GEO MORPHIX™

Humber River Tributaries
Fluvial Geomorphological Assessment

Bolton North Hill Secondary Plan Area
Local Subwatershed Study - Stage 1
Town of Caledon, Ontario

Prepared for:
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Table of Contents

List of Tables

Appendices

1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained to provide fluvial geomorphological services for the Local Subwatershed Study (LSS) being prepared by the multi-disciplinary team led by C. F. Crozier and Associates Inc. (Crozier). The subject lands, known as the Bolton North Hill Secondary Plan Area, extend north and south of Emil Kolb Parkway and east and west of Regional Road 50 in the Town of Caledon, encompassing approximately 178 ha. Multiple tributaries flow in a generally north to south orientation within and adjacent to the subject lands, labeled as Tributaries A to F in **Appendix A**. The existing land use consists primarily of agriculture, with residential development located south of Columbia Way.

This report is prepared in support of Stage 1 of the LSS. It includes an assessment of existing fluvial geomorphological conditions with a focus on tributaries proposed to receive stormwater discharge as part of future development. Dillon Consulting (Dillon) previously completed an assessment of headwater drainage features (HDFs), which are described in the LSS (Crozier et al., 2025).

GEO Morphix completed a fluvial geomorphology assessment along Tributaries B to F downstream of potential stormwater management facility (SWMF) outlets in 2024 to identify reaches along each receiving tributary that may be the most sensitive to erosion. Tributary A was not reviewed as part of this assessment. It is located outside the subject lands and is not proposed to receive stormwater discharge. Specifically, the following tasks have been completed in support of the Stage 1 LSS:

- Review of available background reports and mapping regarding watercourse form and controlling factors related to fluvial geomorphology (i.e., previous site-specific studies, watershed/subwatershed scale studies, geology, topography, conceptual development plans)
- Delineate watercourse reaches based on a desktop assessment
- Conduct rapid field reconnaissance following industry accepted, standard protocols such as the Rapid Geomorphic Assessment (RGA) (MOE, 2003) and Rapid Stream Assessment Technique (RSAT) (Galli, 1996) to confirm reach breaks and evaluate instream and riparian conditions (i.e., evidence of ongoing channel processes, active erosion/deposition, or potential channel instability)

Erosion hazard delineation was not completed for drainage features within the subject lands as they are HDFs and therefore generally have limited erosion potential. Subsequent stages of the LSS will document detailed geomorphological assessments along erosion-sensitive reaches that are proposed to receive stormwater discharge. These data will be used to calculate erosion thresholds, which establish the magnitude of flow required to potentially entrain and transport bed and/or bank material. They are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans.

2 Background Review

The subject lands are located in the Main Humber subwatershed and are comprised primarily of rural and agricultural lands, with industrial/commercial and institutional properties along Regional Road 50 and towards Columbia Way. Headwaters of the overall watershed originate in the Niagara Escarpment and Oak Ridges Moraine and drain to Lake Ontario (TRCA, 2023). Urban land use represented 26.7% of the watershed as of 2020, and 32.7% comprised natural cover. Largely due to urbanization, there are challenges related to lack of natural (riparian) cover, flooding, erosion, and water quality. These impacts are generally most prevalent in the middle and lower watershed (TRCA, 2023) downstream of the subject lands.

2.1 Scoped Subwatershed Study

Wood Environment & Infrastructure Solutions (Wood) (2022) completed a Scoped Subwatershed Study (SSWS) to provide water resources and natural heritage input to the Settlement Area Boundary Expansion (SABE) Study. The SSWS is one in a series of technical documents that informs development in the Region of Peel to 2051. The SSWS was completed in three parts (i.e. A to C). Part A provided an initial characterization of existing conditions and was primarily based on a desktop review of available

information. Part B included more detailed studies and an overview of anticipated impacts due to future development while also providing general guidance for management opportunities and future study requirements at subsequent planning stages. Part C, the Implementation Plan, provided an overview of the recommendations and guidance for management, monitoring programs, and general requirements for future planning stages and design. The Bolton North Hill Secondary Plan Area is located in a Focus Study Area (FSA) in the northeast portion of the SABE.

Concerning fluvial geomorphology, the SSWS identified surface water feature types and extents, characterized general form and function, delineated preliminary erosion hazards, assessed erosion sensitivity for features that may be impacted by development, and provided recommendations and approaches for mitigation. Reaches were delineated for both watercourses and headwater drainage features based on a desktop assessment and a windshield survey, whereby channels were reviewed in the field from road crossings to confirm presence/absence and general conditions. Due to the extensive study area and limited fieldwork, the reaches were to be refined during future planning stages.

A desktop erosion sensitivity assessment was largely completed by air photo interpretation and windshield assessments. A single erosion site was identified within the subject lands and was located at Tributary F near Mount Hope Road. This reach was assessed by GEO Morphix as part of the current study. Stream power mapping was also prepared in Part B of the SSWS to delineate watercourse reaches that were potentially sensitive to erosion; however, verification field work was recommended. Preliminary watercourse constraint rankings were also developed based on the desktop assessment and windshield surveys and were subject to refinement through field work during future planning stages.

The Part C report provided a series of management considerations for fluvial geomorphology. Considerations included identifying erosion hazards to minimize or eliminate risk to public and private property, maintenance of natural cover along stream corridors, and maintenance of natural channel structure, rates of adjustment, and channel length. Concerning stormwater management, maintenance of critical flow exceedance from pre- to post-development for erosion-sensitive reaches and maintenance of pre-development runoff volumes were recommended. Monitoring and adaptive management plans (AMPs) were recommended at future project stages and were to consider baseline and post-development geomorphological monitoring along tributaries proposed to receive stormwater discharge and along constructed naturalized corridors.

2.2 Surficial Geology

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

The subject lands are located within the drumlinized till plains physiographic landform and the South Slope physiographic region. This region, which extends from the Niagara Escarpment to the Trent River and makes up the southern slope of the Oak Ridges Moraine, is characterized by smoothed, faint drumlins and valleys that carry river systems such as the Don and Humber Rivers (Chapman and Putnam, 1984). The surficial geology of the subject lands is characterized by clay to silt-textured till derived from glaciolacustrine deposits or shale. This is consistent with observations collected by GEO Morphix along Tributaries B to F downstream of the subject lands. The surficial geology along the Humber River consists of modern alluvial deposits of 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 and potentially how past changes may affect channel planform in the future. Aerial photographs from 1951 (1:40,000), 1960

(1:25,000), 1995 (1:20,000), 1999 (1:20,000), as well as recent satellite imagery from Google Earth Pro, were reviewed to understand site history. Copies of this imagery are provided in **Appendix B** for reference.

In 1951, the subject lands and areas to the north were largely agricultural, though their current formalized boundaries were not readily apparent. The Town of Bolton was only comprised of a few streets and situated on the northwest edge of its current development extent south of the subject lands. Due to the scale and resolution of the 1951 air photo, characteristics of the low-order drainage features within the subject lands were difficult to discern. Similarly, channel planforms for Tributaries B to F were not discernable downstream of the subject lands. The channel planform of the Humber River was visible to the south, where it contained large meanders as it flowed through agricultural lands and natural areas.

Imagery resolution for the remaining period of record (i.e. 1960 to 2022) is such that the channel characteristics of Tributaries B to F are more readily visible. Tributary A was not reviewed as it is located outside of the study area and stormwater discharge is not proposed to outlet to this feature. Observations from the historical record are summarized below for Tributaries B to F.

2.3.1 Tributary B

In the 1960 image, downstream and upstream portions of the tributary were straightened, likely to facilitate agricultural land uses. Riparian vegetation was removed from the lower and upper portions of the tributary; however, woody vegetation and a sinuous channel planform were visible in the middle portion of the tributary. An online pond was present in the upper section of the tributary and may have been used to support cattle.

By 1995, the upstream extent of the tributary was cultivated and no longer visible, and the online pond had been removed. The upstream extent of the drainage feature was denoted by a narrow swath of woody vegetation that widened in the downstream direction. The channel planform was not visible due to canopy cover. This is consistent with conditions in Google Earth Pro imagery from 2005 to 2022.

2.3.2 Tributary C

In the 1960 image, the upper section of Tributary C lacked natural riparian vegetation and appeared to be straightened to suit agricultural land uses. Crops generally extended to the feature edges. Two online ponds were also present in the upstream portion of the tributary. In the lower portion of the tributary, where the valley was apparent in the imagery, a riparian buffer of natural woody vegetation was visible. Tributaries C and D appeared to flow into an online reservoir at their downstream extent. Areas of disturbance/gully erosion on the eastern valley wall adjacent to the reservoir were visible as bare slopes. Due to the resolution and scale of the 1960 image and the presence of woody vegetation, the channel planform along the lower portion of the tributary was not visible.

By 1995, the reservoir downstream of the confluence of Tributaries C and D was no longer present, and its former footprint was vegetated; however, a remnant of the control structure may have been visible in the 1999 and 2005 images. In addition, gully erosion along the lower eastern valley slope was no longer readily visible in 1995, as the lower portion of the slope was largely vegetated. Exposed surficial materials remained visible on the upper portion of the eastern valley wall from 1995 to 2022.

The cessation of agricultural land uses in the upstream portion of the tributary occurred between 1960 and 1995. Woody riparian vegetation has gradually expanded since approximately 2005, likely improving local instream conditions. Construction of the current alignment of Emil Kolb Parkway was underway by 2013 south of the subject lands. By 2015, a road crossing was constructed over the upstream extent of Tributary C.

2.3.3 Tributary D

The portion of this reach on the tablelands had been straightened prior to 1960 and natural riparian vegetation was absent. A meandering channel planform was visible in the mid- to lower portion of the reach, where it had begun to incise and form a valley. Gullies were visible on the eastern valley slope

where woody vegetation was absent and a farm access road was constructed across the tributary. Agricultural lands were present between Tributaries C and D, although the southern field appeared fallow and had begun to naturalize. In addition, the lower portion of the tributary was impounded, as a backwater was visible in the 1960 image. This likely negatively impacted the flow and sediment transport regime and may have resulted in local increases in instream temperatures.

By 1995, the reservoir had been decommissioned and the former footprint of the pond was vegetated. The southern agricultural field between Tributaries C and D had largely reforested, and woody riparian vegetation on the west side of the tributary had expanded. This likely improved slope stability along the length of the valley. The gully features on the previously exposed eastern valley slope were also largely vegetated by 1995. Commercial/industrial development had established along the upstream extent of the tributary adjacent to Regional Road 50 and had begun to encroach on the channel.

Land use remained relatively consistent between 1995 and 2009. By 2013, the commercial/industrial development in the upstream extent of the tributary had further expanded, and Tributary D had been realigned to the west and consisted of a linear channel. By 2015, a new road crossing was constructed over the upstream extent of Tributary D in association with Emil Kolb Parkway.

2.3.4 Tributary E

Lands adjacent to Tributary E have been actively cultivated prior to 1960. The tributary was historically straightened and generally lacked natural riparian vegetation. Two relatively sizeable online pond/wetland features were visible in 1960. There was little to no change in land use or tributary planform between 1960 and 1995; however, the online pond/wetland features appeared to contain limited open water or significant vegetation in the 1995 image.

The current alignment of Columbia Way was constructed by 1995, and the implementation of residential subdivisions was underway south of the subject lands. These works likely included upgrades to the associated watercourse crossing of Columbia Way over Tributary E. In 2021, construction of an online SWMF commenced on Tributary F south of Columbia Way, while north of the roadway, land use has remained primarily agricultural. The two online ponds constructed in 1960 remain on the landscape in the 2022 imagery in generally the same configuration as 1960.

2.3.5 Tributary F

Similar to the other tributaries outlined above, lands adjacent to Tributary F were actively cultivated by 1960. Flows to this tributary appeared to originate from a relatively small pond and agricultural fields on the west side of Mount Hope Road. Two minor, linear drainage features were visible on the south side of the tributary and may have been constructed or modified to facilitate agriculture. The tributary contained a sinuous channel planform and was faintly visible within the narrow treed corridor. A single rural residence or outbuilding was present on the tablelands south of the tributary.

In 1995, the predominant land use remained agriculture; however, the residence/outbuilding was demolished and the channel planform along the tributary was entirely obscured by woody vegetation. The minor drainage features that were apparent on the south side of the tributary in the 1960 image were faintly visible in the 1999 image. There was limited change in land use between 1999 and 2022. The tributary planform has remained obscured in aerial imagery by vegetation since 1995.

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches or an understanding of a reach, for example, as it relates to a proposed activity. Reaches are typically delineated based on changes in the following:

- Channel planform

- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- 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 (TRCA) (2004). Reaches are first delineated as a desktop exercise using information such as aerial imagery, topographic maps, geology information and physiography maps. The results are then verified in the field.

Reaches were previously delineated by Wood (2022) within and downstream of the subject lands at a broad scale and primarily based on a desktop assessment. Reaches along Tributaries B to F were redefined as part of the current study based on a desktop assessment and field verification. The location and extent of each reach is graphically presented in **Appendix A**. **Appendix A** also includes the locations of HDFs identified by Dillon in support of the LSS.

3.2 Summary of Reach Characteristics

Reach sinuosity, gradient and length were calculated based on watercourse information available from the TRCA (2023) and provincial LiDAR data (MNR,2014) to provide an initial understanding of reach characteristics prior to the completion of field work. **Table 1**, below, provides a desktop summary of reach characteristics.

Table 1: Reach gradient, sinuosity and length

Reach	Gradient (m/m)*	Sinuosity	Length (m)
Tributary B			
THRB-1	0.048	1.02	124
THRB-2	0.062	1.04	292
THRB-3	-0.007	1.00	141
THRB-4	0.029	1.08	238
Tributary C			
THRC	0.017	1.20	242
THRC-1	0.033	1.07	259
THRC-2	0.027	1.23	496
THRC-3	0.009	1.18	270
THRC-4	0.012	1.15	217
THRC-5	0.011	1.01	236
THRC-6	0.019	1.00	186
THRC-7	-0.004	1.09	139
Tributary D			
THRD-1	0.023	1.13	912
THRD-1a	0.113	1.05	216
THRD-2	0.034	1.12	370

Reach	Gradient (m/m)*	Sinuosity	Length (m)
THRD-2a	0.078	N/A – due to reach configuration	168
THRD-2b	0.003	1.05	180
Tributary E			
THRE-1	0.014	1.22	252
THRE-2	0.005	1.00	428
THRE-3	0.000	N/A - Pond	117
THRE-4	0.005	1.05	204
THRE-5	0.009	1.03	236
THRE-6	0.000	1.00	115
THRE-7	0.003	N/A - Pond	187
THRE-8	0.013	1.06	115
Tributary F			
THRF-1	0.036	1.15	194
THRF-2	0.051	1.10	454

*Gradient calculated using LiDAR (MNR, 2014)

3.3 General Field-Based Observations

Field investigations were completed on April 19, 2024, April 22, 2024, November 11, 2024, and November 28, 2024, and included the following reach-by-reach observations:

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

These observations and measurements are summarized in **Table 2**. Field descriptions are supplemented and supported with representative photographs included in **Appendix C**. Detailed descriptions of conditions along each reach are provided in **Section 3.4**.

Table 2: Reach characteristics summary

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed substrate	Bank substrate	Valley Type	Dominant Riparian Condition	Notes
THRF-2	1.90	0.64	Gravel and cobbles	Clay/silt and gravel	Confined	Wide riparian buffer of mature trees and shrubs with moderate encroachment	No flow at time of assessment; intermittent pools throughout reach; two knickpoints
THRE-1	4.35	0.35	[1]Clay/silt		Confined	Moderate riparian buffer of grasses	Poorly defined, multi-thread channel upstream

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed substrate	Bank substrate	Valley Type	Dominant Riparian Condition	Notes
							that transitioned to a deeper, well-defined channel downstream
THRE-2[2]	12.3	0.17	[1]Clay/silt, sand and rootlets		Unconfined	Wide, continuous buffer of grasses	Multi-thread channel within a wetland; poorly defined banks
THRE-3[4]	N/A	N/A	[1]Clay/silt and sand		Unconfined	Limited, fragmented riparian buffer of grasses	Reach consisted of a waterbody
THRE-4[2]	14.7	0.28	[1]Clay/silt, sand and rootlets		Unconfined	Continuous riparian buffer consisting of grasses	Multi-thread channel within a wetland; poorly defined banks
THRE-5	2.27	0.22	Clay/silt to gravel	Clay/silt and sand	Unconfined	Moderate fragmented riparian buffer with mature trees	Irregular meanders; limited erosion and instream morphology
THRE-6	5.35	0.29	[1]Clay/silt and sand		Unconfined	Riparian buffer was absent	Straightened channel connecting two waterbodies
THRE-7[4]	N/A	N/A	[1]Clay/silt and sand		Unconfined	Riparian buffer was absent	Reach contained a waterbody with wetland vegetation
THRE-8	1.86	0.23	Clay/silt, gravel and cobble	Clay/silt and sand	Unconfined	Narrow, fragmented riparian buffer of mature trees and shrubs	Sinuous channel with poor instream morphology (run-dominant)
THRD-1	2.19	0.42	Clay/silt to cobble	Clay/silt to gravel	Confined	Wide riparian buffer with mature trees; excellent canopy cover; grasses and shrubs common in floodplain	Multiple knickpoints; frequent erosion and slumping
THRD-1a	0.93	0.24	[1]Clay/silt, sand, gravel, cobbles and boulders		Confined	Wide riparian buffer consisting of mature trees	Gully feature with frequently eroded banks and undercutting
THRD-2b	1.93	0.24	[1]Silt and sand		Unconfined	Riparian buffer absent; stands of invasive phragmites observed along margins	Flow originated in a wetland and flowed underneath an existing development at the downstream

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed substrate	Bank substrate	Valley Type	Dominant Riparian Condition	Notes
							extent assessed (assumed to be piped)
THRC	1.77	0.47	Gravel and cobbles	Clay/silt, sand and gravel	Confined	Wide riparian buffer of mature trees	Frequent bank erosion and undercutting
THRC-1	2.38	0.47	Clay/silt, gravel and cobble	Clay/silt	Confined	Wide riparian buffer consisting of grasses and mature trees	Knickpoint near the downstream extent of reach; erosion and slumping downstream of knickpoint
THRC-2	3.04	0.52	Clay/silt, gravel and cobble	Clay/silt	Confined	Wide riparian buffer consisting of mature trees	Banks were high and undercut; localized areas of exposed till in banks
THRC-3	3.67	0.47	Cobble	Clay/silt and sand	Confined	Wide riparian buffer consisting of mature trees	Multiple woody debris jams; Bank erosion and undercutting was common along the reach
THRC-4	2.74	0.50	Clay/silt	Clay/silt	Confined	Wide riparian buffer consisting of grasses and mature trees	Irregular meanders; chute identified at the upstream extent of the reach
THRC-5[3]	N/A	N/A	[1]Clay/silt and sand		Unconfined	Fragmented riparian buffer consisting of grasses	Majority of the reach was inaccessible due to recent wetland restoration activities
THRC-6[2]	15.7	0.19	[1]Clay/silt and sand		Unconfined	Fragmented riparian buffer consisting of grasses	Multi-thread channel within a wetland; little to no erosion
THRC-7[2]	18.8	0.17	[1]Clay/silt and sand		Confined	Narrow fragmented riparian buffer consisting primarily of grasses	Multi-thread channel within a wetland; rooted emergent vegetation
THRB-1	2.97	0.52	Gravel and cobbles	Clay/silt to gravel	Partially confined	Wide riparian buffer consisting of mature trees	Meandering channel with riffle-pool morphology; moderate entrenchment

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed substrate	Bank substrate	Valley Type	Dominant Riparian Condition	Notes
THRB-2	1.50	0.42	Sand, gravel and cobble	Clay/silt to gravel	Confined	Wide riparian buffer consisting of mature trees	Meandering channel with bank erosion and undercutting
THRB-3	1.4	0.57	[1]Clay/silt and sand		Confined	Wide, continuous riparian buffer consisting of trees and grasses	Wetland feature contained within a valley
THRB-4	1.88	0.38	Sand, gravel and cobble	Clay/silt and sand	Confined	Wide riparian buffer consisting of mature trees	Moderately entrenched meandering channel; moderate channel gradient

[1] Uniform channel bed, substrate observations reflective of full channel condition.
[2] Average feature width and wetted depth due to lack of channel definition.
[3] Observations were completed roadside and/or at property boundaries due to restricted access.
[4] This reach is a waterbody.
[5] Reaches THRD-3 and THRD-4 were assessed by Dillon as HDFs and therefore were not reviewed by GEO Morphix.

3.4 Reach-Based Rapid Assessments

Rapid assessments were completed to identify dominant geomorphic processes, document stream health, and identify any areas of concern regarding erosion or instability. Channel instability was objectively quantified by applying 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 (1995) model describes the successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system.

A summary of the reach classifications and rapid assessment scores is provided in **Table 2**. Although the majority of Tributary E was characterized as an HDF by Dillon, rapid geomorphic assessment tools were used to assess stability and determine which reach along the feature is the most sensitive to erosion. This information will be used to inform erosion threshold and erosion exceedance analyses in support of the proposed stormwater management strategy, which will be completed during subsequent LSS stages.

Table 3: Rapid assessment results summary

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995) Channel Evolution Model
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
THRF-2	0.33	In Transition	Widening	20	Fair	Channel Stability	e – enlarging
THRE-1	0.107	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable
THRE-2	0.072	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable
THRE-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A
THRE-4	0.072	In Regime	Planimetric Form of Adjustment	N/A	N/A	N/A	N/A
THRE-5	0.122	In Regime	Widening	25	Good	Physical Instream Habitat	S – stable
THRE-6	0.072	In Regime	Aggradation and Widening	N/A	N/A	N/A	S – stable
THRE-7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
THRE-8	0.072	In Regime	Widening	23	Fair	Physical Instream Habitat, Riparian Habitat Conditions	S – stable
THRD-1	0.518	In Adjustment	Widening	21	Fair	Channel Stability	e – enlarging
THRD-1a	0.234	In Transition	Widening	N/A	N/A	N/A	M – lateral migration
THRD-2b	0.036	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable
THRC	0.263	In Transition	Widening	22	Fair	Channel Stability	M – lateral migration
THRC-1	0.372	In Transition	Aggradation	22	Fair	Channel Stability, Physical Instream Habitat	e – enlarging
THRC-2	0.278	In Transition	Widening	27	Good	Channel Stability, Physical Instream Habitat	e – enlarging
THRC-3	0.282	In Transition	Widening	27	Good	Channel Stability	e – enlarging
THRC-4	0.174	In Regime	Aggradation	25	Good	Riparian Habitat Conditions	U – undercutting
THRC-5	0.036	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable
THRC-6	0.036	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995) Channel Evolution Model
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
THRC-7	0.036	In Regime	Planimetric Form Adjustment	N/A	N/A	N/A	S – stable
THRB-1	0.437	In Adjustment	Widening	27	Good	Channel Stability, Riparian Habitat Conditions	U – undercutting
THRB-2	0.384	In Transition	Widening	23	Fair	Channel Stability, Riparian Habitat Conditions	E – enlarging
THRB-3	0.179	In Regime	Widening	N/A	N/A	N/A	S – stable
THRB-4	0.357	In Transition	Widening	23	Fair	Channel Stability, Physical Instream Habitat	e – enlarging

Note: RGAs and/or RSATs were not completed for reaches that were dry at the time of assessment, reaches that contained multi-thread channels within wetlands, reaches that were classified as waterbodies and where site access was restricted. This is denoted as "Not Applicable (N/A)"

3.4.1 Tributary F

Reach THRF-2 is located along Tributary F east of Mount Hope Road in the eastern extent of the study area. The reach contained a single meandering channel within a confined valley. It was moderately entrenched and had a moderate gradient. At the time of assessment, flow was absent and only pools of standing water were noted. The riparian vegetation consisted of mature trees and some shrubs. Ongoing bank erosion was noted, and undercutting was common throughout the reach. Two knickpoints were observed, indicative of channel adjustment (i.e. degradation). Fallen and leaning trees were present, along with accreting point bars. Banks substrates consisted of clay, silt and gravel, and where riffles were present, they also contained cobles. The reach was identified to be in adjustment based on the RGA score. This was largely a result of bank erosion, fallen/leaning trees, accretion on point bars, and siltation in pools. The RSAT score characterized the reach as fair, with the limiting feature being channel stability.

Although **Reach THRF-1** may also receive stormwater discharge as part of future development, it was not field-assessed as based on available information, the potential stormwater outlet will discharge to **Reach THRF-2**. In addition, **Reach THRF-1** is downstream of a tributary confluence and has a shallower gradient than **Reach THRF-2** (refer to **Table 1**), and therefore was assessed to be less sensitive to erosion than **Reach THRF-2**. Should the position of the proposed stormwater outlet to Tributary F be adjusted, further assessment along **Reach THRF-1** may be required as the LSS proceeds.

3.4.2 Tributary E

Reach THRE-1 is located immediately upstream of Columbia Way. The reach had a low sinuosity with variable characteristics upstream versus downstream. The downstream portion of the reach consisted of a well-defined entrenched channel, whilst the upstream portion of the reach consisted of a poorly defined wetland with multiple flow paths. The riparian buffer was comprised of a grassy meadow with a mature forest set back from the feature. The bed and bank substrates consisted of clay and silt with heavier siltation occurring closer to the culvert at the downstream extent of the reach. The reach was in regime based on the RGA score. The RSAT was not applied as the reach was poorly defined with multiple flow paths.

Reach THRE-2 is characterized by a wetland feature that contained a multi-thread flow path within two agricultural fields. It was generally poorly defined, with localized portions of the reach that were slightly more defined. These locations included the inlet to a pond and just upstream of a phragmites stand. Bank erosion was not observed, and bank and bed substrate consisted of clay, silt, and sand.

The riparian vegetation buffer consisted of established grasses that heavily encroached on the channels. Pooling was observed mid-reach, where a lack of instream and riparian vegetation existed. The reach was identified to be in regime based on the RGA score. The RSAT was not applied as the reach was poorly defined with multiple flow paths.

Reach THRE-3 consists of a waterbody. Grasses, cattails and wetland vegetation persisted in fragmented pockets around the pond periphery. Agricultural fields were tilled up to the edge of the riparian vegetation. The bed and bank substrates consisted of clay, silt, and sand and erosion was generally absent. RGA and RSAT tools were not applied to this reach as it consisted of a pond.

Reach THRE-4 is characterized by a wetland feature that contained a poorly-defined multi-thread flow path. The riparian vegetation consisted of established grasses that heavily encroached on the flow path. The reach had a low gradient and low entrenchment and lacked riffle-pool morphology. Bank erosion was not observed and bank and bed substrate consisted of clay, silt, and sand. The reach was identified to be in regime based on the RGA score. The RSAT was not applied as the reach was poorly defined with multiple flow paths.

Reach THRE-5 contained a channel having a low sinuosity and irregular meanders. The riparian zone was fragmented and consisted of established forest vegetation. There was a low density of woody debris, some exposed tree roots and leaning and fallen trees. Generally, the reach was run-dominant with a few riffles. The bed substrate consisted of clay, silt, sand and some gravel while the bank substrate consisted of clay, silt and sand. The reach was identified to be in regime and in good condition based on the RGA and RSAT scores, respectively. The limiting feature for the RSAT was physical instream habitat based on the lack of diverse instream morphology.

Reach THRE-6 is a straight channel that connects two waterbodies. The reach was moderately entrenched with little to no erosion present along the banks. The bed and bank substrate were uniform and consisted of clay, silt, and sand. Natural riparian vegetation was not present as the reach was historically altered, and the channel was flowing between two agricultural fields. Old woody debris and fallen trees were found in the channel but were not blocking flow. The reach was in regime based on the RGA score.

Reach THRE-7 is a waterbody along the tributary. A riparian buffer was not observed along the reach as agricultural fields were tilled up to the edge of the pond. Cattails and wetland vegetation were observed within the edges of the pond in fragmented pockets. The bed and bank substrate consisted of clay, silt, and sand with a lack of erosion present. RGA/RSAT sheets were not completed for this reach as it was not applicable as it is a waterbody.

Reach THRE-8 is a sinuous single reach with a low gradient and entrenchment. The downstream portion of the reach was a straight single channel that was historically altered to connect to the waterbody downstream. The upstream portion of the reach was a sinuous channel that began where a tile drain entered the feature. The riparian buffer was fragmented and consisted of forest, although the buffer was absent at the downstream portion of the reach. The stream bed and banks were relatively stable with some exposed roots and fallen and leaning trees. The reach was in regime based on the RGA score; however, geomorphological indicators included exposed tree roots and the formation of a chute. Riparian conditions were limited due to the fragmented forest cover, while physical instream habitat was limited as the reach was run-dominant (i.e., few riffles and pools).

3.4.3 Tributary D

Reach THRD-1 is a meandering channel within a confined valley. The riparian zone was forested, with grasses in the immediate floodplain. Based on the rapid assessments the reach was in adjustment. The dominant processes were widening, with exposed roots, woody debris, several rooted knickpoints, fracture lines, recent tree falls and failed culverts. Other geomorphological indicators included medial bars, accretion on point bars, formation of cut-off channels, and head cutting due to knickpoint migration. Multiple bank failures and a remnant channel were also present. The primary reason for the woody debris and trees falls was valley wall contact in multiple locations. High levels of erosion were observed with undercutting measured up to 1.0 m deep. Abrupt gradient changes were evident along

the reach due to several rooted knickpoints. The creek had also worn down to the clay/till parent material, resulting in deep entrenchment.

Reach THRD-1a is a gully feature within a mature forest and confined valley. The channel was generally straight and had a steep gradient and entrenchment ratio. Undercutting and erosion were observed, with undercuts measuring up to 0.69 m deep. The channel was dry during the assessment and as such, riffle pool morphology was not observed. The bank substrate consisted of clay, silt, sand, and gravel. The channel bed substrate was comprised of substrates ranging from clay to cobbles and boulders. The reach was evaluated to be transition based on the RGA score with the dominant process being widening. This was evidenced by tree falls, exposed tree roots and scour.

Reach THRD-2b is characterized by a poorly defined, straightened channel along the property boundary between an agricultural field and existing commercial development. The channel began at the roadside and flowed through a stand of phragmites before ultimately discharging underneath the adjacent development (assumed to be piped). The channel bed was highly silted and lacked riffle-pool morphology. The bed and bank substrates consisted of clay, silt and sand. Little to no erosion was observed along this reach. The reach was identified to be in regime based on the RGA score. The RSAT was not applied as the channel was poorly defined and contained multiple flow paths.

Reaches THRD-3, and **THRD-4** were not assessed by GEO Morphix but were characterized as HDFs by Dillon (Crozier et al., 2025).

3.4.4 Tributary C

Reach THRC is a well-defined meandering channel within a confined valley. The channel meandered through a well-established, forested buffer. Fallen and leaning trees and exposed roots were commonly found throughout the reach. A moderate density of woody debris was present as a result. Riffle-pool morphology was observed; however, the reach was generally run-dominant with a small number of pools. Undercuts and vegetated slumps were present, with undercuts measured up to 0.53 m deep. The reach was evaluated to be in transition based on the RGA score, with dominant systematic indicators of widening and aggradation. This was evidenced by exposed roots, fallen trees, organic debris, siltation in pools, accretion on point bars and deposition in the overbank zone.

Reach THRC-1 is a meandering channel within a confined valley. The riparian zone immediately adjacent to the channel consisted of grasses within a wider forested buffer. This portion of the reach significantly widened following the input of a tributary. Erosion was observed throughout the reach, with bank failures following a rooted knickpoint. Fallen and leaning trees, exposed roots, and woody debris jams were common throughout the reach. Some undercutting was also observed, which measured up to 0.50 m deep. The channel had eroded into clay/till parent material and entrenchment increased in the downstream direction. The RGA score indicated the reach was in transition, with dominant systemic adjustments consisting of aggradation. This was evidenced by siltation in pools, accretion on point bars, and deposition in the overbank zone.

Reach THRC-2 is a meandering channel within a confined valley with high entrenchment. Erosion and extensive undercutting were common, with undercuts measuring up to 1.63 m deep. Riffle-pool morphology was well-developed. Riffle substrates consisted of gravel and cobbles and pool substrates consisted of pools clay, silt, and sand. The water was clear, and fluvial entrainment was observed at the time of the assessment. The reach was evaluated to be in transition based on the RGA score. The dominant channel adjustment process was widening. This was evidenced by tree falls, exposed tree roots, organic debris and extensive erosion. Siltation in pools, accretion on point bars, and embedded coarse riffle materials were observed.

Reach THRC-3 is a meandering channel within a confined valley with high entrenchment. Pools and channel banks generally consisted of sand, clay, and silt substrates. The riffles generally consisted of cobbles. The riparian vegetation was comprised of a mature, wide and continuous forest. Woody debris was found within the channel and substantial bank erosion was observed. Due to bank erosion and undercutting, bank failures were observed. Undercuts measured up to 0.78 m deep. The reach was in transition based on the RGA score with the dominant processes being widening. This was evidenced by tree falls, organic debris, siltation in pools, and the accretion on point bars.

Reach THRC-4 is a single-thread channel with irregular meanders, moderate entrenchment and a moderate gradient. The riparian buffer consisted of a grassy meadow through a wide forested buffer. The grassy riparian vegetation was heavily encroaching into the channel in addition to rooted emergent aquatic vegetation. Channel morphology was well-developed as riffles, pools, and runs were observed along the reach. Pool substrate consisted primarily of clay and silt while the riffles consisted of clay, silt and some gravel and cobble. Bank erosion was present and undercuts measured up to 0.72 m deep. The reach was in regime based on the RGA score and the dominant processes was aggradation. This was evidenced by siltation in pools and deposition in the overbank zone.

Reach THRC-5 is characterized by a wetland feature that appeared to be recently restored. This reach was generally not accessible due to the recent restoration activities. The channel was straight and flowed through the wetland via multiple flow paths. The riparian vegetation consisted of a narrow, fragmented buffer of grasses. Little to no erosion was observed and bed and bank substrates were comprised of clay, silt and sand. The reach was identified to be in regime based on the RGA score and lacked geomorphological indicators. The RSAT was not applied as the reach was poorly defined and had multiple flow paths.

Reach THRC-6 and **THRC-7** is characterized by a wetland feature that contained a poorly defined channel with multiple flow paths. The riparian vegetation consisted of a narrow, fragmented buffer consisting of grasses. Little to no erosion was observed and bed and bank substrates were comprised of clay, silt, and sand. The reach was identified to be in regime based on the RGA score and lacked geomorphological indicators. The RSAT was not applied as the reach was poorly defined and had multiple flow paths.

3.4.5 Tributary B

Reach THRB-1 is a single channel with irregular meanders, a moderate gradient and moderate entrenchment. Substantial bank erosion was present and undercuts measured up to 0.65 m deep. The bed has incised into the clay/till parent material. The riparian buffer consisted of a wide, mature forest. Minimal vegetation encroachment was present throughout the reach, although woody debris was present in the channel and cutbank. Riffle-pool morphology was well developed as riffles, pools, and runs were observed. Riffle substrate consisted primarily of gravel and cobbles and pools were highly silted and contained clay, silt, sand and some gravel. The reach was in adjustment based on the RGA score. The dominant channel process was widening, although sections of channel showed degradation and aggradation. This was evidenced by tree falls, exposed tree roots, and basal scour throughout the reach. Siltation in pools, exposed bridge footings, and scour pools downstream of culverts were also observed.

Reach THRB-2 is a confined channel with irregular meanders. The riparian buffer consisted of a wide, mature forest. Substantial bank erosion was observed and undercuts measured up to 1.0 m deep. Riffle-pool morphology was well developed as riffles, pools, and runs were observed. Riffles substrates consisted of sand, gravel and cobbles and pools contained clay, silt, sand and some gravel. The channel bed had also incised into the clay/till parent material. The water was turbid at the time of assessment due to a rain event and fluvial entrainment was observed. The reach was in transition based on the RGA score. The dominant adjustment process was widening, as evidenced by tree falls, exposed tree roots, exposed previously buried utilities, and basal scour throughout the reach. Siltation in pools, deposition in the overbank zone, and scour pools downstream of culverts were also observed.

Reach THRB-3 is characterized by a wetland feature upstream of Duffy's Lane. The reach was sinuous and contained multiple flow paths before flowing through a culvert and connecting to the downstream reach. The reach began as a single-thread channel before evolving to a multi-thread channel downstream. The reach was confined within a valley and had a wide riparian buffer of grasses that were heavily encroaching the feature. Woody debris, fallen and leaning trees, exposed roots, and organic debris were observed in the channel. Minimal erosion was observed, although occasional shallow undercuts measuring up to 0.14 m deep were noted. The bed and bank substrates consisted of clay, silt, and sand. The reach was identified to be in regime based on the RGA score. The RSAT was not applied as the reach was poorly defined with multiple flow paths.

Reach THRB-4 is a single channel with a meandering planform and high entrenchment. Substantial bank erosion was present, with undercuts measured up to 0.63 m deep. The channel bed had incised

into the clay/till parent material. The riparian buffer consisted of a wide, mature forest. Riffle pool morphology was well developed as riffles, pools, and runs were present; however, riffles were difficult to observed due to the abundance of woody debris jams. Riffle substrate consisted primarily of sand, gravel and cobbles and pool substrate consisted of clay, silt, and sand. The reach was evaluated to be in adjustment based on the RGA score. The dominant channel process was widening; however, evidence of degradation and aggradation were also noted. This was evidenced by tree falls, exposed tree roots, and extensive basal scour throughout the reach. Siltation in pools, embedded coarse riffle materials, and scour pools downstream of culverts were also observed.

4 Summary and Recommendations

GEO Morphix was retained to complete a fluvial geomorphological assessment in support of Stage 1 of the LSS for the Bolton North Hill Secondary Plan Area, which is being led by Crozier. The assessment focussed on characterizing reaches downstream of the subject lands that may receive stormwater discharge as part of future development. Tributaries within, adjacent to and downstream of the subject lands are referred to as Tributares A to F in this Report. As Tributary A is located outside (i.e., west) of the subject lands and is not proposed to receive stormwater discharge, it was not reviewed as part of this study. Findings of the fluvial geomorphology assessment are summarized as follows:

- The SSWS (Wood, 2022a; Wood, 2022b; Wood, 2022c) included a fluvial geomorphology assessment of all watercourses and HDFs at a broad scale. Watercourses and HDFs were delineated largely based on a desktop assessment and windshield surveys, and were subject to refinement at future project stages.
- All reaches within the subject lands consist of HDFs and were characterized by Dillon (Crozier et al., 2025). An erosion hazard assessment was not completed due to the limited erosion potential associated with these features.
- Watercourse reaches downstream of the subject lands were re-defined as part of the current study based on site-specific field observations.
- Aerial imagery spanning the years 1960 to 2022 indicated that HDF reaches within the subject lands were historically impacted by agricultural land uses, and more recently by local commercial development. Tributary planforms downstream of the subject lands were not clearly visible due to woody canopy cover and/or imagery scale and resolution. The lower extents of Tributaries C and D contained reservoirs in the 1960 imagery. Channel adjustments observed along these tributaries during field reconnaissance in 2024 may be attributed, at least in part, to historical impoundment.
- Reaches downstream of proposed stormwater management facilities were characterized and evaluated using rapid assessment tools, including the RGA (MOE, 2003), RSAT (Galli, 1996) and Downs (1995) models to determine which reaches along each receiving tributary are the most erosion-sensitive.
- Although Tributary E was largely characterized as an HDF by Dillon, it was evaluated from geomorphic and erosion sensitivity perspectives as it is proposed to receive stormwater discharge as part of future development.
- In general, the upper reaches of Tributaries B, C, as well as the entirety of Tributary E, were evaluated to be in regime based on the RGA results
- The lower reach of Tributary B (i.e., **THRB-1**), the portion of Tributary C assessed by GEO Morphix and **Reach THRF-2** were evaluated to be in adjustment based on the RGA results
- The lower reach of Tributary C (i.e., **THRC-1**) was evaluated to be in transition based on the RGA results

GEO Morphix is completing detailed geomorphic field assessments on erosion-sensitive reaches of Tributaries B to F to support erosion threshold determination. Detailed assessments include the following measurements/observations:

- longitudinal profile survey of the channel centreline
- cross-section surveys to document bankfull channel geometry
- detailed review of channel substrate and bank material composition and structure
- characterize bank height, angle, root density and riparian conditions

These data will be used to calculate erosion thresholds for channels proposed to receive stormwater discharge to support overall stormwater management designs completed by Crozier. An erosion mitigation plan will be developed based on post- to pre-development comparisons of erosion threshold exceedance duration, exceedance frequency, cumulative exceedance volume, and cumulative excess work. Erosion exceedance modelling will be completed using our in-house models, which can be applied to synthetic storm events or continuous hydrology records.

At this time, it is recommended that the proposed stormwater management strategy include retention of the first 5 mm of every rainfall event and 48-72 hour detention of the 25 mm event. This approach generally follows TRCA (2012) stormwater management guidelines and will be refined as the erosion mitigation assessment proceeds.

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

Respectfully submitted,

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Senior Environmental Scientist

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Reach Delineation

Tributaries of Humber River

Bolton North Hill Secondary Plan Area

Local Subwatershed Study, Town of Caledon

Legend

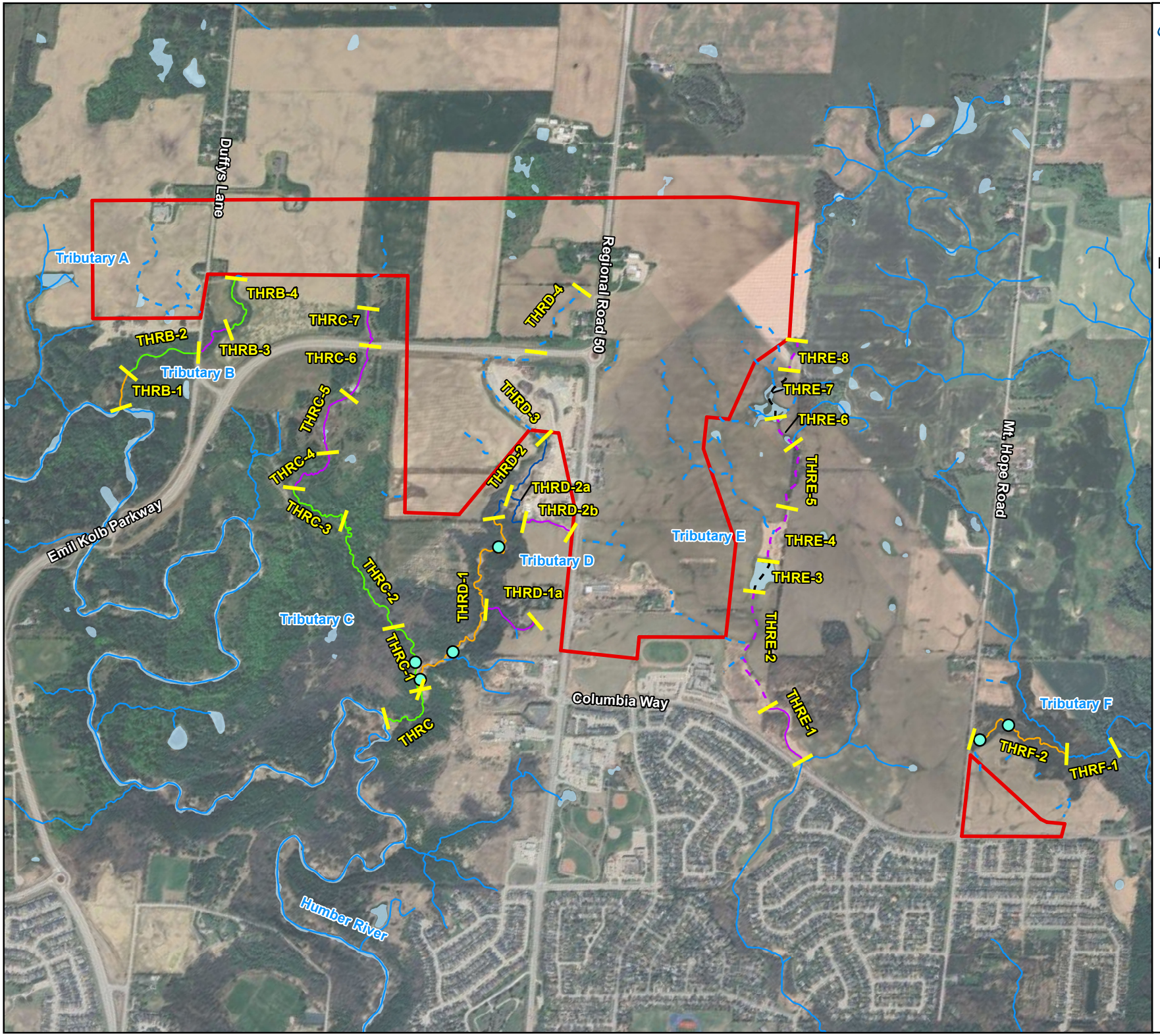
- Reach Break and ID
- 0.5 m Contour
- Watercourse
- Watercourse (No Access)
- HDF
- Property Boundary
- Waterbody

INTERNAL USE ONLY

0 275 550

Metres

Imagery: Google Earth, 2022. Watercourse: TRCA, 2023. Approximate Property Boundary, HDFs: Crozier., 2025. 0.5 m Contour: MNR, 2014. Reach Break and ID: GEO Morphix Ltd., 2024. Waterbody: MNRF, 2024. PN24048. Print Date: February 2025. Drawn By: M.O., S.S.O., G.U.



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Reach Delineation

Tributaries of Humber River

Bolton North Hill Secondary Plan Area
Local Subwatershed Study, Town of Caledon

Legend

- Reach Break and ID
- Knickpoint
- Watercourse
- Watercourse (No Access)
- HDF
- In Transition
- In Regime
- In Regime (HDF)
- In Adjustment
- HDF (Not Applicable, Waterbody)
- Property Boundary
- Waterbody

N

0 275 550
Metres

Imagery: Google Earth, 2022. Watercourse: TRCA, 2023. Approximate Property Boundary, HDFs: Crozier., 2025. 0.5 m Contour: MNR, 2014. Waterbody: MNRF, 2024. Reach Break and ID, Knickpoint: GEO Morphix Ltd., 2024. PN24084. Print Date: February 2025. Drawn By: M.O., S.S.O., G.U.

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Appendix A:
Reach Delineation

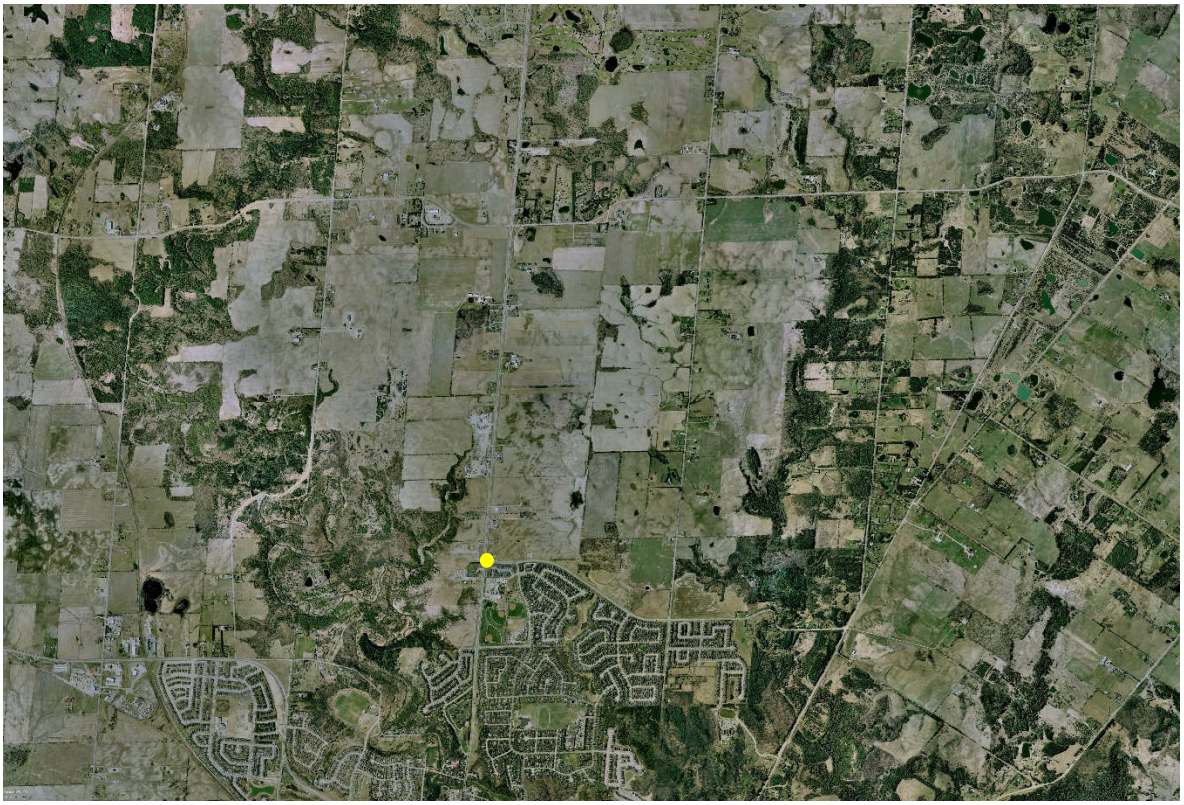
Appendix B:
Historical Aerial Imagery

Location: Caledon, ON
Year: 1951
Scale: 1:40,000
Source: National Air Photo Library
Yellow Point: Intersection of Regional Road 50 and Columbia Way

Location: Caledon, ON
Year: 1960
Scale: 1:25,000
Source: National Air Photo Library
Yellow Point: Intersection of Regional Road 50 and Columbia Way

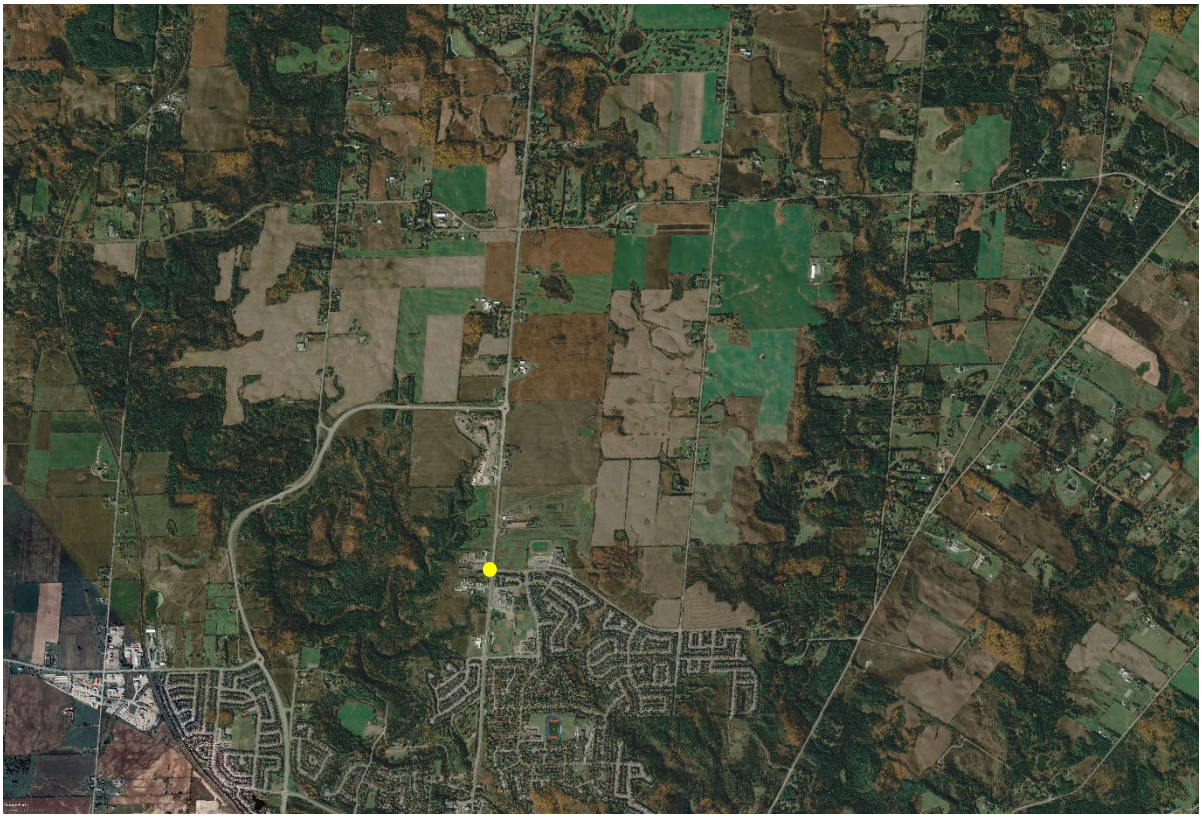
Location: Caledon, ON
Year: 1995
Scale: Digital Orthoimagery
Source: Ministry of Natural Resources
Yellow Point: Intersection of Regional Road 50 and Columbia Way

Location: Caledon, ON
Year: 1999
Scale: Digital Orthoimagery
Source: Ministry of Natural Resources
Yellow Point: Intersection of Regional Road 50 and Columbia Way

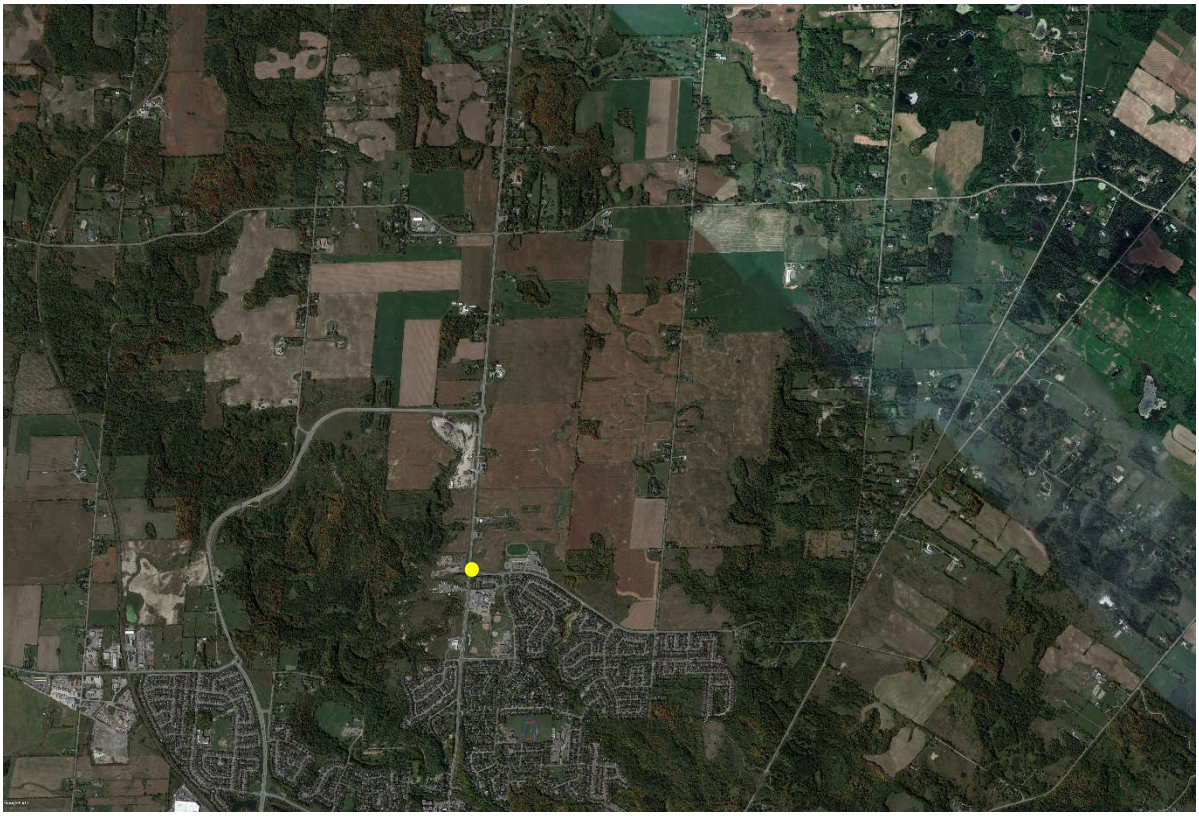


Location: Caledon, ON
Year: 2005
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Regional Road 50 and Columbia Way

Location: Caledon, ON
Year: 2015
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Regional Road 50 and Columbia Way



Location: Caledon, ON
Year: 2019
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Regional Road 50 and Columbia Way



Location: Caledon, ON
Year: 2022
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Regional Road 50 and Columbia Way

Appendix C:
Photographic Record

Photo 1
Tributary of the Humber River - Reach THRF-2, Caledon, Ontario

In the upstream portion of the reach erosion and undercutting was commonly observed. Undercuts were measured up to 0.48 m.

Photo 2
Tributary of the Humber River – Reach THRF-2, Caledon, Ontario

The bed substrate consisted of gravel and cobbles and the bank substrate consisted of clay, silt, and gravel primarily.

Photo 3 Tributary of the Humber River – Reach THRF-2, Caledon, Ontario	 The gradient along the reach was high and entrenchment increased at localized sections where knickpoints were present.
Photo 4 Tributary of the Humber River - Reach THRF-2, Caledon, Ontario	 Woody debris, leaning and fallen trees, and exposed roots were common, with the highest concentration in the upstream section of the reach.

Photo 5 Tributary of the Humber River - Reach THRE-1, Caledon, Ontario	
	A few leaning trees and exposed roots were observed throughout the reach.
Photo 5 Tributary of the Humber River - Reach THRE-1, Caledon, Ontario	
	The downstream portion of the reach was characterized by a straight, defined channel with a steep gradient.

Photo 5 Tributary of the Humber River - Reach THRE-1, Caledon, Ontario	
	The majority of the reach, and particularly the upstream portion, was characterized as a grassy meadow with multiple flow paths.
Photo 6 Tributary of the Humber River - Reach THRE-1, Caledon, Ontario	
	Localized areas of definition and pooling were observed throughout the reach.

Photo 7 Tributary of the Humber River - Reach THRE-2, Caledon, Ontario	
	Reach consisted of a poorly defined wetland with multiple flow paths. Grasses heavily encroached the channel.
Photo 8 Tributary of the Humber River - Reach THRE-2, Caledon, Ontario	
	Feature was intermittently defined and water was turbid at the time of the assessment.

Photo 9 Tributary of the Humber River - Reach THRE-2, Caledon, Ontario	 Pooling and flooding were observed along the poorly defined section of reach between two agricultural fields.
Photo 10 Tributary of the Humber River - Reach THRE-2, Caledon, Ontario	 The pond outlet showed evidence of widening. Cattails and wetland vegetation were present at the outlet.

Photo 11 Tributary of the Humber River - Reach THRE-3, Caledon, Ontario	 This reach consisted of a waterbody. Cattails and wetland vegetation surrounded the margins of the pond.
Photo 12 Tributary of the Humber River – Reach THRE-4, Caledon, Ontario	 Wetland feature with poorly defined banks and multiple flow paths. The riparian vegetation consisted of grasses that extensively encroached the channel.

Photo 13 Tributary of the Humber River - Reach THRE-4, Caledon, Ontario	
	Reach was better defined in the upstream extent and at the inlet to the pond.
Photo 14 Tributary of the Humber River - Reach THRE-5, Caledon, Ontario	
	Fallen and leaning trees, exposed roots, and organic debris were observed throughout the reach.

Photo 15
Tributary of the Humber River - Reach THRE-5, Caledon, Ontario

The riparian buffer consisted of forest but was fragmented by adjacent agricultural fields.

Photo 16
Tributary of the Humber River - Reach THRE-5, Caledon, Ontario

Bed substrate consisted of clay, silt, sand and some gravel. The gravel was very embedded. The bank substrate generally consisted of clay, silt and sand.

Photo 17
Tributary of the Humber River - Reach THRE-5, Caledon, Ontario

A knickpoint measuring 0.26 m was observed in the downstream portion of the reach. A small pool had formed downstream of the knickpoint.

Photo 18
Tributary of the Humber River - Reach THRE-6, Caledon, Ontario

Rooted emergent instream vegetation, including cattails and wetland vegetation, was present in patches throughout the reach; however, the patches were concentrated in the furthest upstream and downstream portions at connections to waterbodies.

Photo 19
Tributary of the Humber River - Reach THRE-6, Caledon, Ontario

A pond was present at the downstream portion of the reach. Agricultural fields directly abut both sides of the reach.

Photo 20
Tributary of the Humber River - Reach THRE-6, Caledon, Ontario

Old woody debris was observed in the channel in the connection between the two waterbodies.

Photo 21
Tributary of the Humber River – Reach THRE-6, Caledon, Ontario

The bed and bank substrate were generally uniformly clay, silt, and sand.

Photo 22
Tributary of the Humber River - Reach THRE-7, Caledon, Ontario

This reach consisted of ponding between two agricultural fields. The banks were gently sloping, and erosion was not observed.

Photo 23
Tributary of the Humber River - Reach THRE-7, Caledon, Ontario

Rooted emergent instream vegetation was present throughout 65% of the reach. Large patches of cattails and wetland vegetation occurred at the inlet and outlet of the waterbody.

Photo 24
Tributary of the Humber River - Reach THRE-8, Caledon, Ontario

This reach was run-dominant; however, riffles and pools were observed in localized areas.

Photo 25
Tributary of the Humber River - Reach THRE-8, Caledon, Ontario

The bed substrate was comprised of clay, silt, gravel, and cobbles. The bank substrate consisted of clay, silt and sand.

Photo 26
Tributary of the Humber River - Reach THRE-8, Caledon, Ontario

At the downstream portion of the reach the channel flowed between two agricultural fields before connecting to a pond. This portion of the reach was likely historically straightened (facing downstream).

Photo 27 Tributary of the Humber River - Reach THRE-8, Caledon, Ontario	 A tile drain with rip rap erosion protection was located at the upstream end of the reach. The riparian vegetation was fragmented in the upstream extent, where grasses were prevalent.
Photo 28 Tributary of the Humber River - Reach THRD-1, Caledon, Ontario	 Multiple locations along the reach contained mass failures and fracture lines along the banks.

Photo 29
Tributary of the Humber River - Reach THRD-1, Caledon, Ontario

Multiple large knickpoints and scour pools occurred along the reach, indicative of channel adjustment.

Photo 30
Tributary of the Humber River - Reach THRD-1, Caledon, Ontario

Medial bars and point bars were identified throughout the reach and consisted of sand, gravel and cobbles.

Photo 31 Tributary of the Humber River - Reach THRD-1, Caledon, Ontario	 Iron staining was present in various locations throughout the reach, indicating the presence of groundwater.
Photo 32 Tributary of the Humber River - Reach THRD-2b, Caledon, Ontario	 The downstream portion of the reach flowed under a concrete wall and was assumed to be piped. Due to access limitations, this was the furthest downstream observation collected along this reach.

Photo 33 Tributary of the Humber River - Reach THRD-2b, Caledon, Ontario	
	The majority of the reach was poorly defined and contained stands of phragmites.
Photo 34 Tributary of the Humber River - Reach THRD-2b, Caledon, Ontario	
	The upstream portion of the reach contained a defined, straightened channel along an agricultural field. The water was turbid from the recent rainfall.

Photo 35 Tributary of the Humber River - Reach THRD-2b, Caledon, Ontario	
	The rectangular concrete culvert at the road was silted and at approximately 75% capacity.
Photo 36 Tributary of the Humber River - Reach THRC-1, Caledon, Ontario	
	Valley wall contact occurred in multiple locations along the reach. The reach has steep banks, erosion, and undercuts measuring up to 0.5 m.

Photo 37 Tributary of the Humber River - Reach THRC-1, Caledon, Ontario	
	Exposed roots, leaning and fallen trees and organic debris were observed throughout the reach.
Photo 38 Tributary of the Humber River - Reach THRC-1, Caledon, Ontario	
	A knickpoint and scour pool were present in the downstream portion of the reach, where increased erosion was also noted.

Photo 39 Tributary of the Humber River - Reach THRC-1, Caledon, Ontario	 Mass failures were observed along this reach, particularly following large knickpoints. The mass failures and valley wall contacts contributed to the woody debris in the channel.
Photo 40 Tributary of the Humber River - Reach THRC-2, Caledon, Ontario	 Erosion was found throughout the reach and undercuts measured up to 1.63 m.

Photo 41 Tributary of the Humber River - Reach THRC-2, Caledon, Ontario	
	The channel meandered within a confined valley and was highly entrenched.
Photo 42 Tributary of the Humber River - Reach THRC-2, Caledon, Ontario	
	The channel had deeply incised into the clay/till parent material. Bed substrate consisted of till/clay, silt, gravel and cobbles.

Photo 43
Tributary of the Humber River - Reach THRC-2, Caledon, Ontario

Instream morphology consisted of well-developed riffle-pool sequences

Photo 44
Tributary of the Humber River - Reach THRC-3, Caledon, Ontario

Accretion (sand and gravel) on point bars was observed along the reach. Channel substrate was predominantly comprised of cobble.

Photo 45 Tributary of the Humber River - Reach THRC-3, Caledon, Ontario	
	Undercuts were observed in various locations along the reach and measured up to 0.78 m.
Photo 46 Tributary of the Humber River - Reach THRC-3, Caledon, Ontario	
	Woody debris was observed in the channel with a few rooted emergent instream vegetation patches.

Photo 47 Tributary of the Humber River - Reach THRC-3, Caledon, Ontario	
	The channel flowed through a confined valley with a forested riparian buffer.
Photo 48 Tributary of the Humber River - Reach THRC-4, Caledon, Ontario	
	The channel flowed through a grassy meadow within a confined valley; however the valley walls were set back from the channel.

Photo 49 Tributary of the Humber River - Reach THRC-4, Caledon, Ontario	
	Although woody debris was present throughout the reach, woody debris jams were uncommon.
Photo 50 Tributary of the Humber River - Reach THRC-4, Caledon, Ontario	
	Grasses were growing in the channel along 60% of the reach.

Photo 51 Tributary of the Humber River - Reach THRC-4, Caledon, Ontario	
	Erosion was observed throughout the reach. Meadow grasses covered the channel banks. Minor undercutting was observed.
Photo 52 Tributary of the Humber River - Reach THRC-5, Caledon, Ontario	
	The reach contained a wetland feature that had recently been restored. Erosion control measures were placed at the outlet from a pond to the wetland feature.

Photo 53
Tributary of the Humber River - Reach THRC-5, Caledon, Ontario

Access to the reach was limited due to recent restoration activities. Grasses were present along 90% of the reach, which contained multiple flow paths.

Photo 54
Tributary of the Humber River - Reach THRC-6, Caledon, Ontario

At the upstream extent of the reach the channel had been straightened under the bridge crossing.

Photo 55
Tributary of the Humber River - Reach THRC-6, Caledon, Ontario

The reach was poorly defined, contained multiple flow paths and riparian vegetation consisted of predominantly cattails and other wetland species.

Photo 56
Tributary of the Humber River - Reach THRC-6, Caledon, Ontario

The downstream portion of the reach connected to an online wetland and was unconfined.

Photo 57
Tributary of the Humber River - Reach THRC-7, Caledon, Ontario

The reach contained a low gradient, multi-thread channel with shallow banks and was unconfined.

Photo 58
Tributary of the Humber River - Reach THRC-7, Caledon, Ontario

Instream vegetation generally consisted of rooted emergent species that occupied the entirety of the reach.

Photo 59
Tributary of the Humber River - Reach THRB-1, Caledon, Ontario

Sand deposits were common, including in the overbank zone.

Photo 60
Tributary of the Humber River - Reach THRB-1, Caledon, Ontario

The channel had steep banks and ongoing active erosion. Valley wall contacts and bank undercutting were observed.

Photo 61
Tributary of the Humber River - Reach THRB-1, Caledon, Ontario

The bank substrate primarily consisted of cobbles. Instream vegetation was present in approximately 20% of the reach.

Photo 62
Tributary of the Humber River - Reach THRB-1, Caledon, Ontario

A previously buried culvert was entirely exposed upstream a small crossing.

Photo 63
Tributary of the Humber River - Reach THRB-2, Caledon, Ontario

A mass failure had occurred at the downstream portion of the reach, exposing a pipe that was discharging into the channel.

Photo 64
Tributary of the Humber River - Reach THRB-2, Caledon, Ontario

Accretion of sand and gravel on point bars was common. Deposition was also observed in the overbank zone.

Photo 65
Tributary of the Humber River - Reach THRB-2, Caledon, Ontario

An outfall was present at the upstream extent of the reach at Duffy's Lane. Following the outfall the gradient changed significantly and erosion was observed immediately downstream (yellow arrow). Channel hardening was also present at this location.

Photo 66
Tributary of the Humber River - Reach THRB-2, Caledon, Ontario

Iron staining was observed, suggesting that groundwater may be present.

Photo 67 Tributary of the Humber River - Reach THRB-3, Caledon, Ontario	 Woody and organic debris, leaning and fallen trees, and exposed roots were noted along the reach
Photo 68 Tributary of the Humber River - Reach THRB-3, Caledon, Ontario	 Trees and grasses heavily encroached the channel throughout the reach.

Photo 69
Tributary of the Humber River - Reach THRB-3, Caledon, Ontario

The wetland feature was confined within a forested valley.

Photo 70
Tributary of the Humber River - Reach THRB-3, Caledon, Ontario

The channel transitioned from single-thread to multi-thread in the downstream direction.

Photo 71
Tributary of the Humber River - Reach THRB-4, Caledon, Ontario

Woody debris was present throughout the reach as it flowed through a narrow, confined valley.

Photo 72
Tributary of the Humber River - Reach THRB-4, Caledon, Ontario

Gullies were observed cutting through the valley wall and flowing into the channel in various locations.

Photo 73
Tributary of the Humber River - Reach THRB-4, Caledon, Ontario

The channel bed substrate consisted of sand, gravel, and cobbles. The bank substrate was comprised of clay, silt and sand.

Photo 74
Tributary of the Humber River - Reach THRB-4, Caledon, Ontario

The water was turbid due to the recent rainfall and had no odour.

Photo 75 Tributary of the Humber River - Reach THRD-1a, Caledon, Ontario	
	The feature consisted of a sinuous gully with a steep gradient and moderate entrenchment.
Photo 76 Tributary of the Humber River - Reach THRD-1a, Caledon, Ontario	
	The channel was actively widening and contained undercuts measuring up to 0.69 m.

Photo 77 Tributary of the Humber River - Reach THRD-1a, Caledon, Ontario	
	Numerous fallen and leaning trees were observed, particularly in the downstream portion of the reach.
Photo 78 Tributary of the Humber River - Reach THRD-1a, Caledon, Ontario	
	The channel bed substrate ranged from clay/silt to boulders. Channel banks were comprised of clay/silt to gravel.

Photo 79 Tributary of the Humber River - Reach THRC, Caledon, Ontario	
	The reach contained primarily riffles and runs, with only a few pools identified.
Photo 80 Tributary of the Humber River - Reach THRC, Caledon, Ontario	
	Sand deposits were common in the channel and on point bars.

Photo 81 Tributary of the Humber River - Reach THRC, Caledon, Ontario	
	Woody debris, leaning and fallen trees, and exposed roots were commonly found in the channel and in the cutbank.