Reach 7, Caledon, Ontario	 Photograph was taken at the downstream extent. Aquatic vegetation was present along 45% of the reach. Watercress was commonly observed indicating evidence of potential groundwater inputs.

Appendix D
Field Observations

GEO MORPHIX™

General Site Characteristics

Project Number: PN23013

Date:	2023-06-13.	Stream:	Trib W Humber
Time:		Reach:	Reach 4a
Weather:	Sunny 18°	Location:	Dixie Rd Caledon
Survey Staff:	AV SH	Watershed/Subwatershed:	W Humber

Legend

Reach break	Station location
Cross-section	Flow direction
Riffle	Pool
Sediment bar	Eroded bank/slope
Undercut bank	Bank stabilization
Leaning tree	Fence
Culvert/outfall	Swamp/wetland
Grasses	Tree
Instream log/tree	Woody debris
Beaver dam	Vegetated island

Monitoring

Long-profile	Monumented XS
Monumented photo	Monumented photo direction
Sediment sampling	Erosion pins
Scour chains	

Additional Symbols

Flow Type

FT1	Standing water	FTBA	Back water
FT2	Scarcely perceptible flow		
FT3	Smooth surface flow		
FT4	Upwelling		
FT5	Rippled		
FT6	Unbroken standing wave		
FT7	Broken standing wave		
FT8	Chute		
FT9	Free fall	FTDA	Dissipates below free fall

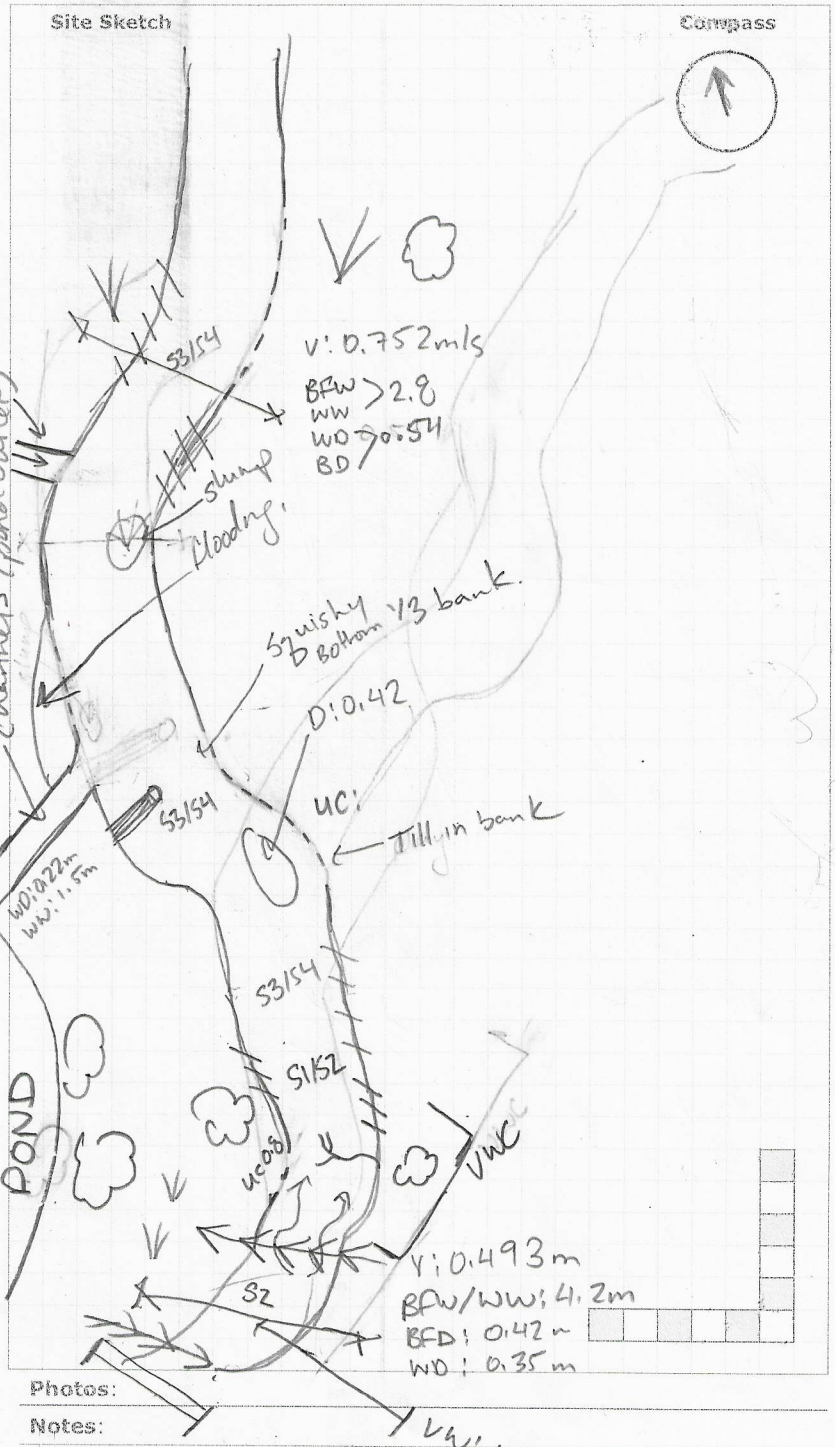
Substrate

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

Other

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

Site Sketch



Photos:

Notes: Bottom 1/3 of bank highly erodable material, slumping noted through entire reach. high water level US, Pools no riffles

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

General Site Characteristics

Project Number: PN23013

Date:	2023-06-13	Stream:	Trib. W, Humber
Time:		Reach:	Reach 4a
Weather:	Sunny 18°C	Location:	Dixie Road
Field Staff:	SH AV	Watershed/Subwatershed:	W. Humber

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

Flow Type

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

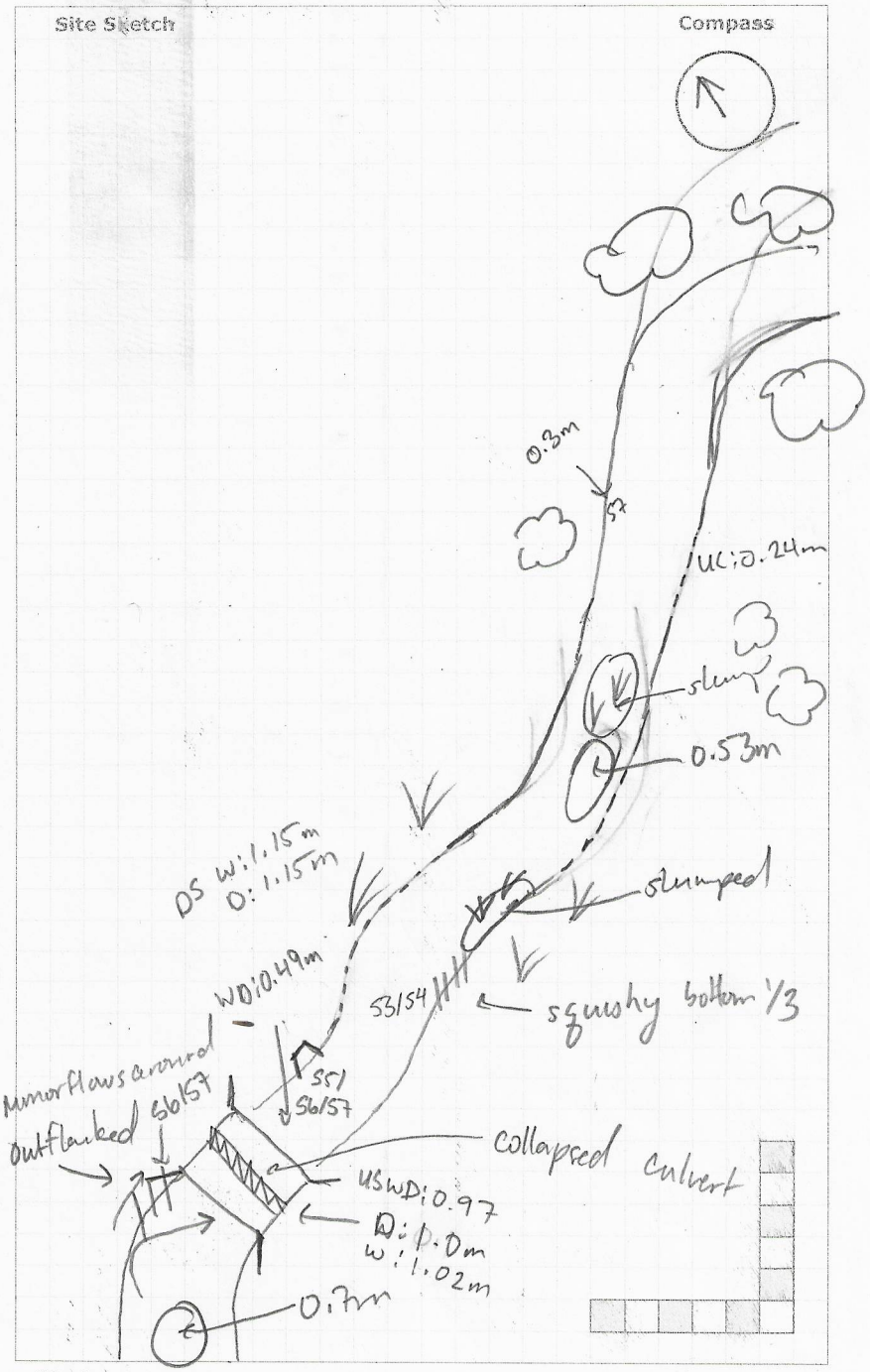
Substrate

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

Other

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

Site Sketch



Photos:

Notes:

GEO MORPHIX

General Site Characteristics

Project Number: Z3013

Date:	2023-06-13	Stream:	Trib. W Humber
Time:		Reach:	Reach 4a
Weather:	Sunny 18°C	Location:	Dixie Road
Field Staff:	SH AV	Watershed/Subwatershed:	W Humber

Features

- Reach break
- Station location
- Cross-section
- Flow direction
- Riffle
- Pool
- Sediment bar
- Eroded bank/slope
- Undercut bank
- Bank stabilization
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Beaver dam
- Vegetated island

Monitoring

- Long-profile
- Monumented XS
- Monumented photo
- Monumented photo direction
- Sediment sampling
- Erosion pins
- Scour chains

Historical Symbols

Flow Type

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

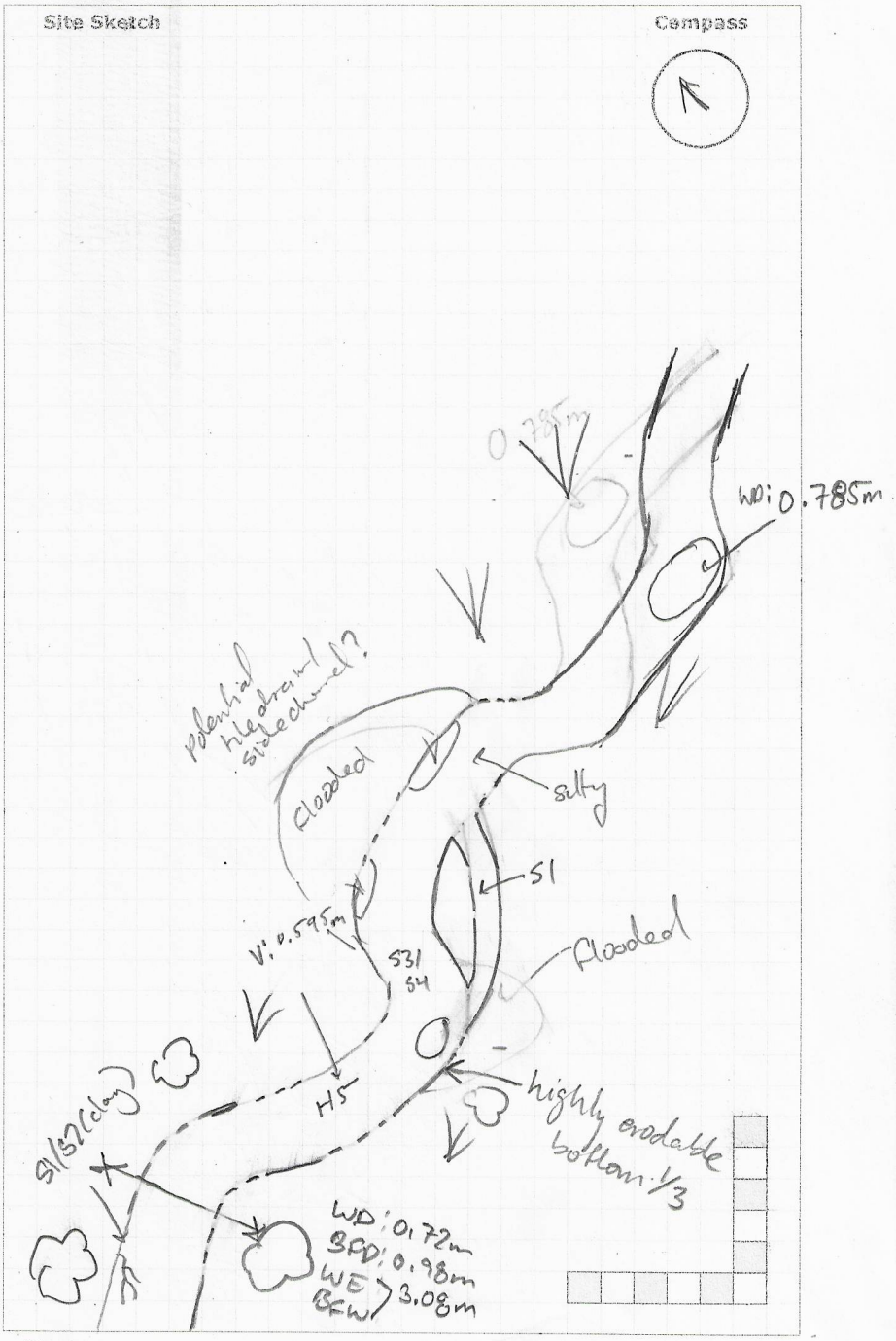
Substrate

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

Other

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

Site Sketch



Photos:

Notes: Bank clay sand silt - pools no riffles undercutting/slumping, entire channel

GEO MORPHIX™

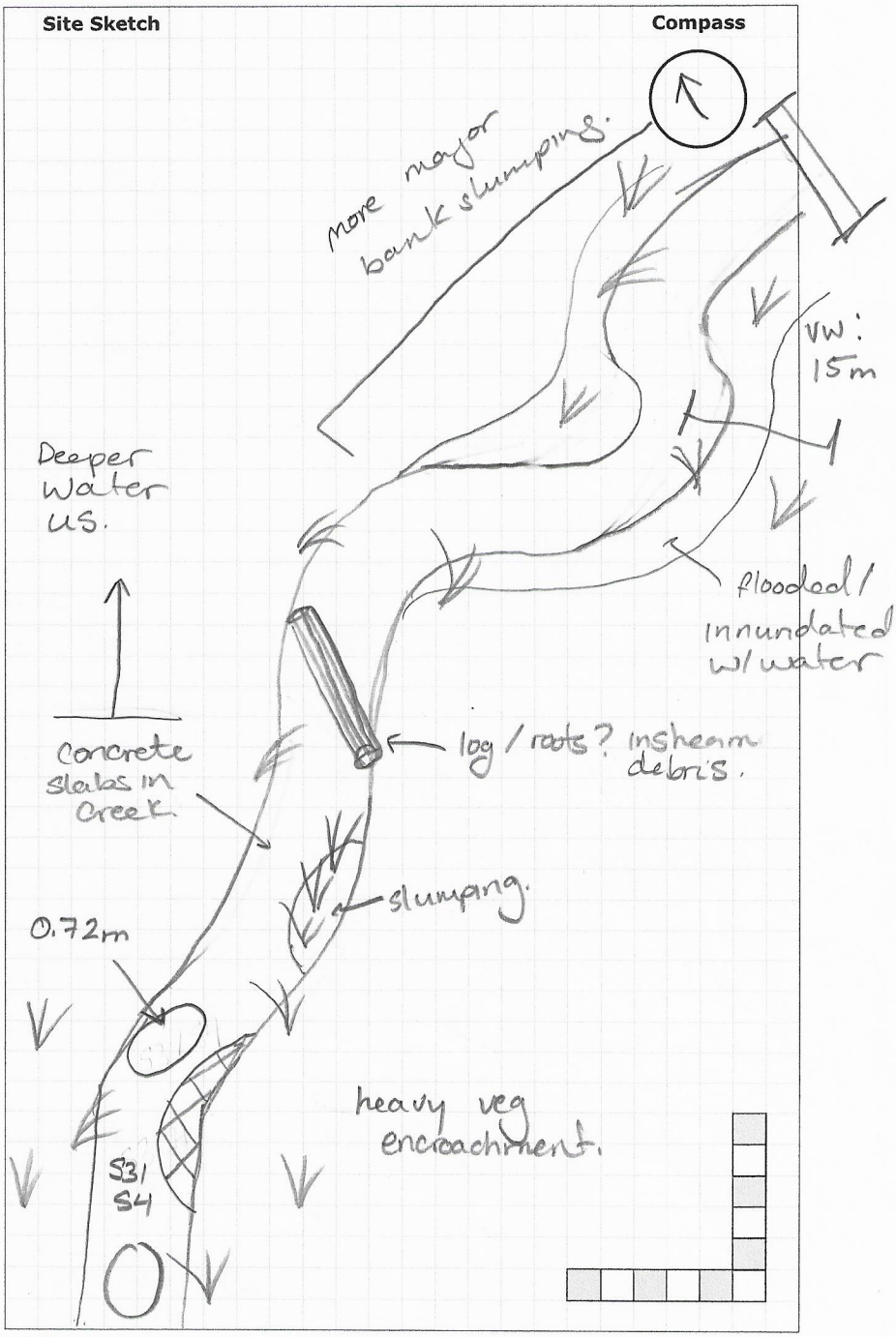
General Site Characteristics

Project Number: PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4a
Weather:	Sunny/18°	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W. Humber

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 Geomorphic Assessment

Project Number: PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4a
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon.
Field Staff:	AV SH	**Watershed/Subwatershed:**	W Humber

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	1/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	0.143
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	1	6	
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	MIA		1/6
	2	Exposed sanitary / storm sewer / pipeline / etc. check		✓	
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.		✓	
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	0.1667
	9	Suspended armour layer visible in bank ~~8~~	✓		
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	1	5	
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	3/8
	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.		✓	
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc. ~~8~~		✓	0.375
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		✓	
		Sum of indices =	3	5	
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		1/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	0.143
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	1	6	

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.207

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

Version #3
Last edited: 10/02/2023

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

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4a
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon.
Field Staff:	AV SH	**Watershed/Subwatershed:**	W Humber

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

predominantly D5

Version #2
Last edited: 10/02/2023

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

GEO MORPHIX

Date:	2023-06-13	PN:	23013	Location:	Trib. W. Humber

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) = 23	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: AV

GEO MORPHIX™

Reach Characteristics Project Number: PN23013

Date:	2023-06-13	**Field Staff:**	AV SH	**Watershed/Subwatershed:**	W Humber
Time:		**Stream:**	Trib W. Humber	**UTM (Upstream):**	
Weather:	Sunny 18°	**Reach:**	Reach 4a	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 3
Encroachment (Table 7): 4

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

Aquatic & Instream Vegetation

Type (Table 8):
Reach Coverage %: 0

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

WDJ/50m:

Water Quality

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

Channel Characteristics

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

Sinuosity Degree (Table 10): 2
# of Channels (Table 12): 1
Bank Failure (Table 14): 1/2
Bankfull Indicators (Table 18): 1/7
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23):
% Riffles: 0 **% Pools**: 20

Bank Angle	Bank Erosion
☐ 0 - 30	☐ < 5%
☒ 30 - 60	☐ 5 - 30%
☐ 60 - 90	☒ 30 - 60%
☒ Undercut	☐ 60 - 100%

(Table 19)

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

Bankfull Width (m)	4.2	2.8	0.98	**Wetted Width (m)**	4.2	2.8	3.08
Bankfull Depth (m)	0.42	0.54		**Wetted Depth (m)**	0.35	0.54	0.72
Undercuts (m)				**Velocity (m/s)**		0.752	0.595
Pool Depth (m)	0.42	0.785		**Velocity Estimate Method**		wiffle	wiffle
Riffle Length (m)				**Meander Amplitude (m)**	/	/	/

Notes: size indicate saltation likely - flows unlikely to produce

E- best possible choice ~ lacking scour

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

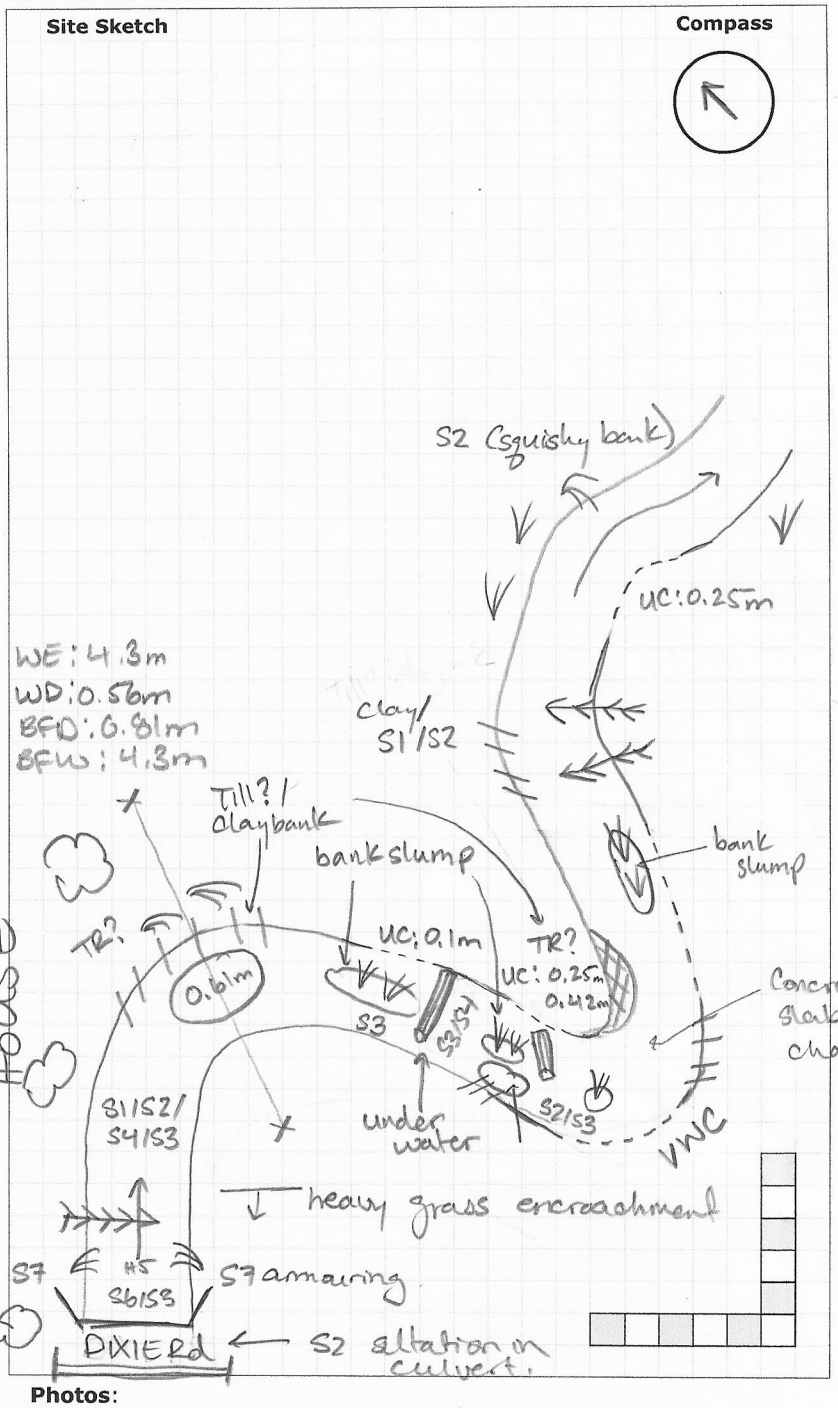
General Site Characteristics

Project Number: AD 2303

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4b
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AVSH	**Watershed/Subwatershed:**	W Humber

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

Site Sketch



Flow Type

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

Substrate

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

Other

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

Photos:

Notes: eroded & undercut banks, slumping & grass slumps in channel. Bed substrate primarily S3/S4 - some finer sed @ EO reach. Pond bank breached & connected w/ channel - likely a result of high flows

GEO MORPHIX™

General Site Characteristics

Project Number: PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4b
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W. Humber

Features

- Reach break
- Station location
- Cross-section
- Flow direction
- Riffle
- Pool
- Sediment bar
- Eroded bank/slope
- Undercut bank
- Bank stabilization
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Beaver dam
- Vegetated island

Monitoring

- Long-profile
- Monumented XS
- Monumented photo
- Monumented photo direction
- Sediment sampling
- Erosion pins
- Scour chains

Additional Symbols

Flow Type

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

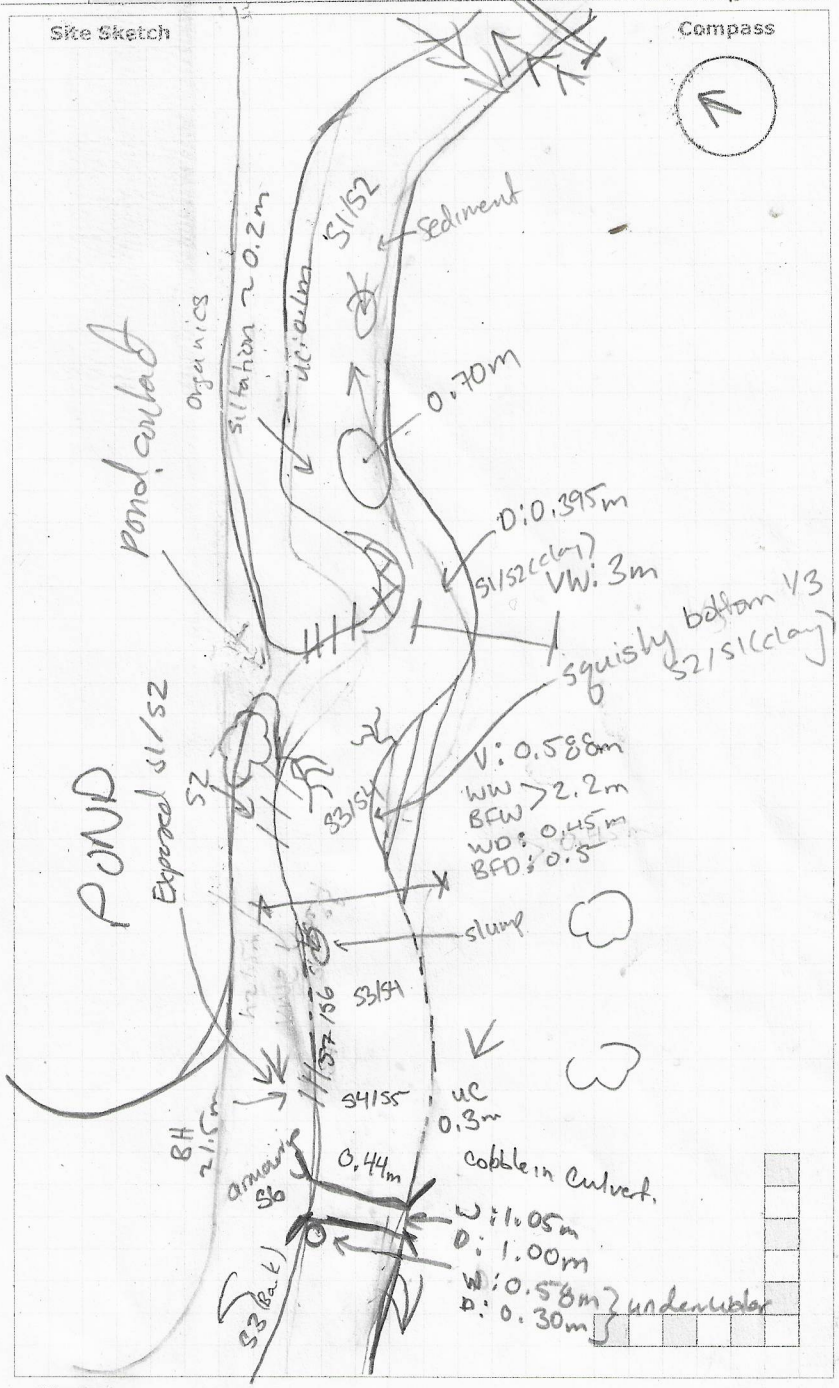
Substrate

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

Other

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

Site Sketch



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4b
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W. Humber

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	0/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools		✓	
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials *		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	0	7	0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		✓	0/7
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	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		✓	
	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 * Some clay till?		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	0	7	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	6/9
	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. @ one culvert	✓		
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =	6	9	0.667
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		2/7
	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 @1 spot		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	2	7	0.286

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.238

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

Version #3
Last edited: 10/02/2023

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

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: PN23013

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 4b
Weather:	Sunny 18	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH.	**Watershed/Subwatershed:**	W. Humber

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

@ bankfull

no point bars

Version #2
Last edited: 10/02/2023

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

GEO MORPHIX™

Date:	2023-06-13	PN:	23013	Location:	Caledon

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 N/A
	• 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 N/A
	• 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 Tea
	• 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) =	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: AV

GEO MORPHIX™

Reach Characteristics Project Number: PN23013

Date:	2023-06-13	**Field Staff:**	AV SH	**Watershed/Subwatershed:**	W Humber
Time:		**Stream:**	Trib W. Humber	**UTM (Upstream):**	
Weather:	Sunny 18	**Reach:**	Reach 4b	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 3/1 some

Encroachment (Table 7): 3

Coverage: ☐ None ☐ Fragmented ☑ Continuous

Channel Widths: ☐ 1 - 4 ☐ 4 - 10 ☑ > 10 less on pond side

Age (yrs): ☑ Immature (<5) ☐ Established (5-30) ☐ Mature (>30 trees)

Aquatic & Instream Vegetation

Type (Table 8): 2

Reach Coverage %: 5

Woody Debris: ☐ In Cutbank ☑ In Channel ☐ Not Present

WD Density: ☑ Low ☐ Mod ☐ High

WDJ/50m:

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity Type (Table 9): 2

Gradient (Table 11): 1 — VWC pond banks

Entrenchment (Table 13): 2

Down's Model (Table 15): E — placed material around culverts

Sed Sorting (Table 20): 3

Transport Mode (Table 21): 1

Geomorphic Units (Table 22): 10

Riffle-Pool Spacing (m): N/A

Sinuosity Degree (Table 10): 2

# of Channels (Table 12): 1

Bank Failure (Table 14): 1/2

Bankfull Indicators (Table 18): 1/7

Sediment Transport Observed? ☐ Yes ☑ No ☐ Not Visible — unlikely

% of Bed Active: 0

Mass Movement (Table 23): 1

% Riffles: 0 **% Pools**: 20

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

Bank Erosion: ☐ < 5% ☑ 5 – 30% ☐ 30 – 60% ☐ 60 – 100% — v. high flows causing chutes.

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

Bankfull Width (m)	4.3	2.2		**Wetted Width (m)**	4.3	2.2	
Bankfull Depth (m)	0.81	0.5		**Wetted Depth (m)**	0.56	0.5	
Undercuts (m)	0.10 0.25	0.42	0.25	**Velocity (m/s)**	0.296	0.588	
Pool Depth (m)	0.61	0.67	0.70	**Velocity Estimate Method**	wiffle	wiffle	
Riffle Length (m)				**Meander Amplitude (m)**			

Notes: unable to measure.

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

General Site Characteristics

Project Number: PN 23012

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 7
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W Humber

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	R = exposed roots	
	Bank stabilization	ET = exposed till	
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

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

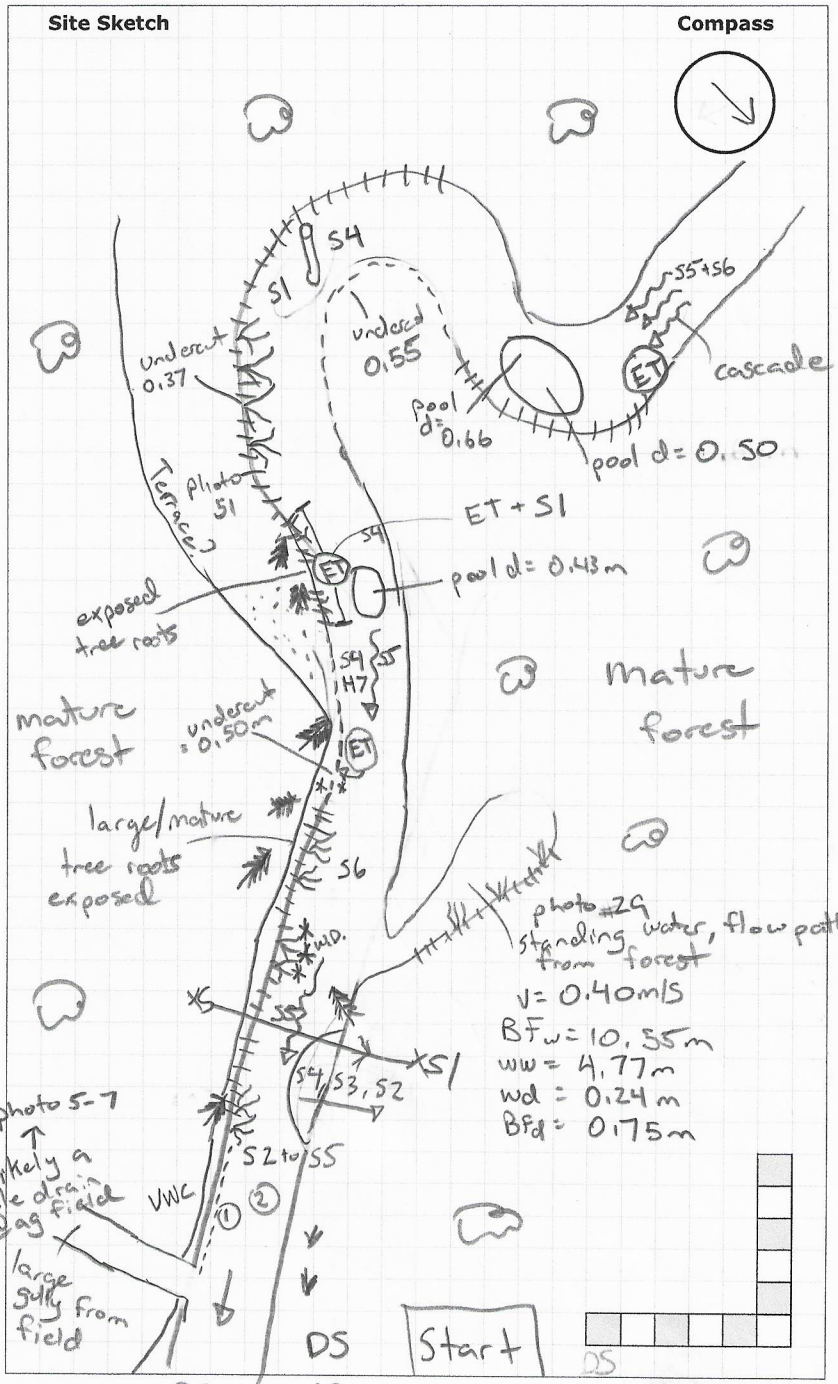
Substrate

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

Other

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

Site Sketch



Photos: DS to US

Notes: * aquatic veg (attached emergent)

① undercut = 0.17m w old + young exposed tree roots, leaning trees

② Slaty + sub-angular substrate

* leaning trees along valley wall

Version #4
Last edited: 21/02/2023

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

* minor substrate fouling on substrate tops
* minnows in channel

Walked DS to US

GEO MORPHIX™

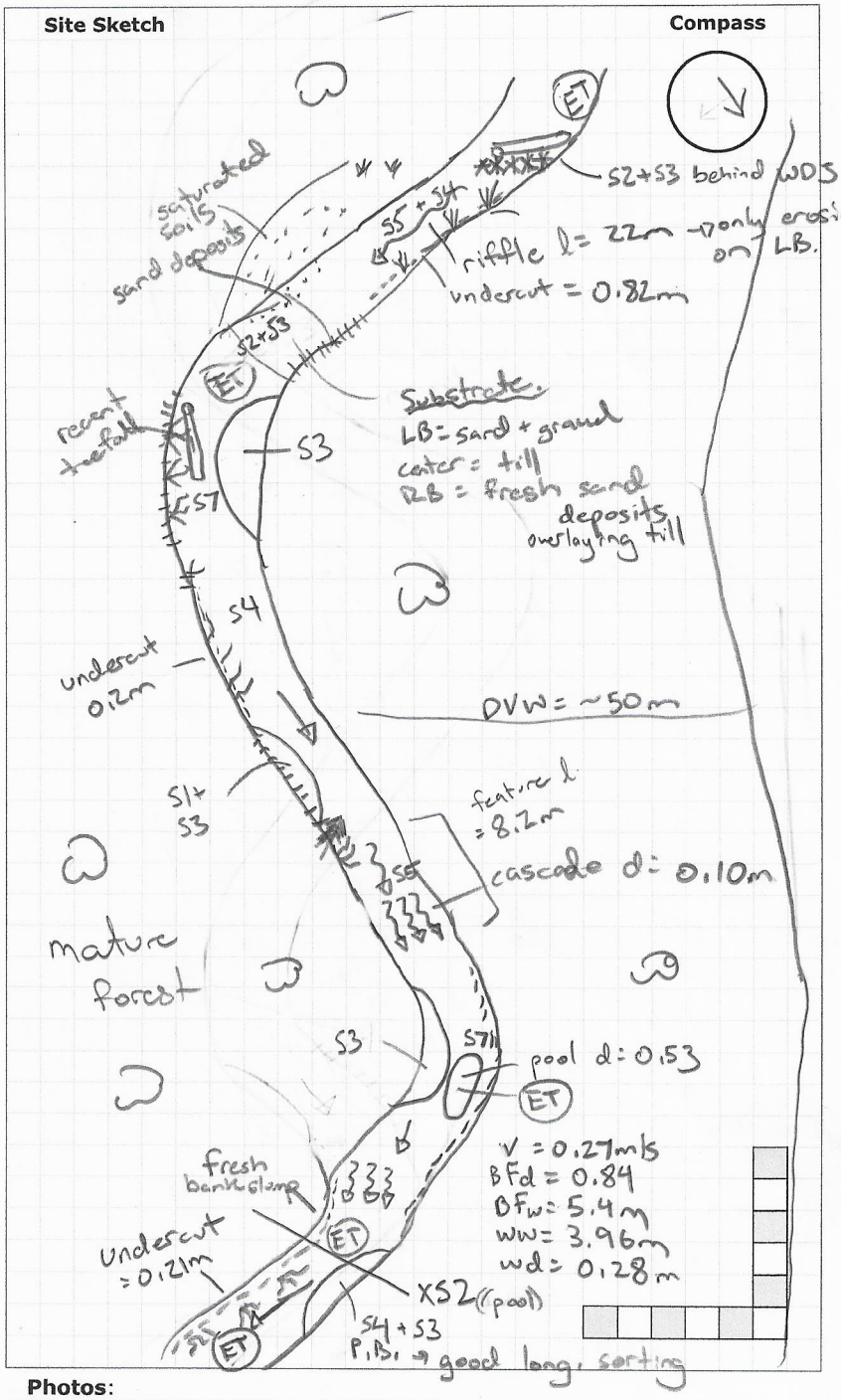
General Site Characteristics

Project Number: PN23012

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 7
Weather:	Sunny 18	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W Humber

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	$\$\$\$$ = cascade	
	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:

- Cascade-pool sequence
- rooted submergent (veg underwater but high flows)

GEO MORPHIX™

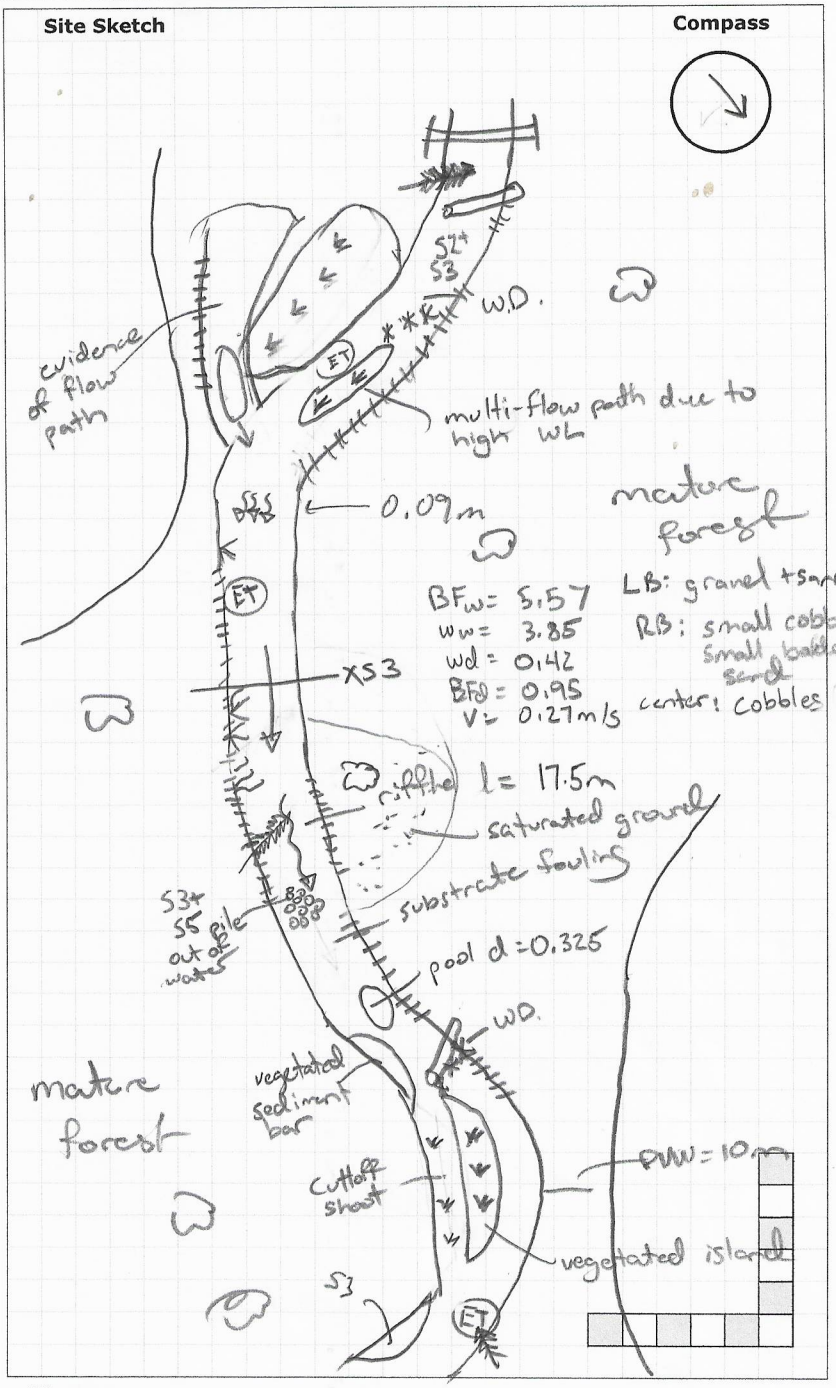
General Site Characteristics

Project Number: PN2302

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 7
Weather:	Sunny 18°	**Location:**	Dixie Rd. Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W Humber

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

Site Sketch



Photos:

Notes:

Flow Type

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

Substrate

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

Other

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

GEO MORPHIX

Rapid Geomorphic Assessment **Project Number:** PN23012

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 7
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AV SH	**Watershed/Subwatershed:**	W. Humber River

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	1/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools		✓	
	4	Medial bars		✓	
	5	Accretion on point bars	✓		
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	1	6	0.143
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		1/5
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	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	✓		
		Sum of indices =	1	4	0.20
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		5/7
	2	Occurrence of large organic debris Some *	✓		
	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. *	N/A		
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation	N/A		
		Sum of indices =	5	2	0.714
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		3/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)	✓		
	5	Formation of island(s)	✓		
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	3	4	0.429

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.372

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

Version #3
Last edited: 10/02/2023

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

GEO MORPHIX™

Rapid Stream Assessment Technique **Project Number:** PN23012

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 7
Weather:	Sunny 18	**Location:**	Dixie Rd Caledon.
Field Staff:	AV SH	**Watershed/Subwatershed:**	W. Humber River

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

Version #2
Last edited: 10/02/2023

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

GEO MORPHIX

Date:	2023-06-14	PN:	23012	Location:	Dixie Road

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) =	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: _____

GEO MORPHIX™

Reach Characteristics

Project Number: PN23012

Date:	2023-06-13	**Field Staff:**	AV SH	**Watershed/Subwatershed:**	West Humber River
Time:		**Stream:**	Trib W. Humber	**UTM (Upstream):**	
Weather:	Sunny 18°	**Reach:**	Reach 7	**UTM (Downstream):**	

Land Use (Table 1)	**Valley Type** (Table 2)	**Channel Type** (Table 3)	**Channel Zone** (Table 4)	**Flow Type** (Table 5)
1	2	8	2	1

☐ Evidence of Groundwater Location:__________ Photo:______

Riparian Vegetation

- **Dominant Type** (Table 6): 1/3
- **Encroachment** (Table 7): 1
- **Coverage:** ☐ None ☐ Fragmented ☒ Continuous
- **Channel Widths:** ☐ 1 - 4 ☐ 4 - 10 ☒ > 10
- **Age (yrs):** ☐ Immature (<5) ☐ Established (5-30) ☒ Mature (>30)

Aquatic & Instream Vegetation

- **Type** (Table 8): 1,2
- **Reach Coverage %:** 5
- **Woody Debris:** ☒ In Cutbank ☒ In Channel ☐ Not Present
- **WD Density:** ☒ Low ☐ Mod ☐ High
- **WDJ/50m:** 0.5

Water Quality

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

Channel Characteristics

Sinuosity Type (Table 9)	2	**Sinuosity Degree** (Table 10)	3
Gradient (Table 11)	2	**# of Channels** (Table 12)	1
Entrenchment (Table 13)	1	**Bank Failure** (Table 14)	1/2
Down's Model (Table 15)	U	**Bankfull Indicators** (Table 18)	1/5/7
Sed Sorting (Table 20)	3	**Sediment Transport Observed?**	☐ Yes ☒ No ☐ Not Visible
Transport Mode (Table 21)	3	**% of Bed Active**	0
Geomorphic Units (Table 22)	2,5,6,8	**Mass Movement** (Table 23)	1
Riffle-Pool Spacing (m):		☆ **% Riffles:** 30	☆ **% Pools:** 45

Bank Angle ☆: ☒ 0 – 30 → outside meanders ☐ 30 – 60 ☒ 60 – 90 ☒ Undercut (only at valley wall contact)

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

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

Bankfull Width (m)	10.55	5.4	5.57	**Wetted Width (m)**	4.77	3.96	3.85
Bankfull Depth (m)	0.75	0.84	0.95	**Wetted Depth (m)**	0.24	0.28	0.42
Undercuts (m)	0.17 (0.55, 0.82)	0.50 (0.21)	0.37 (0.2)	**Velocity (m/s)**	0.40	0.27	0.27
Pool Depth (m)	0.43 (0.33)	0.66	0.53	**Velocity Estimate Method**	wiffle	wiffle	wiffle
Riffle Length (m)	22.0	17.5	/	**Meander Amplitude (m)**	/	/	/

Notes: Riffles include cascades

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

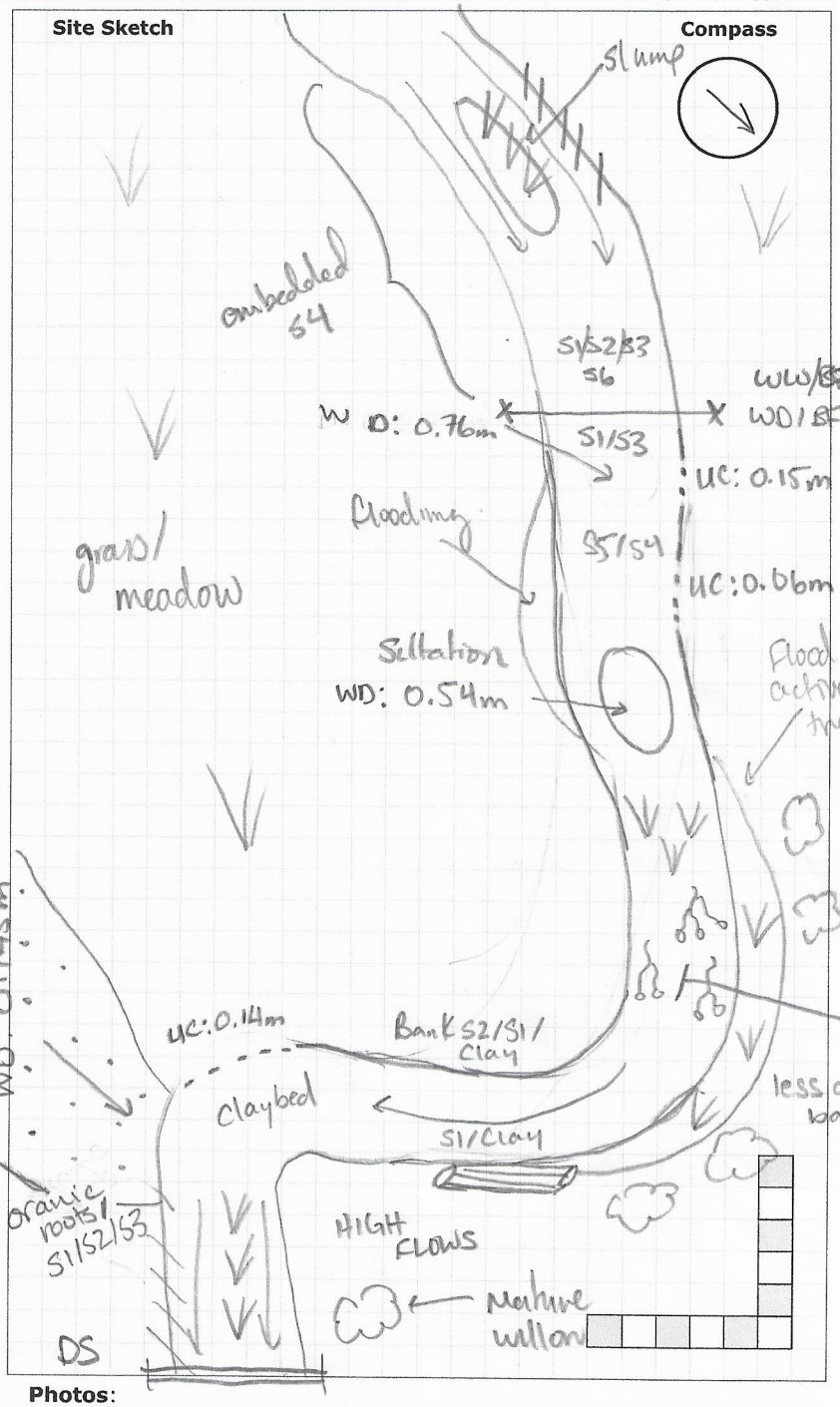
General Site Characteristics

Project Number: PN23012

Date:	2023-06-13	**Stream:**	Trib W. Humber
Time:		**Reach:**	Reach 8
Weather:	Sunny 18°	**Location:**	Dixie Rd Caledon
Field Staff:	AVSA	**Watershed/Subwatershed:**	W Humber.

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

Site Sketch



Flow Type

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

Substrate

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

Other

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

Photos:

Notes: channel @ close to BF conditions. DS → grassy meadow US → fragmented forest cover more LWD

Walked DS to US

GEO MORPHIX™

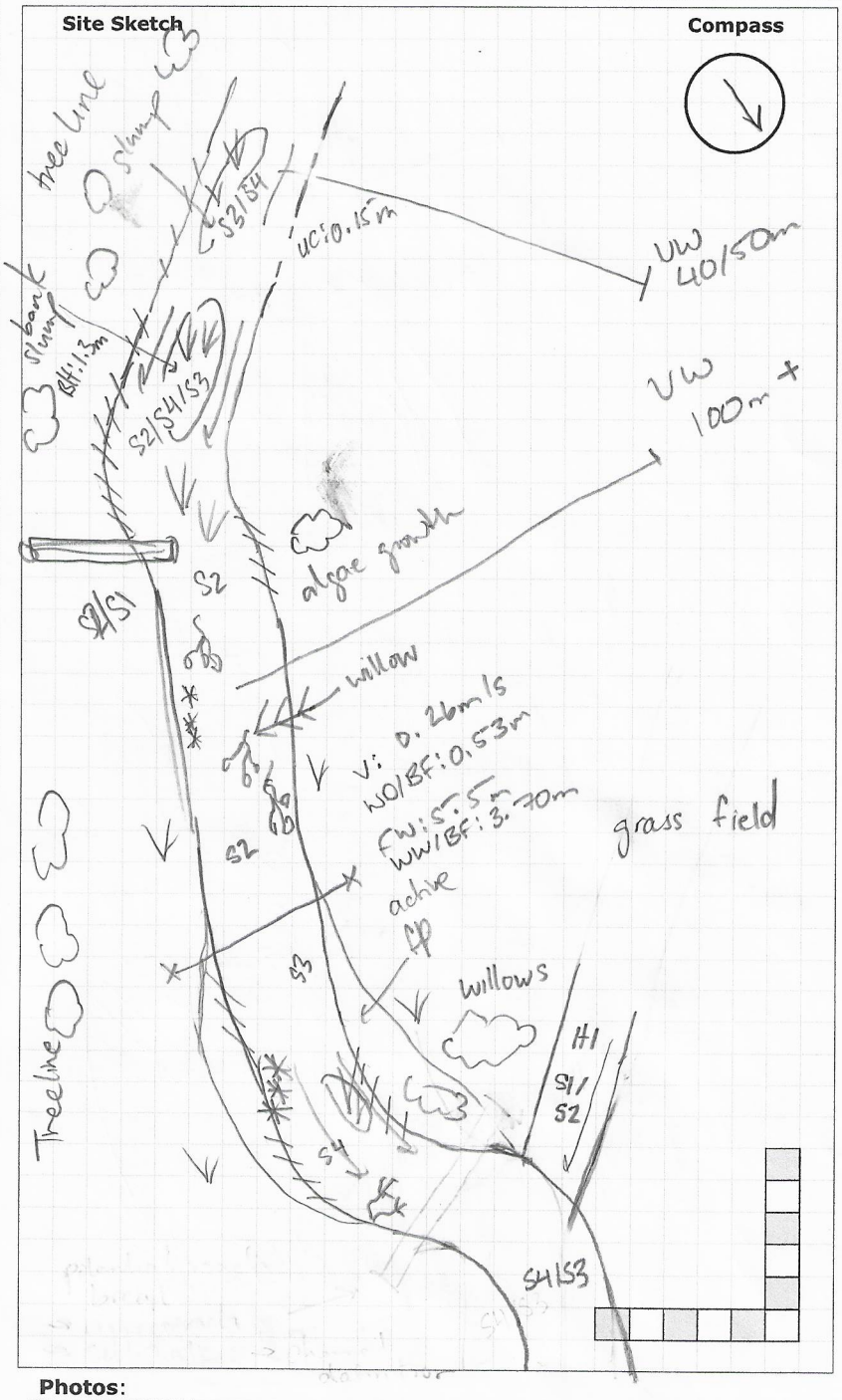
General Site Characteristics

Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib of W. Humber River
Time:		**Reach:**	Reach 8
Weather:	Sunny 18°C	**Location:**	Dixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

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

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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™

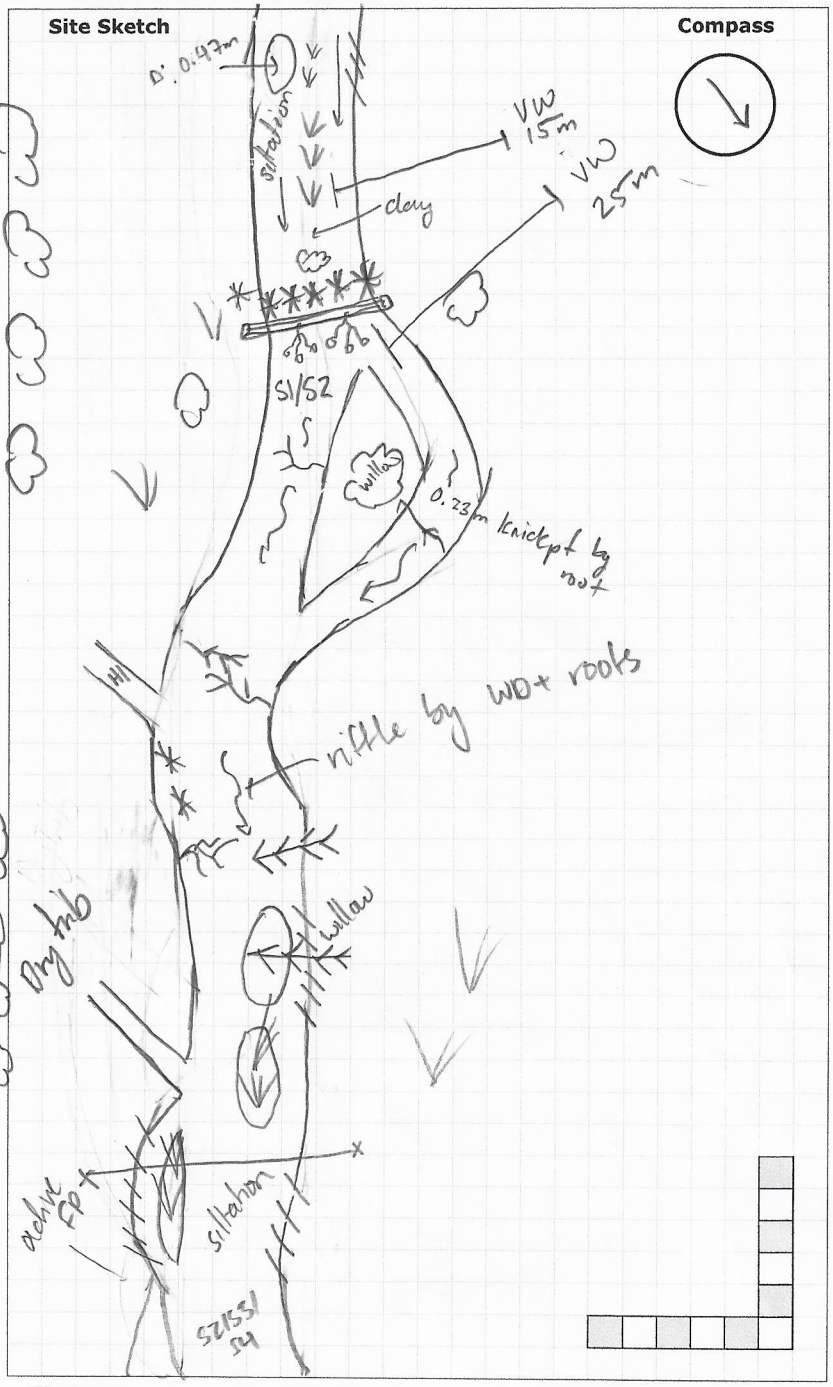
General Site Characteristics

Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib of West Humber River
Time:		**Reach:**	Reach 8
Weather:	Sunny 18°C	**Location:**	Dixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	W. Humber River

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

Site Sketch



Flow Type			
H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
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H8	Chute		
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Substrate			
S1	Silt	**S6**	Small boulder
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S3	Gravel	**S8**	Bimodal
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S5	Large cobble		

Other			
BM	Benchmark	**EP**	Erosion pin
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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: 23012

Date:	2023-06-13	Stream:	Trib. of West Humber river
Time:		Reach:	Reach 8
Weather:	Sunny 18°C	Location:	Dixie Road
Field Staff:	SH AV	Watershed/Subwatershed:	West Humber river

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		
x-x-x	Fence		
	Culvert/outfall		
	Swamp/wetland		
VVV	Grass		
	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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Substrate			
S1	Silt	S6	Small boulder
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Other			
BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
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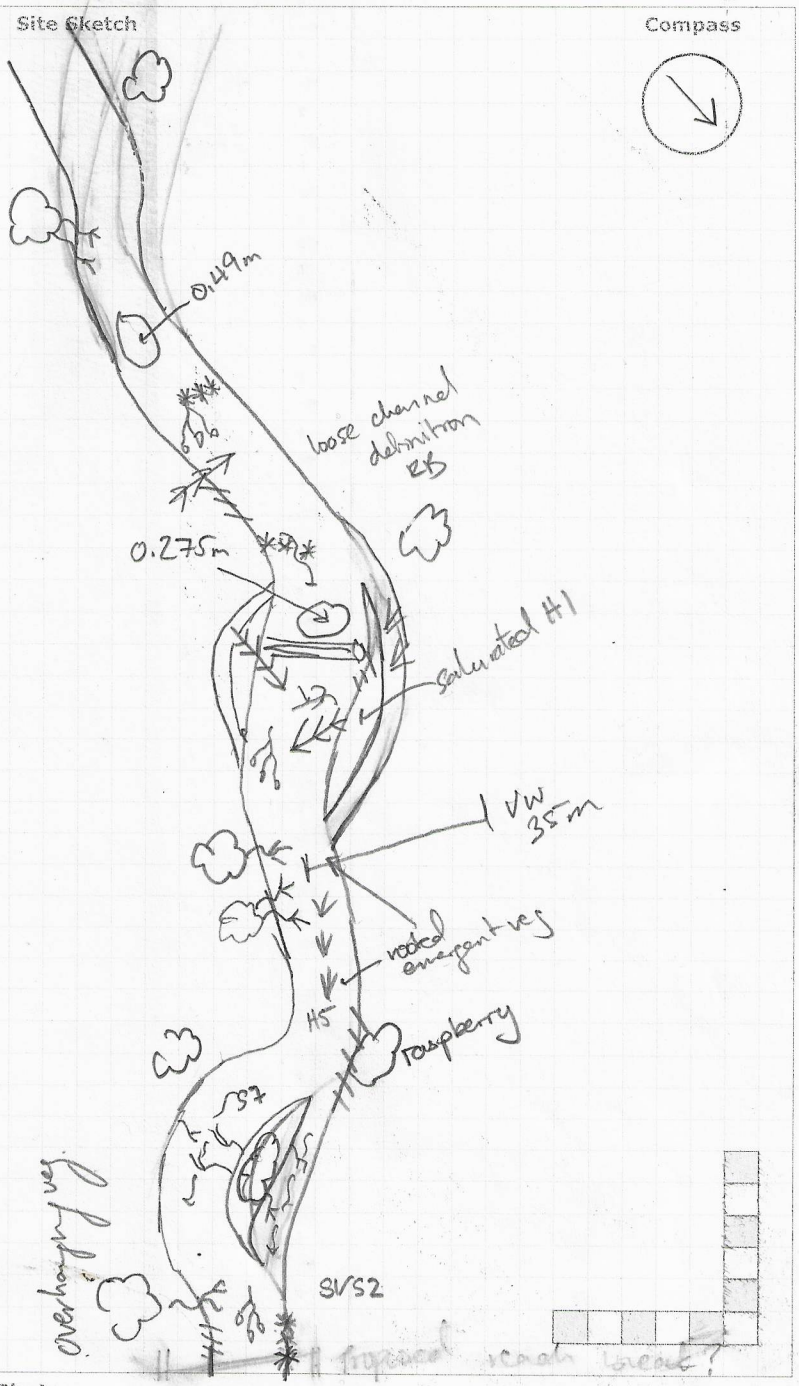
Site Sketch



Photos:

Notes: root exposures across channel bed (downcut)
Veg → willows rhubarb raspberry grasses

GEO MORPHIX

General Site Characteristics

Project Number: 23012

Date:	2023-06-13	Stream:	Trib. of West Humber River
Time:		Reach:	Reach 8
Weather:	Sunny 18°C	Location:	Dixie Road
Field Staff:	AV SH	Watershed/Subwatershed:	West Humber river

Features		Monitoring	
	Reach break		Long-profile
R	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		
	Trees		
	Upstream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type			
H1	Standing water	H1A	Back water
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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
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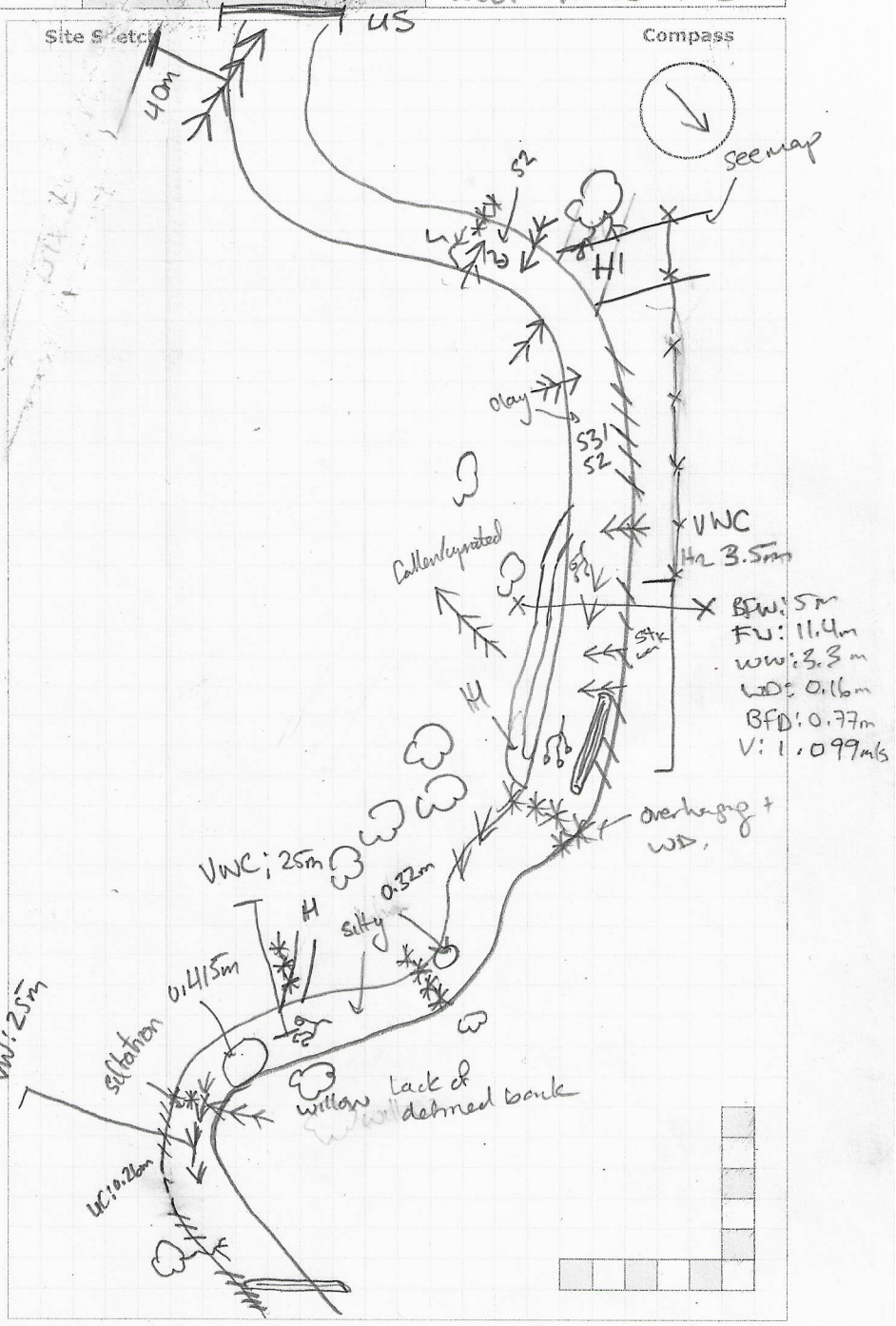
Site Sketch



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 23012

Date:	2023-06-13	**Stream:**	Trib of West Humber River
Time:		**Reach:**	Reach 8
Weather:	Sunny 18°C	**Location:**	12861 Dixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	1/6
	2	Coarse materials in riffles embedded		N/A	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	0.1667
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	1	5	6
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		✓	0/5
	2	Exposed sanitary / storm sewer / pipeline / etc.		✓	
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.		✓	
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	0.00
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	0	5	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		3/11
	2	Occurrence of large organic debris	✓		
	3	Exposed tree roots	✓		
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.		✓	
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.		✓	0.273
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =	3	8	11
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		4/7
	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		✓	0.571
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	4	3	7

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.253

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

Version #3
Last edited: 10/02/2023

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

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib of West Humber river
Time:		**Reach:**	Reach 8
Weather:	Sunny 18°C	**Location:**	12861 Dixie Road
Field Staff:	SA AV	**Watershed/Subwatershed:**	West Humber River

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

Version #2
Last edited: 10/02/2023

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

GEO MORPHIX™

Date:	2023-06-13	PN:	23012	Location:	Caledon

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) = 25	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: _____

GEO MORPHIX™

Reach Characteristics Project Number: 23012

Date:	2023-06-13	**Field Staff:**	SH AV	**Watershed/Subwatershed:**	West Humber River
Time:		**Stream:**	Trib. of West Humber River	**UTM (Upstream):**	
Weather:	Sunny 18°C	**Reach:**	Reach 8	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 1/2

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 %: 25

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

WDJ/50m:

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity Type (Table 9): 2

Gradient (Table 11): 1

Entrenchment (Table 13): 1

Down's Model (Table 15): E

Sed Sorting (Table 20): 4

Transport Mode (Table 21): 3-

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

Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 3

# of Channels (Table 12): 2

Bank Failure (Table 14): 1, 2

Bankfull Indicators (Table 18): 1, 7

Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible

% of Bed Active: 0

Mass Movement (Table 23): 1

% Riffles: / **% Pools:** 20

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

(Table 19)

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

Bankfull Width (m)	3.60		3.70		5.0	**Wetted Width (m)**	3.60	3.70	3.3
Bankfull Depth (m)	0.70		0.53		0.77	**Wetted Depth (m)**	0.70	0.53	0.16
Undercuts (m)	0.14	0.15	0.06		0.15	**Velocity (m/s)**		0.26	1.099
Pool Depth (m)	0.54	0.32	0.47	0.49	0.1415	**Velocity Estimate Method**		wiffle	wiffle
Riffle Length (m)						**Meander Amplitude (m)**	/	/	/

Notes:

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

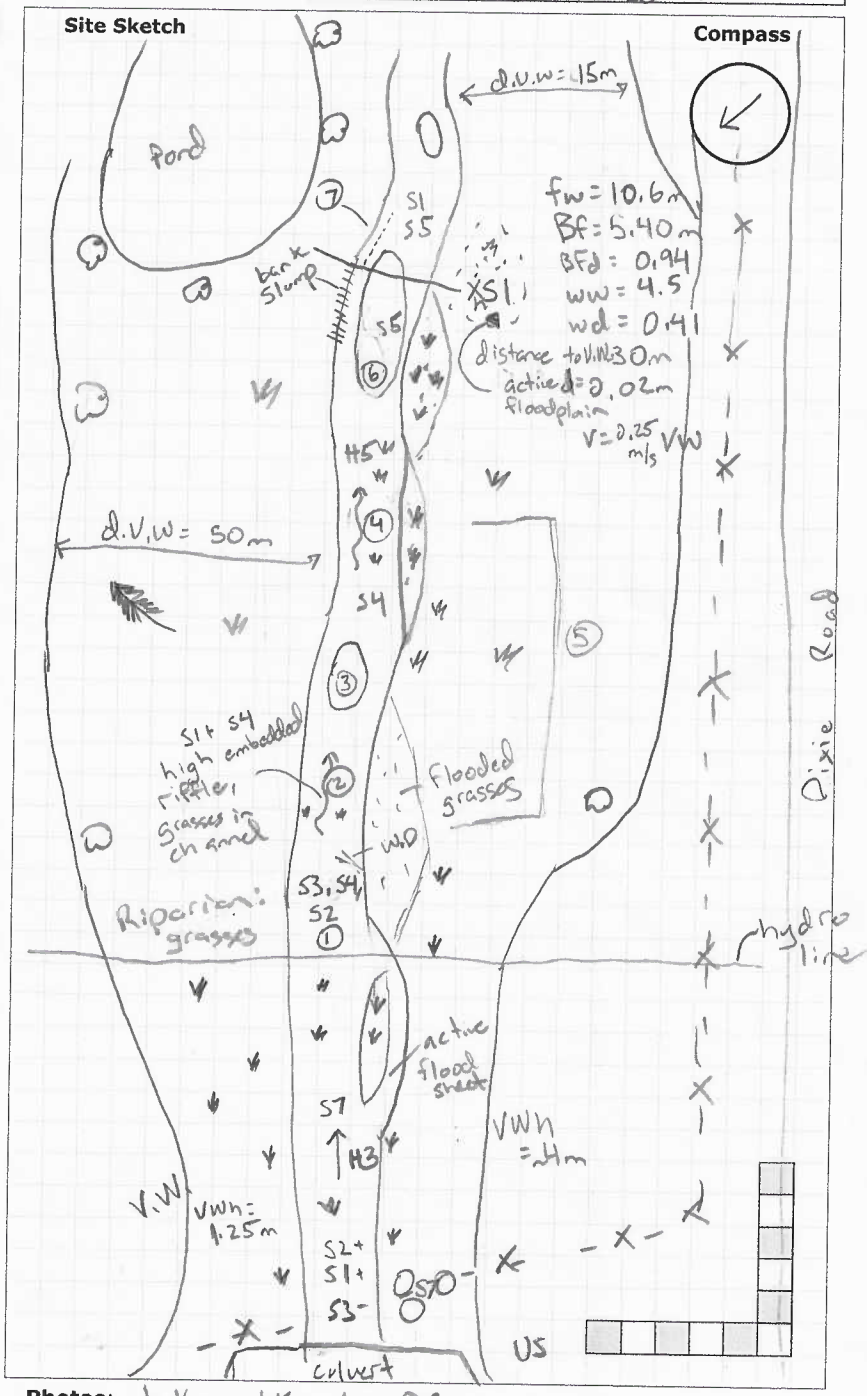
General Site Characteristics

Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib. of West Humber River
Time:		**Reach:**	Reach 8a
Weather:	Sunny 18°C	**Location:**	12861 Dixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

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	d.V.W:	distance to valley wall
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch



Photos: taken US to DS

Notes: high water levels after sign. rainfall

* high level of substrate fouling
* grasses growing instream, arrow root
* All slackwater/slow glide/smooth surface flow
* 20-30% embeddedness

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

① d = 0.45m, active floodplain d: 0.18m

② riffle l = ~7m

③ pool d = 0.51m

④ riffle l = 12.30m

⑤ Riffle-pool spacing = 22.40m

⑥ pool d = 0.55m

⑦ undercut: 0.14m

Walked US to DS

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX

General Site Characteristics

Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib. of west Humber river
Time:		**Reach:**	Reach 8a
Weather:	Sunny 18°C	**Location:**	12861 Dixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

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

Flow Type

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

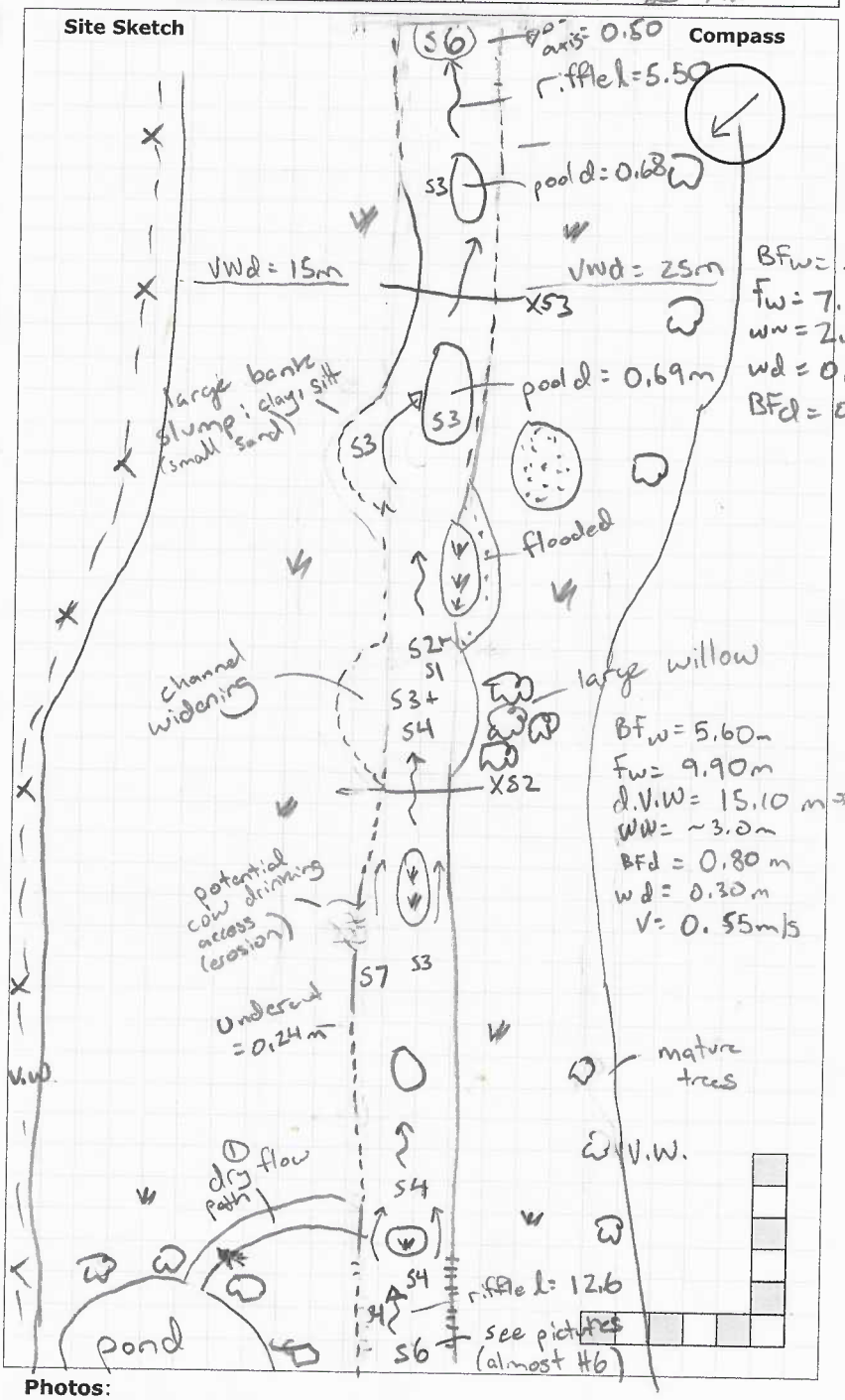
Substrate

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

Other

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

Site Sketch



Photos:

Notes:

① gap in berm of pond w dry flow path to channel. Potentially manmade drainage ditch
* instream veg: grasses + arrowroot + algae * rooted emergent + algae
* in low flow channel likely meanderless now

Version #4
Last edited: 21/02/2023

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

* Bank slumping throughout channel. Actie floodplain where erosion not occurring

GEO MORPHIX

General Site Characteristics

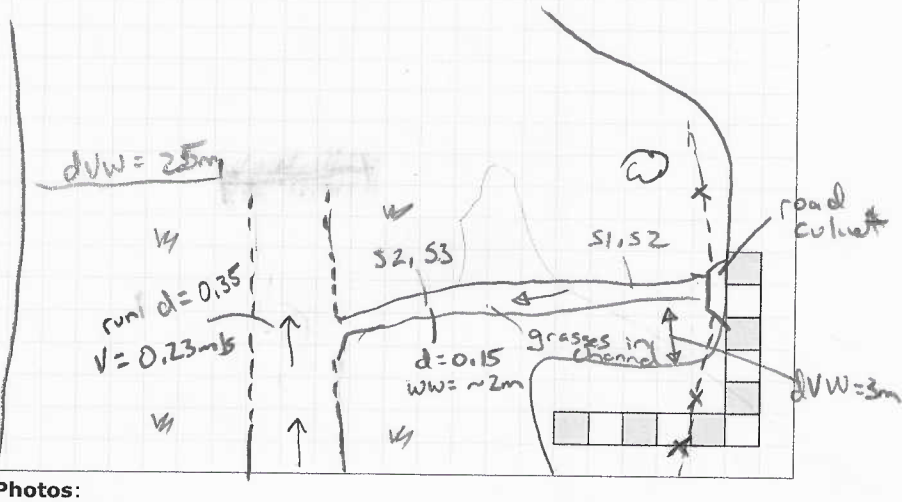
Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib. of West Humber River
Time:		**Reach:**	Reach 8a
Weather:	Sunny 18°C	**Location:**	12861 Pixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

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:

- L bank has more bank slumping than R bank
- Cutoff channel had cow-smell

GEO MORPHIX™

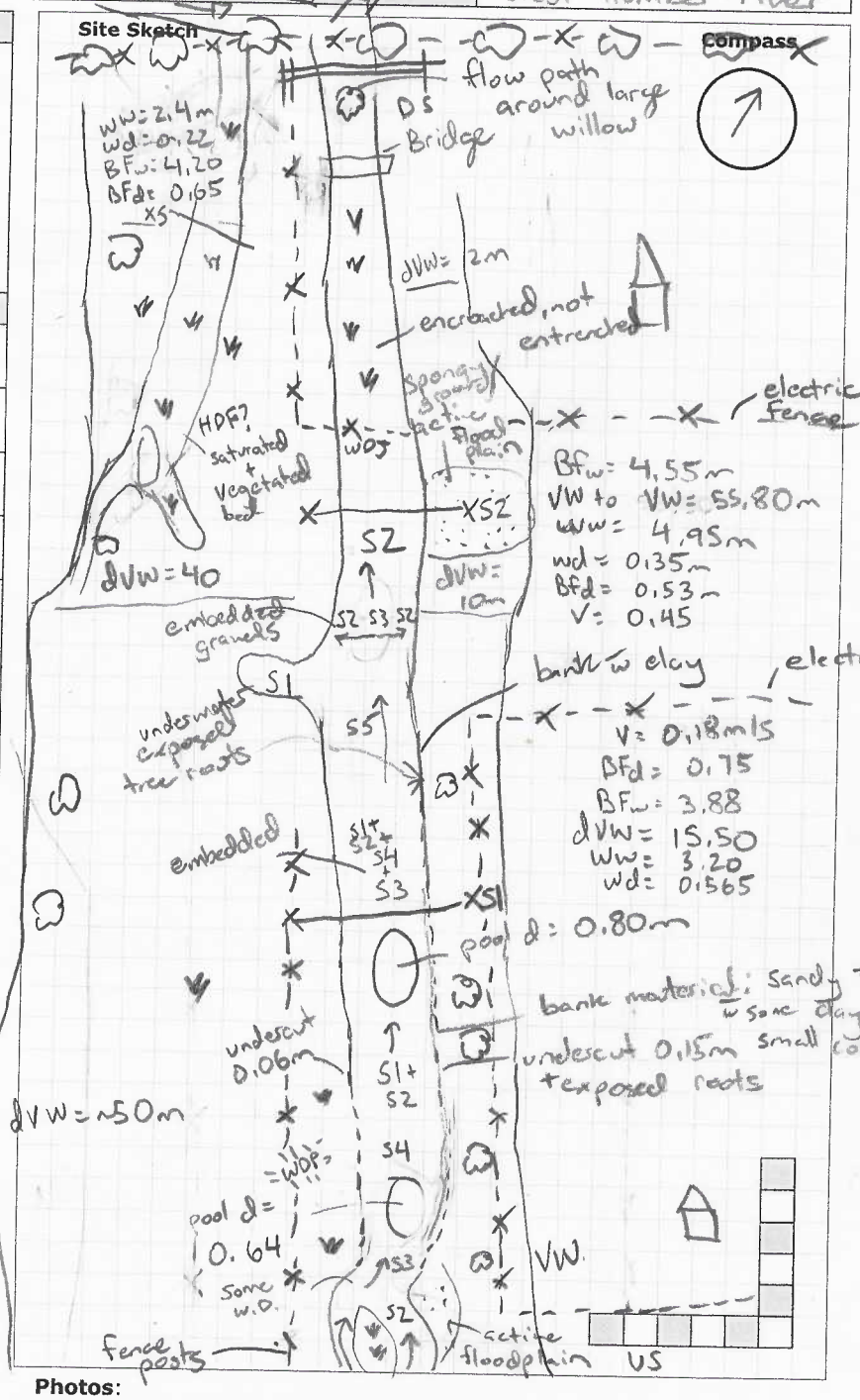
General Site Characteristics

Project Number: 23012

Date:	2023-06-13	**Stream:**	Trib of W. Humber river
Time:		**Reach:**	Reach 8a
Weather:	Sunny 18°C	**Location:**	12861 Pixie Road
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber river

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: #5 all reach

- Instream grasses, algae, aquatic veg
- high levels of sedimentation
- both banks slumping / turned into encroachment
- Some large cobble in banks (platy)
- Reach is more entrenched than TWDR-2b, but still some bank slumping
- minnows in channel
- neighbour says channel is dry in summer

(→ substrate: more sand + silt than TWDR-2b, Some gravel

Walked US to DS

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

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

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 23012

Date:	2023-06-13	**Stream:**	Trib of West Humber River
Time:		**Reach:**	Reach 8a
Weather:	SUN 18°C	**Location:**	12861 Dixie Rd
Field Staff:	SH AV	**Watershed/Subwatershed:**	West Humber River

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	3/7
	2	Coarse materials in riffles embedded	✓		
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone		✓	
		Sum of indices =	3	4	0.429
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		N/A	0/5
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	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		✓	
		Sum of indices =	0	5	0.0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1/8
	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.		✓	
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =	1	8	0.125
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	1/6
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)	✓		
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	1	6	0.143

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.174

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

Version #3
Last edited: 10/02/2023

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

high flows may skew

GEO MORPHIX

Date:	2023-06-13	PN:	23012	Location:	Dixie Road

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) = 23	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: _____

GEO MORPHIX

Reach Characteristics Project Number: 23012

Date:	2023-06-13	**Field Staff:**	SH AV	**Watershed/Subwatershed:**	West Humber river
Time:		**Stream:**	Trib of west Humber river	**UTM (Upstream):**	
Weather:	Sunny 18°C	**Reach:**	Reach 8a	**UTM (Downstream):**	

Land Use (Table 1): 2 | **Valley Type** (Table 2): 2 | **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): 3
Encroachment (Table 7): 2

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

Aquatic & Instream Vegetation

Type (Table 8): 1/6
Reach Coverage %: 45

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

WDJ/50m: N/A

Water Quality

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

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 1
Down's Model (Table 15): E
Sed Sorting (Table 20): 3
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 9/10
Riffle-Pool Spacing (m): 22.40

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): 1/2
Bankfull Indicators (Table 18): 1/7
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23): 1
% Riffles: 25 **% 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)	5.40		5.60		3.60	**Wetted Width (m)**	4.5	~3.0	2.7
Bankfull Depth (m)	0.94		0.80		0.93	**Wetted Depth (m)**	0.41	0.30	0.56
Undercuts (m)	0.24		0.14		0.06	**Velocity (m/s)**	0.25	0.55	0.23
Pool Depth (m)	0.69	0.55	0.68		0.51	**Velocity Estimate Method**	wiffle	wiffle	wiffle
Riffle Length (m)	12.6	5.50	7m		12.3	**Meander Amplitude (m)**			

Notes:
* Downs model: enlarging in some areas. Bed not scoured through entire reach. Likely experiencing channel widening in areas due to a lack of bank competency (bank materials easily erodible) in upstream portion of reach
L Riffle not visible due to high WL but substrate present in some areas for riffle formation
Substrates finer in downstream portion of reach

Photos:

Version #4
Last edited: 04/04/2023

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