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Fluvial Geomorphology Assessment and Conceptual Natural Corridor Design

Mount Hope West Secondary Plan Area
Local Subwatershed Study

Town of Caledon, Ontario

Prepared for:
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GEO Morphix Project No. 25026

GEO MORPHIX™

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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained to complete the fluvial geomorphology assessment supporting the Local Subwatershed Study (LSS) for the Mount Hope West Secondary Plan Area. The Secondary Plan Area, hereafter referred to as the subject lands, is generally bounded by Columbia Way to the south, Mount Hope Road to the east, and agricultural lands to the west and north (**Appendix A**). A tributary of Cold Creek flows generally in a northeast to southwest orientation through the central portion of the subject lands. The eastern portion of the site drains eastward towards Mount Hope Road and a separate tributary of Cold Creek offsite.

This report serves as a supporting document to the Local Subwatershed Study (LSS). The LSS guides land use planning by confirming and/or refining the extent and management of the natural heritage system. This, in turn, directs development within the subject lands. The LSS and the fluvial geomorphology assessment are built upon the Scoped Subwatershed Study (SSWS) (Wood, 2022) conducted by the Region of Peel as part of the Settlement Area Boundary Expansion (SABE).

The fluvial geomorphology assessment is a comprehensive study that includes watercourse characterization and delineation of erosion hazards. This information is crucial to identifying the opportunities and constraints to development. The report also summarizes erosion mitigation targets to address stormwater management requirements and documents the conceptual natural corridor design for the proposed realignment of a section of the central Cold Creek tributary north of Columbia Way. The assessment, as summarized in this report, is in full accordance with the Terms of Reference prepared by the Consultant Team.

Specifically, the following activities were completed by GEO Morphix as part of the fluvial geomorphology assessment:

- Review of available background reports and mapping (i.e., watershed/subwatershed studies, geology, topography, conceptual development plans)
- Refine watercourse reaches previously delineated in the SSWS based on a desktop assessment of available data and confirmed through field reconnaissance
- Review recent and historical aerial photographs to understand historical changes in channel form and function, land use and land cover
- Conduct event-based baseline surface water quality sampling between the months of April and November along the Cold Creek tributary east of Mount Hope Road
- Conduct reach-level rapid geomorphological field assessments following standard protocols (e.g., RGA, RSAT) to evaluate instream and riparian conditions
- Complete detailed geomorphological field surveys to support the overall erosion mitigation plan for stormwater management and the conceptual natural corridor design
- Review/confirm the erosion hazard delineated by others in support of defining, in part, the limit of development
- Provide support in the development of an erosion mitigation approach for the future stormwater management plan
- Prepare conceptual natural corridor design plans for the proposed channel realignment (planform, cross-sections, floodplain features, and bioengineering details)

2 Background Review

The subject lands are located in the Humber River watershed and are comprised primarily of agricultural lands, an adjacent woodlot, and a residential dwelling along Mount Hope Road. 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 Settlement Area Boundary Expansion Scoped Subwatershed Study (Wood, 2022)

The SSWS (Wood, 2022) is one of a series of technical studies completed to provide input to the larger Settlement Area Boundary Expansion (SABE) Study to develop a Regional Official Plan Amendment (ROPA) to accommodate growth to 2051. The SSWS was completed in three phases, Parts A to C. The eastern extent of the main SWSS Focus Study Area (FSA) included the subject lands. 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.

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 watercourses based on a desktop assessment and a windshield survey, whereby channels were reviewed in the field from road crossings to confirm general conditions. Due to the extensive study area and limited fieldwork, the reaches were to be refined during future planning stages.

Preliminary meander belt widths were delineated for unconfined reaches by drawing parallel lines tangential to the outside bends of laterally extreme meanders. A 20% safety factor was then applied in place of calculated 100-year migration rates. The erosion hazard for confined reaches was delineated based on Table 3 in the Ministry of Natural Resources (MNR) (2002) guideline and a review of the Mayfield West Phase 2 Comprehensive Environmental Implementation Plan (CEISMP) (AMEC, 2014). Where the channel was within 15 m of the valley toe, toe erosion allowances of 2 m (no active erosion) and 8 m (evidence of active erosion) were delineated for all confined reaches. A stable slope allowance and erosion access allowance were then applied, consistent with MNR (2002) guidelines and Conservation Authority requirements. The erosion hazard limits are further refined as part of the current LSS based on site specific field observations and a review of topographic mapping and aerial imagery.

A desktop erosion sensitivity assessment was largely completed by air photo interpretation and windshield assessments. Erosion mitigation assessments completed for the subject lands were also summarized. Preliminary assessments indicated a potential erosion site where Tributary F exits the eastern extent of subject lands. Stream power mapping was prepared to identify sensitive reaches within and downstream of the FSA that were to be prioritized for future field assessment and monitoring to evaluate potential impacts to instream erosion due to future development. Preliminary watercourse constraint rankings were also developed based on the desktop assessment and windshield surveys and were subject to refinement as part of this LSS.

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.

2.2 Fluvial Geomorphology Assessment (GEI, 2025)

GEI Consultants Ltd (GEI) (2025) previously completed a fluvial geomorphology study, which included a review of site history, an assessment of existing conditions within and downstream of the subject lands, and meander belt width delineation for the tributary of Cold Creek that flows through the central portion of the subject lands. GEI (2025) generally adopted the reach naming convention and extents delineated in the SSWS (Wood, 2022). These have been revised as part of the current study based on channel conditions and to be consistent with ongoing studies on lands to the west. For a detailed description of existing conditions based on field observations collected by GEO Morphix, refer to **Sections 4.2** and **4.3** of this Report.

Meander belt widths were delineated by GEI (2025) for the central tributary as the channel was assessed to be unconfined (i.e., no defined valley). Meander belt widths were first delineated using meander amplitudes measured from historical and recent aerial imagery, and were 18 m for the lower portion of the tributary in the agricultural field and 33 m for the portion of tributary extending north into the woodlot. These values were compared to meander belt widths calculated using a suite of empirical equations. The empirical equations were only applied to the upstream reach extending through the woodlot as the lower reach was ploughed at the time of GEI's field work and therefore bankfull channel dimensions could not be measured. Modelled meander belt widths for the upper reach ranged from 21 to 26 m. The final meander belt widths were 33 m for the upper reach and 18 m for the lower reach based on meander amplitude measurements (GEI, 2025). These values are reviewed in the context of refined reach extents and field observations collected by GEO Morphix in 2025.

3 Desktop Assessment

3.1 Physiography and 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). Surficial geology mapping indicates the deposits within the subject lands are of glaciolacustrine origin and comprised of primarily clay to silt-textured till (OGS, 2010).

Soil Engineers Ltd (SEL, 2025) completed a geotechnical investigation in support of the proposed development, which indicated strata of silty clay till (made up of clay to gravel) and silty clay (comprised of some sand, occasional fine gravel) deposits with layers of silt, sandy silt, sand and silty sand interstratified between layers. The majority of subsurface materials consisted of silty clay till and silty clay, as indicated by the borehole logs. These findings are generally consistent with published mapping and field observations collected by GEO Morphix.

3.2 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.

3.2.1 Tributary E

The eastern segment of Tributary E was altered frequently during the period of available record. The earliest discernable images of this tributary are from 1951, though the image is low resolution. At this time, the Town of Bolton had not developed north beyond King Street East and Columbia Way was in a different configuration, curving to the north instead of south. The central tributary was straightened for agriculture and flowed in a northeast to southwest direction from a pond, through a forest, agricultural land with little to no natural riparian vegetation, and joined the western segment of Tributary E. The conjoined channel continued to flow in a southerly direction towards Columbia Way. There were at least 2 small ponds in the woodlot at the time the photo was taken. In 1960, the pond to the north of the woodlot appeared to increase in size. Downstream of the woodlot, the stream appeared to flow through a shallow valley. Additionally, what appeared to be a small wetland had formed downstream of the confluence with the western segment of Tributary E.

In 1995, it appeared that a farm crossing was in use over the tributary just downstream of the woodlot, and further downstream past the confluence with the western segment of Tributary E, vegetation consistent with a wetland was visible. The valley originally seen in 1960 was not readily visible. Additionally, Columbia Way had been adjusted to its current alignment, where the tributaries were crossing through the culvert at their meeting point, as opposed to downstream of the confluence. In 1999, a channel to the tributary from a straightened artificial drainage feature was visible just downstream of the woodlot. At the north end of the woodlot, the main channel of the tributary had two branches, one which was directed northwest towards the pond which appeared to be dry, and the other which was directed northeast and likely was fed by low order drainage features. The main tributary appeared to have been artificially straightened and deepened through the woodlot, and a wetland was visible at the upstream entrance to the woodlot. An additional tributary to the eastern segment of Tributary E appeared to be flowing from a wetland at a southeast to northeast curve in the stream.

In 2001, many of the trees were down in the woodlot and had been anthropogenically moved, the tributary that appeared in 1999 within the woodlot at the southeast to northeast curve was not visible. The farm crossing moved south of the tributary downstream of the woodlot that was present in 1999. The downstream extent of the main tributary began to lose definition, which continued to present day. By 2003, the farm at Columbia Way began to scale down and no longer appeared to be active. The pond at the upstream extent of the tributary had grown to its present-day extent. Some of the land around it had been reclaimed for agricultural use, and the additional tributary downstream of the woodlot gained definition. The additional tributary downstream of the woodlot generally maintained definition until 2023, when it was converted to agricultural lands.

Between 2013 and 2023, the area that was originally part of the farm and then converted to agricultural land was permitted to naturalize. The area of the woodlot that had been altered had also been permitted to naturalize. Water appeared to be pooling at the north end of the woodlot from 2019, and became extensive in 2024. In 2023, after the downstream extent of the tributary had been converted to agriculture, the channel lost definition, pooled in multiple locations, and had multiple flow path in some locations. As of 2024, the downstream extent had no defined features beyond some minor definition immediately downstream of the woodlot.

3.2.2 Tributary F

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.

4 Watercourse Characteristics

4.1 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
- Historical channel modifications

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.

Reaches within the subject lands were previously delineated at a high-level as part of the SWS (Wood, 2022) and subsequently reviewed in the field by GEI (2025). Based on site-specific detailed field work and to be consistent with ongoing studies west of the subject lands, the watercourse reach naming convention has been revised as part of the current study. The main tributary on the subject lands was divided up into three reaches. **Reach TCC(1)-2** was renamed **THRE-1-1** and **Reach TCC(1)-1** was subdivided and renamed to **THRE-1-2** and **THRE-1-3**. Revised watercourse reach delineation and the locations and extents of HDFs delineated by GEI (2025) are graphically presented in **Appendix A**.

4.2 Reach Observations

Field investigations were completed on February 27, March 14 and March 26, 2025, and included the following observations on a reach basis:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Confirmation of valley form (i.e., unconfined, partially confined, confined)
- Observations of erosion, scour, or deposition
- Collection of photographs to document watercourses, riparian areas, adjacent land use, and channel disturbances such as crossing structures

These observations and measurements are summarized in **Table 1**. Field descriptions are supplemented and supported with representative photographs included in **Appendix C**. Field sheets, including those completed for reach characterization and rapid assessments, are provided in **Appendix D**.

Table 1: General reach characteristics

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed Substrate	Bank Materials	Valley Type	Dominant Riparian Conditions	Notes
THRE-1-1	1.1	0.19	Clay, silt and sand	Clay and silt	Unconfined	Narrow riparian buffer of grasses and herbaceous plants	Poorly defined feature with the exception of the downstream extent where a small knickpoint (0.8 m) and shallow scour pool (0.13 m) had formed

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Bed Substrate	Bank Materials	Valley Type	Dominant Riparian Conditions	Notes
THRE-1-2	3.66*	0.42*	Clay and silt		Unconfined	Moderate riparian buffer of grasses and mature trees	Channel was inundated at the time of assessment
THRE-1-3	1.58	0.2	Clay and silt		Unconfined	Narrow riparian buffer of grasses and immature/mature trees	Poorly defined feature that gained definition at the downstream extent, flanked by agricultural fields
THRF-1	3.07*	0.28*	Clay/ silt to boulders and parent material		Confined	Wide continuous riparian buffer of mature trees	Heavily entrenched with high banks, evidence of erosion, terraces
THRF-2	2.26*	0.34*	Clay/silt, gravel	Clay/silt to gravel	Confined	Wide continuous riparian buffer of mature trees and shrubs	Highly eroded with many treefalls, multiple relatively small knickpoints

*Channel dimensions based on detailed geomorphological assessments

THRE-1-1 was the furthest downstream reach of Tributary E on the subject lands. The majority of the reach was artificially straightened and cultivated, resulting in poor definition. Additionally, there was little to no riparian vegetation along the reach. The downstream extent of the reach had a knickpoint of 0.8 m, after which point the channel became better defined until it reached the confluence with **THRE-1**. Bed and bank substrates were composed of clay/silt. The average bankfull width and depth were 1.1 m and 0.19 m, respectively.

THRE-1-2 flowed along the margin and within a woodlot. Riparian vegetation was composed of grasses and trees. The channel widened upstream, though the forest was inundated with water at the time of the assessment. Historical air photos indicated that the current channel form could be due, at least in part, to historical modifications (dug ponds and tree clearing). Bed and bank substrates were composed of clay and silt and moderately sorted. A detailed assessment on the downstream extent of **THRE-1-2** indicated that the average bankfull width and depth were 3.66 and 0.42, respectively.

THRE-1-3 transitioned from forest to agricultural land uses. The downstream extent of the reach had a narrow riparian corridor with mature trees that encroached the channel that then transitioned to grasses. Riffle and pool morphology was absent and channel substrates were comprised of clay and silt. Bankfull width was approximately 1.58 m and bankfull depth was approximately 0.2 m.

THRF-1 was a forested reach in a confined valley system. The reach exhibited sinuous meanders, had a moderate gradient and a high degree of entrenchment, with banks approximately 2 m in height. Erosion was observed along the length of the reach and the channel was trapezoidal in shape. Riparian vegetation primarily consisted of large, mature trees. Woody debris and treefalls were prevalent and undercuts of up to 0.64 m were measured. Bed and bank substrates ranged from clay/silt to boulders and exposed till. The reach contained predominantly riffles and channel substrates were poorly sorted. Based on detailed channel cross-section surveys, average bankfull channel width was 3.07 m and average bankfull channel depth was 0.28 m.

THRF-2 was located along Tributary F immediately east of Mount Hope Road. 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. Bank substrates consisted of clay, silt and gravel, and where riffles were present, they also contained cobbles.

4.3 Rapid Assessments

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 (MOE) (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.

The reaches were also classified according to a modified Downs (1995) Channel Evolution Model, which describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve, or respond to an alteration to the system.

Although the RGA and RSAT tools are intended to be generally used on natural systems with defined channels, which were not present outside of the woodlot on the subject lands, results are reported below as they still provide an assessment of channel stability and overall stream health. A summary of the reach classifications and rapid assessment scores is provided in **Table 2**.

Table 2: Summary of rapid assessment results

Reach	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995)
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
THRE-1-1	0.20	In regime	Planimetric form adjustment	18	Fair	Riparian habitat conditions	S
THRE-1-2	0.28	In transition	Aggradation and widening	26	Good	Channel scouring/sediment deposition	m
THRE-1-3	0.13	In regime	Aggradation	23	Fair	Riparian habitat conditions	m
THRF-1	0.68	In adjustment	Widening	24	Fair	Channel stability	e
THRF-2	0.33	In transition	Widening	20	Fair	Channel stability	e

Reach THRE-1-1 was assigned an RGA score of 0.2, indicating the reach was in regime. The dominant systematic adjustment was evidence of planimetric form adjustment as indicated by single thread to multi thread channel and the poor formation and reworking of bar forms. The RSAT resulted in a score of 18, indicating it was in fair condition. The limiting factor was riparian habitat conditions due to the lack of canopy cover over the channel. The Downs (1995) classification indicates that this reach was stable (s).

Reach THRE-1-2 was assigned an RGA score of 0.28, indicating the reach was in transition/stress. The dominant process of systematic adjustment was evidence of aggradation and evidence of widening due to falling/leaning trees and exposed tree roots. The RSAT resulted in a score of 26, indicating it was in good condition. The categories scored similarly, but the most limiting factors were riparian habitat conditions due to lack of consistent riparian cover and channel scouring/sediment deposition due to sandy pools and embedded riffles. The Downs (1995) classification indicated that this reach was laterally migrating (m).

Reach THRE-1-3 was assigned an RGA score of 0.13, indicating the reach was in regime. The dominant process of systematic adjustment was evidence of aggradation due to deposition in pools and sediment deposits on the overbank. The RSAT resulted in a score of 23, indicating it was in fair condition. The limiting factor was riparian habitat conditions due to poor canopy cover and lack of woody vegetation. The Downs (1995) classification indicated that this reach was laterally migrating (m).

Reach THRF-1 was assigned an RGA score of 0.68, indicating the reach was in adjustment. The dominant process of systematic adjustment was evidence of widening due to a variety of factors including fallen/leaning trees, exposed tree roots, extensive basal scouring, and fracture lines/basal scouring along the banks. The RSAT resulted in a score of 24, indicating the reach was in fair condition. The limiting factor was channel stability due to low stability of the bank network, erodibility of bottom 1/3 of bank, and trapezoidal cross-section. The Downs (1995) classification indicated that this reach was enlarging (e).

In general, the rapid assessments completed by GEI (2025) were comparable with the GEO Morphix assessment for **Reach THRE-1-2**. GEI (2025) did not observe a channel along **Reach THRE-1-1** as it was ploughed through at the time, whereas the feature was apparent during field work conducted by GEO Morphix in 2025.

4.4 Detailed Geomorphological Assessments

Obtaining detailed geomorphological measurements and observations allows for a more complete characterization of channel geometry, flow and sediment characteristics. Instream surveys are typically used to support natural corridor designs and erosion threshold calculations. A detailed geomorphological assessment was completed along **Reach THRE-1-2** on March 14. 2025 in support of the proposed natural corridor design as it represented a more natural channel segment when compared to **THRE-1-1** within the agricultural field**.** An additional detailed assessment was completed along **Reach THRF-1** on April 14, 2025, as this reach was determined to be the most sensitive to erosion downstream of the proposed SWM pond that will outlet to the tributary east of Mount Hope Road.

The survey at each location included the following measurements:

- Longitudinal survey of the channel centre line
- Detailed surveys of eight to ten detailed cross-sections
- Instream measurements of bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density at each surveyed cross-section
- Bed material sampling at each cross-section following a modified Wolman (1954) pebble count or substrate sample, as appropriate

The results of the detailed assessments are presented in **Table 3**. A full summary of each detailed assessment is provided in **Appendix E**.

Table 3: Measured and calculated bankfull channel parameters

Channel parameter	Reach		
	THRE-1-2	THRF-1	THRF-2
Measured			
Average bankfull channel width (m)	3.66	3.07	2.26
Average bankfull channel depth (m)	0.42	0.28	0.34
Bankfull channel gradient (%)	0.37	3.06	5.79
D_{50} (mm)*	< 2	19.1	<2.0
D_{84} (mm)*	< 2	58.9	46.0
Manning's n roughness coefficient	0.035	0.050	0.050
Computed			
Bankfull discharge (m^3/s) [a]	1.51	1.29	1.77
Average bankfull velocity (m/s)	0.97	1.50	2.33
Unit stream power at bankfull discharge (W/m^2)	15	126	446
Critical shear stress (N/m^2) [b]	----	13.92	----
Flow competency for D_{50} (m/s) [c]	----	0.77	----
Flow competency for D_{84} (m/s) [c]	----	1.29	1.15

[a] Based on Manning's equation

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

[c] Based on Komar (1987)

5 Baseline Surface Water Quality Sampling

In addition to the baseline surface water monitoring being conducted within the subject lands by Soil Engineers Ltd, GEO Morphix has undertaken baseline surface water quality monitoring along the tributary east of Mount Hope Road downstream of proposed stormwater outlets. Baseline monitoring is being conducted between the months of April and November at one (1) location along **Reach THRF-1**. In total, six (6) sampling events will occur on an annual basis. Each season (spring, summer, fall), one (1) wet/rain event (i.e., ≥10 mm of rain in 24 hours) and one (1) dry event (i.e., 48 hours with no precipitation) will be sampled. Note, during wet weather events, two (2) separate grab samples are collected during the rising and falling limbs of the hydrograph. This approach is consistent with baseline surface water monitoring being completed by GEO Morphix on lands to the west for the current study area.

The grab samples for each wet weather and dry weather event are being analyzed for the following parameters:

- Ammonia
- Anions (Nitrate, Nitrite, Phosphate, Chloride)
- BOD5 (Biochemical Oxygen Demand)
- Conductivity
- Dissolved Oxygen
- Metals (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, W, U, V, Zn, Zr)
- PAH (Polycyclic Aromatic Hydrocarbons)
- pH
- Alkalinity
- Total Kjeldahl Nitrogen (TKN)

- Total Phosphorous
- Total Suspended Solids (TSS)
- Turbidity

The spring wet weather sampling event was completed on May 22 (rising limb of hydrograph) and 23 (falling limb of hydrograph), 2025 during a 28 mm precipitation event. Laboratory results are not available at the time of this report but will be included in subsequent submissions of the Local Subwatershed Study. Surface water quality sampling will continue in 2025 to capture seasonal conditions.

6 Meander Belt Width Delineation

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform provided there are no topographical or spatial constraints. When defining the limits of an erosion hazard for a watercourse, unconfined and confined systems are assessed differently (TRCA, 2004 and MNR, 2002). Unconfined systems are those with streams in open areas (i.e., valley not apparent) or with valley walls that are positioned at a sufficient distance where the channel cannot reasonably be expected to contact because of migration under existing or future hydrologic scenarios. In this type of setting, the extent of the erosion hazard is delineated by the meander belt width, which is defined as the lateral extent that a channel has historically occupied and will likely occupy in the future.

Following MNR (2002), the 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.

Confined systems, in contrast, are those where a watercourse is contained within a defined valley where meander bend migration may be constrained by valley walls. 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. In these settings, where the channel is positioned within 15 m of a valley slope, the erosion hazard is generally defined by the toe erosion allowance, stable slope allowance, and erosion access allowance. In some instances, a meander belt width may also apply in partially confined systems (i.e., where the channel is greater than 15 m from the valley slope toe).

The central tributary within the subject lands was evaluated to be unconfined and as such, the meander belt width defines the erosion hazard. As noted in **Section 2.2**, GEI previously completed a meander belt width based on meander amplitudes in historical and recent aerial imagery. A meander belt width of 33 m were delineated for **Reaches THRE-1-2** and **THRE-1-3**, and a meander belt width of 18 m was delineated for **Reach THRE-1-1**.

GEO Morphix has reviewed the previously delineated meander belt widths based on spring 2025 field observations and measurements of channel dimensions. Given the extent of historical modifications, GEO Morphix completed a detailed review of empirical models to confirm the appropriateness of the 33 m and 18 m meander belt widths noted above.

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

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

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

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

The Ward et al. (2002) channel width and drainage area models were also used to determine a meander belt width (ft):

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

$$B_w = 120DA^{0.43} \qquad \text{[Eq. 4]}$$

where DA is the drainage area (square miles). The resulting value was then converted to the metric system (m). A 20% factor of safety was not applied to the Ward et al. (2002) channel width value due to the approach used in the modelling (i.e., hazard envelope rather than a linear relationship). A 20% factor of safety is included in the Ward et al. (2002) drainage area equation.

Lastly, meander belt widths were also calculated based on TRCA's (2004) empirical model:

$$B_w = -14.827 + 8.319\ln\left(\rho g Q S * DA\right) \qquad \text{[Eq. 5]}$$

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). Reach gradients were determined using topographic data. The drainage area (0.40 km^2) was provided by Schaeffers Consulting Engineers (2025) for the downstream extent of **Reach THRE-1-1** and was applied to all reaches as a conservative approach. The two-year discharge of 0.41 m^3/s was provided by Schaeffers Consulting Engineers.

Empirical modelling results are summarized in **Table 4**, below.

Table 4: Summary of modelled meander belt widths for existing conditions

Reach	Modified Williams (1986) Area*	Modified Williams (1986) Width*	Ward et al. (2002) Width	Ward et al. (2002) Drainage Area*	TRCA (2004)**	Recommended Meander Belt Width (m)
THRE-1-1	9	7	8	16	22	18
THRE-1-2	32	26	29	16	7	33
THRE-1-3	12	11	12	16	11	33

** Includes 20% factor of safety*
*** Includes one standard error (8.63 m) as factor of safety*

Regarding **Reach THRE-1-1**, the modelled belt widths based on channel dimensions are relatively low when compared to those based on drainage area. This is attributed to extensive channel modification due to agricultural land uses. Meander amplitudes measured in the field by GEO Morphix along this reach ranged from approximately 9.7 to 12.2 m. The 18 m meander belt width calculated by GEI (2025) is larger than amplitudes measured in the field and is within the range of belt widths calculated using the Ward et al. (2002) drainage area equation and TRCA (2004). It is recommended that the 18 m meander belt width be adopted for the current study. Notably, this reach is proposed for realignment and a meander belt width for the designed channel is documented in **Section 7.5** to ensure the erosion hazard is adequately addressed.

For **Reach THRE-1-2**, the meander belt widths summarized in **Table 4** that are based on channel dimensions are comparable to the 33 m meander belt width delineated by GEI (2025), while modelled meander belt widths based on the Ward et al. (2002) drainage area equation and TRCA (2004) are substantially smaller. It is recommended that the 33 m meander belt width be adopted for the current study. This reach is also located within a woodlot and the limiting constraint in this area is therefore the drip line and associated buffer.

The meander belt widths calculated by GEO Morphix for **Reach THRE-1-3** are substantially lower than the meander belt width delineated by GEI (2025). This is largely due to GEI not subdividing this reach north of the woodlot, as meander belt widths are typically delineated on a reach basis. This reach is located within the Greenbelt and proposed development is set well back from the tributary. For consistency with the downstream reach and the assessment completed by GEI (2025), it is recommended that the 33 m meander belt width be applied.

7 Erosion Mitigation Assessment

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia et al., 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. An erosion threshold was modelled from detailed field observations of **Reaches THRF-1** and **THRF-2**. The two reaches were selected for an erosion threshold analysis as they were identified as the most erosion-sensitive reaches are within the potential zone of impact along the receiving watercourse east of Mount Hope Road. The erosion threshold is a theoretical value, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the physical properties 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 for the subject reach.

7.1 Methodology

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

An erosion threshold is quantified based on the bed and bank materials and local channel geometry in the form of a critical discharge (Villard and Parish, 2003; TRCA 2012). Theoretically, in streamflow which exceeds this discharge, entrainment and transport of sediment can occur. To determine the critical discharge, the velocity, U, or Shear Stress, τ, is calculated at various depths for a representative cross-section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using Manning's approach, where Manning's *n* value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. A Manning's *n* value of 0.045 was used for the assessment, based on the physical characteristics of the subject reach. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2} \qquad \text{[Eq. 6]}$$

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

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

$$\tau_0 = d\rho g S \qquad \text{[Eq. 7]}$$

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

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

7.2 Results

Reach THRF-1 is located downstream of **THRF-2** and drains an area of 60 hectares. Based on the results of the detailed assessment, bank materials in this reach were identified as hard clay. Using the criteria for entrainment of hard clay from Julien (1998), a critical velocity of 0.76 m/s was applied, yielding a critical discharge of 0.326 m^3/s for the bank materials. The bed materials were composed of a mixture of graded silt to cobbles, with a corresponding critical velocity of 1.14 m/s based on Julien (1998), resulting in a critical discharge of 0.465 m^3/s. As the more conservative value, the critical discharge for the bank materials (0.326 m^3/s) was adopted as the erosion threshold for **Reach THRF-1**. With a drainage area of 60 ha, the defined critical discharge yields a unitary erosion threshold of 0.0054 $m^3/s/ha$.

Reach THRF-2, located upstream of **THRF-1**, drains a smaller contributing area of 13.1 hectares. The bank materials in this reach consist of clay till. Based on Fischenich (2001), a critical velocity of 1.00 m/s was used to evaluate the erosion threshold of the bank materials, resulting in a critical discharge of 0.305 m^3/s. Bed materials were more resistant, ranging from clay to cobbles, with a critical velocity of 1.52 m/s (Fischenich, 2001), yielding a slightly higher critical discharge of 0.466 m^3/s. As the more conservative value, the critical discharge for the bank materials (0.305 m^3/s) was adopted as the erosion threshold for **Reach THRF-2**. Using a drainage area of 13.1 ha, the defined critical discharge yields a unitary erosion threshold of 0.023 $m^3/s/ha$.

Channel parameters and erosion threshold results are summarized in **Table 5**. Bankfull discharge and velocity calculated as part of the erosion threshold analysis differ slightly from the detailed assessment values as they are derived from a detailed analysis of four representative cross-sections extracted from the assessment.

Table 5: Channel parameters and erosion threshold results

Channel parameters	**THRF-1** (downstream of THRF-2)	**THRF-2** (upstream of THRF-1)
Drainage area (ha)	60	13.1
Gradient (%)	3.06	5.99* (reach gradient including a clay knickpoint)
		3.80 (gradient upstream from knickpoint)
		4.32 (gradient downstream from knickpoint)
Bankfull width (m)	3.07	2.26
Bankfull depth (m)	0.28	0.34
Manning's n	0.050	0.050
D50 (mm)	19.1	<2.0
D84 (mm)	58.9	46.0
Calculated bankfull discharge (m^3/s)	1.29	2.54
Calculated bankfull velocity (m/s)	1.50	3.33
Erosion threshold		
Bank		
Criteria	Hard clay	Clay till
Critical velocity (m/s)	0.76 (Julien, 1998)	1.00 (Fischenich, 2001)
Apparent shear stress (N/m^2)	40.78	32.89
Critical discharge (m^3/s)	0.326	0.305
Bed		
Criteria	Graded silt to cobbles	Clay to cobbles
Critical velocity (m/s)	1.14 (Julien, 1998)	1.52 (Fischenich, 2001)

Channel parameters	**THRF-1** (downstream of THRF-2)	**THRF-2** (upstream of THRF-1)
Apparent shear stress (N/m^2)	49.23	65.11
Critical discharge (m^3/s)	0.465	0.466
Erosion threshold (m^3/s)	**0.326**	**0.305**
Unitary erosion threshold (m^3/s/ha)	**0.0054**	**0.023**

* To remain conservative, the reach gradient including the knickpoint was used to calculate the erosion threshold for **THRF-2** and to perform the erosion exceedance analysis.

8 Pre- to Post-Development Erosion Exceedance Analysis

In support of the proposed stormwater management (SWM) plan, an erosion exceedance analysis was completed for the receiving watercourse (CVC, 2015; TRCA, 2012). The application of erosion threshold analysis for evaluating the effectiveness of stormwater management facilities in mitigating changes in downstream erosion potential is a concept developed with support by a co-author of the present report (Dr. Paul Villard) and detailed in guidelines prepared by Dr. Villard on behalf of the Credit Valley Conservation Authority and Toronto and Region Conservation Authority and in Villard and Parish (2003).

Runoff from the proposed SWM pond will be directed to the tributary east of Mount Hope Road (i.e., **Reaches THRF-2** and **THRF-1**). Using the results of the erosion threshold analysis and hydrological modelling provided by Schaeffers Consulting Engineers (2025) for post- and pre-development conditions, additional analyses regarding the impacts of SWM controls on potential erosion within the watercourses were completed with our own in-house model, based on the following three indices:

1) Cumulative time of exceedance (t_{ex})
2) Cumulative effective volume (CEV)
3) Cumulative effective work/stream power index (CEWI)

These indices were developed in response to the limitations of traditional peak flow-based stormwater design (Villard and Parish, 2003; Villard and Ness, 2006). They have been applied in various southern Ontario Jurisdictions, including Conservation Halton (CH), Toronto Region Conservation Authority (TRCA), Credit Valley Conservation (CVC). These indices, as a product, provide an evaluation of the number of events, as well as the duration and magnitude of sediment transport (Villard and Ness, 2006). The most relevant indicator is the cumulative effective stream power, as it reflects both the duration and magnitude of erosion exceedance events.

Time of exceedance, average effective discharge, and cumulative effective volume can be calculated from the discharge record and established critical discharge. The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold. The cumulative time of exceedance simply quantifies the duration that the threshold is exceeded but does not provide information on the work or erosive force of flows once the thresholds are exceeded (TRCA, 2012). The average effective discharge represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event, whereas the cumulative effective volume represents the total discharge volume that exceeds the erosion threshold throughout the modelled discharge record.

For more relevant indicators, namely the cumulative effective work index, channel hydraulic information is required. Our model applies discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-sectional geometry and channel roughness. This provides analysis that is site appropriate and specific.

The post- and pre-development hydrological modelling reflects changes to the hydrological regime resulting from implementing SWM measures within the catchment. For each of the modeling nodes, event-based hydrological simulation results were provided by Schaeffers Consulting Engineers. Streamflow discharge was provided at 5-minute intervals for existing and proposed conditions. Two distinct scenarios (uncontrolled and controlled) were modelled under various storm event magnitudes (25 mm, 2-year, 5-year, and 10-year events). The modeled post-development scenarios with stormwater management controls accounted for a 24-hour extended detention time and an initial abstraction (IA) value of 1.5 mm.

8.1 Methodology

To calculate work terms, both velocity and shear stress were determined at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using the Manning's approach, consistent with practices outlined in Chow (1959) and employed in TRCA (2012). This is a conservative approach as it allows dissipation of flood energy in the floodplain, reducing overestimation of erosive potential.

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

$$Q_{T=}\sum Q_i \qquad \text{[Eq. 8]}$$

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

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 9]}$$

where, U_i, w_i and d_i are velocity, width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area (Villard and Parish, 2003).

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{\max}}$ based on:

$$\tau_{o_{\max}} = d_{\max}\rho g S \qquad \text{[Eq. 10]}$$

where, $d_{\max}$ is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S is the channel slope.

Cumulative total work, ϖ_{tot} is defined as:

$$\varpi_{\text{tot}} = \sum \tau_{0_{\max}} . U_{\text{avg}} . \Delta t \qquad \text{[Eq. 11]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ϖ_{eff}) is defined by:

$$\varpi_{\text{eff}} = \sum \tau - \tau_{cr} . U . \Delta t, \varpi < 0 = 0 \qquad \text{[Eq. 12]}$$

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

Time of exceedance t_{ex} defined as:

$$t_{\text{ex}} = \sum \Delta t \;\; \text{for } (Q_T > Q_{\text{threshold}}) \qquad \text{[Eq. 13]}$$

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

The cumulative effective volume (CEV) is defined as:

$\text{CEV} = \sum Q$ (for $Q > Q_{threshold}$) [Eq. 14]

8.2 Results

Erosion exceedance modelling results indicate that the proposed SWM plan effectively mitigates the risk of increases in erosion potential within the receiving watercourse. The analysis compared pre-development and post-development conditions using a range of design storm events under various SWM scenarios. Each scenario evaluated the effectiveness of proposed SWM controls in reducing erosive flows by examining changes in the key erosion indices: cumulative effective volume (CEV), cumulative effective work index (CEWI), and duration of exceedance. The scenarios reflect progressively larger storm events. The post-development (proposed) scenario was modelled with a 24-hour extended detention (ED) time and 1.5mm IA.

In terms of the modeled erosion indices, we note that the CEWI (ϖeff) is considered the most relevant index with respect to erosion potential, as it reflects both the flow magnitude and exceedance duration of a given erosion event. Results over +/-5% are considered to be significant enough to result in a detectable change in erosion potential within the receiving watercourse. Of secondary relevance is the CEV indicator, representing the total streamflow volume which exceeds the established critical discharge during the stormflow event. The pre-development and post-development hydrographs are included in **Appendix F**. The results for the 25mm storm event under uncontrolled conditions are shown in **Table 6**. The results for the pre- and post-development analysis for the 25mm, 2-year, 5-year, and 10-year storm events are provided in **Table 7** and **Table 8**.

Uncontrolled Post-Development Conditions

Reaches THRF-1 and **THRF-2** Scenario 1 were modelled with the 25 mm storm event under uncontrolled post-development conditions. Hydrograph analysis shows that under existing conditions the peak flows for the 25 mm storm event do not exceed the erosion threshold for either reach. Under uncontrolled post-development conditions, the peak flow exceeds the erosion threshold at both reaches by at least a factor of 3. The hydrographs show that peak flow occurs several hours sooner under uncontrolled conditions with a much higher magnitude of peak flow relative to existing conditions. This shift in the form of the storm event hydrograph to higher magnitude flows that occur more rapidly is typical of the shift in rainfall-runoff response associated with an increase in landscape imperviousness (ex: suburban development of agricultural land uses). Overall, the 25 mm storm event hydrographs for both **Reach THRF-1** and **Reach THRF-2** indicate that if runoff remains uncontrolled, the development would significantly increase erosion potential along the receiving watercourse.

Table 6: Results of the 25mm event-based hydrology exceedance analysis for the post- to pre- development under uncontrolled conditions for Reach THRF-1 and THRF-2

Scenario		CEV (m^3)	ϖeff (N/m^2)	Duration of exceedances (hrs)
THRF-1	**Pre**	0	0	0
	Post	1494.9	48.61	1.5
	Change (%)	----	----	----
THRF-2	**Pre**	0	0	0
	Post	742.8	51.95	0.75
	Change (%)	----	----	----

Controlled Post-Development Conditions

For the 25 mm storm event, no erosion exceedances were predicted under existing or proposed conditions for both reaches. Similarly, for the 2-year storm, exceedances were not predicted for **Reach THRF-2**, however they were predicted for the **Reach THRF-1** (downstream of THRF-2), with decreases in CEV and CEWI of 54%.

Under the 5- and 10-year storm events, **Reach THRF-1** also exhibited reductions in CEV and CEWI, with predicted reductions ranging from approximately 34% to 38%. For **Reach THRF-2**, erosion exceedances observed under pre-development conditions for the 5- and 10-year events were fully mitigated under proposed conditions, with CEV, CEWI, and duration of exceedance all reduced to zero. While these results suggest that the proposed stormwater management strategies may be overcontrolling flows to **Reach THRF-1**, the reach is an actively eroding reach characterized by multiple knickpoints. The predicted flow reductions may serve to reduce erosion and increase channel stability along this reach.

Table 7: Results of the event-based hydrology exceedance analysis for the post- to pre-development under controlled conditions for Reach THRF-1

Scenario		CEV (m^3)	ωeff (N/m^2)	Duration of exceedances (hrs)
25mm	**Pre**	0	0	0
	Post	0	0	0
	Change (%)	----	----	----
2-Year	**Pre**	2305.5	75.19	3.92
	Post	1055.7	34.28	3.42
	Change (%)	**-54.2**	**-54.41**	**-12.77**
5-Year	**Pre**	7132.8	232.94	5.25
	Post	4452.6	145.82	5.17
	Change (%)	**-37.6**	**-37.40**	**-1.59**
10-Year	**Pre**	9201.3	298.83	4.75
	Post	5993.4	195.79	4.92
	Change (%)	**-34.9**	**-34.48**	**3.51**

Table 8: Results of the event-based hydrology exceedance analysis for the post- to pre-development under controlled conditions for Reach THRF-2

Scenario		CEV (m^3)	ωeff (N/m^2)	Duration of exceedances (hrs)
25mm	**Pre**	0	0	0
	Post	0	0	0
	Change (%)	----	----	----
2-Year	**Pre**	0	0	0
	Post	0	0	0
	Change (%)	----	----	----
5-Year	**Pre**	319.5	22.13	2.08
	Post	0	0	0
	Change (%)	----	----	----
10-Year	**Pre**	1063.8	74.44	2.67
	Post	0	0	0
	Change (%)	----	----	----

These modelling results indicate that the proposed SWM plan effectively reduces erosion potential along the receiving watercourse. The model predicts that erosion potential along **Reach THRF-2** is completely mitigated for storm events up to and including the 10-year storm. For **Reach THRF-2** the erosion exceedance modeling indicates significant post-development decreases in erosion potential. The predicted decreases in erosion potential may help increase channel stability by reducing active degradation and widening within the watercourse. As such, the proposed SWM plan is not anticipated to exacerbate erosion within the channel, and thus adequately addresses concerns relating to potential erosion impacts of the development on the receiving watercourse.

9 Conceptual Natural Corridor Design

9.1 Design Objectives

Given that **Reach THRE-1-1** is proposed to be restored and realigned, there is an opportunity to replace the existing morphologically-limited channel with a naturalized shallow and deep undulating typology, with cross sectional dimensions closer to that of a naturalized watercourse conveying similar flows. The granular is provided for substrate variability, filtration and infiltration value. The undulations extend wet and dry periods, enhancing organic breakdown and extending periods where it can provide wet/moist habitat. Conceptual natural corridor design drawings are provided in **Appendix G**.

The design will complement the existing channel located within the upstream woodland. The naturalized watercourse will significantly improve channel form and function per unit length. The channel realignment and naturalization are expected to improve riparian and aquatic conditions and provide a well-developed bankfull channel with morphological variability. Improvement in morphology and function will provide additional benefits to sediment balance, floodplain storage, vegetation communities and terrestrial habitat features, edge impacts, water balance, fish passage and water quality. From a habitat perspective, the important contributions of the watercourse includes the provision of seasonal habitat, organic inputs to the system, provision of a more complex corridor system with elements that have a wide range of hydroperiods, and aquatic and terrestrial habitat elements.

The primary objectives of the design are to:

- Restore the physical form of the channel including planform and in-channel characteristics
- Ensure channel stability and function during low flow periods
- Improve the function of the channel and promote interaction with the floodplain and offline wetlands
- Improve water quality by extending detention of water through offline wetland features
- Create a low-flow channel that accommodates, at most, the 1.25-year return flow to improve the function of the channel corridor and increase interactions with the floodplain
- Create a floodplain that includes interconnected wet meadow and linear wetland features of variable depth, shape, and hydroperiod
- Provide a mix of coarse and fine sediment sources throughout the low-flow channel and floodplain
- Enhance aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows
- Improve riparian habitat by installing woody plantings and dynamic floodplain features
- Mitigate potential hazards to the development as well as lands surrounding the development

Technical details are provided in subsequent sections to outline the approach used for channel sizing and habitat restoration.

9.2 Bankfull Channel

The recommended restoration design focuses on shallow-deep undulation typology. The typology will provide significant improvements to not only the channel, as it essentially mimics a natural system, but also to aquatic habitat. In summary, a shallow and deep undulating system offers numerous benefits, namely:

- Channel bed relief for flow variability
- Water aeration in shallow sections
- Improve feature function and interaction with the floodplain
- Increased depths in pools to provide relatively cool water
- In-channel energy dissipation

In the development of a natural channel design, the length of the watercourse proposed to be realigned is typically replicated or exceeded, to provide an overall gain in habitat. The length of the existing channel to be realigned for **Reach THRE-1-1** is approximately 253 m. The length of channel proposed in the design is approximately 324 m for **Reach 1** and **Reach 2**. The additional length of channel provides a significant increase in the area for restoration and habitat enhancement.

Channel design dimensions are determined by bankfull discharge, as this represents what is generally referred to as the "*channel-forming discharge*" or the "*dominant discharge*". Several methods can be applied to select an appropriate bankfull discharge. Back calculation of discharge from a reference reach along with support from hydrological modelling is usually the most appropriate. Given the significant historical channel modifications and the changes in hydrology likely to occur because of the proposed development on site, a discharge based on hydrological modelling was determined for **Reach 1** and **Reach 2** and then subsequently used to define channel bankfull geometry. The discharge used to size the bankfull channel was assumed to be equivalent to the modelled 1.25-year flow. As such, the bankfull discharge was defined as 0.12 m^3/s for **Reach 1** and **Reach 2** as provided by Schaeffers Consulting Engineers (2025). Bankfull capacity for channels generally have a range from the 1- to 2-year return events.

A simple Manning's approach was used to iteratively back-calculate bankfull dimensions for the proposed channels. Since pools are designed to contain ineffective space, this model over-predicts the amount of discharge that they convey. As such, the modelled values for the shallow undulation section give a better prediction of the channel's capacity. Shallow and deep geometries, as well as anticipated bankfull conditions for the proposed channel, are provided in **Table 9**.

For **Reach 1** the channel has an overall gradient of 0.54% for 191 m. The bankfull width and depth of the channel range from 1.5 m to 2.1 m, and 0.20 m to 0.40 m, respectively. The average shallow gradient is 1.63%. For **Reach 2** the channel has an overall gradient of 2.87% for 133 m. The bankfull width and depth of the channel range from 1.5 m to 2.1 m, and 0.20 m to 0.60 m, respectively. The average shallow gradient is 7.95%.

Table 9: Bankfull parameters for Reach 1 and Reach 2

Channel parameter	Reach 1		Reach 2	
	Shallow	Deep	Shallow	Deep
Bankfull width (m)	1.50	2.10	1.50	2.10
Average bankfull depth (m)	0.15	0.22	0.15	0.30
Maximum bankfull depth (m)	0.20	0.40	0.20	0.60
Bankfull width-to-depth ratio	10.34	9.34	10.34	7.00
Channel gradient (%)	1.63	0.54	7.95	2.87
Bankfull gradient (%)	0.54		2.87	
Average radius of curvature (m) *	4		4	
Riffle-pool spacing (m) **	13		13	
Manning's roughness coefficient, *n*	0.04	0.03	0.04	0.03
Mean bankfull velocity (m/s) †	0.78	0.79	1.73	2.14
Bankfull discharge (m^3/s) †	0.17	0.37	0.38	1.34
Discharge to accommodate (m^3/s)	0.12		0.12	
Tractive force at bankfull (N/m^2)	32	21	156	169
Stream power (W/m)	27	20	294	377
Unit stream power (W/m^2)	18	9	196	180
Froude Number (unitless)	0.66	0.54	1.45	1.24
Maximum grain size entrained (m) ††	0.03	0.02	0.16	0.17

Channel parameter	Reach 1		Reach 2	
	Shallow	Deep	Shallow	Deep
Mean grain size entrained (m) ††	0.02	0.01	0.12	0.09

* Based on Williams (1986)
** Based on Hey and Thorne (1986)
† Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not representative
†† Based on Shields equation assuming Shields parameter equals 0.06 (gravel)

After preliminary geometries were determined the radius of curvature and shallow-deep spacing were calculated using relations from Williams (1986) and Hey and Thorne (1986). As discussed above once the planform parameters and bankfull geometries were determined the channel centreline was designed and geometries were finalized based on the final gradient.

9.3 Channel Planform

The initial channel planform layouts were created using the modelled radius of curvature value (*Rc*) as a guide. The radius of curvature (*Rc*) of meanders can be used to evaluate channel stability. For example, stable meanders typically exhibit larger *Rc* values as opposed to lower values that indicate increased channel bank erosion and avulsion. Bankfull width is often an appropriate indicator for this instability. Hickin and Nanson (1983) note that channel avulsions are common when meander *Rc* is approximately 1-2 times the channel bankfull width. For larger *Rc* (e.g., >5), the upstream limb of the meander will migrate more rapidly than the downstream limb (Hooke, 1975). Based on the above bankfull widths the radius of curvatures and feature spacing were determined.

Williams (1986) was used to derive values for the channel radius of curvature, using the following equation:

$$Rc = 2.43 \times w \quad \text{[Eq. 15]}$$

where *Rc* is the radius of curvature and *w* is the average bankfull width.

Empirical models derived by Hey and Thorne (1986) were followed to determine the shallow undulation section spacing. Hey and Thorne's (1986) modelled values are often applied in larger watercourses. As such, multiple methods (Eq. 16 – 18) were considered in order to provide a range of shallow undulation section spacing values. These are:

$$Z = 6.31 \times w \quad \text{[Eq. 16]}$$

$$Z = 9.1186 \times w^{0.8846} \quad \text{[Eq. 17]}$$

$$Z = 7.36 \times w^{0.896} \times S^{-0.03} \quad \text{[Eq. 18]}$$

where *Z* represents shallow undulation section spacing.

Stream power and unit stream power were calculated as a function of bankfull discharge and channel gradient (Eq. 19 and 20). Stream power values are important to determine the need for mitigating channel bank and bed erosion. Stream power is given by:

$$\Omega = \rho \times g \times d \times S \quad \text{[Eq. 19]}$$

where ρ is the density of water (kg/m^3), *g* is the acceleration due to gravity (m/s^2), and *Q* and *S* are discharge (m^3/s) and channel gradient, respectively.

Stream power per unit width (Eq. 20), is given by:

$$\omega = \frac{\Omega}{w} \quad \text{[Eq. 20]}$$

where as before, Ω and *w* are stream power and bankfull width, respectively.

The final channel planform is established through an iterative process. First, a cross section with defined bankfull geometry was developed to calculate parameters for the planform (i.e., radius of curvature). The cross section was then further refined, and riffle and pool lengths were determined based on channel gradient.

9.4 Channel Substrate Hydraulic Sizing

The sizing of proposed substrate materials was guided by a review of hydraulic conditions (i.e., tractive force, flow competency) in the typical cross-sections. The channel bed substrate is derived by balancing the average shear stress acting on the bed with the critical shear stress for the material. When the critical shear stress slightly exceeds the average shear stress acting on the bed, sediment transport is initiated.

To provide for a stable bed and level of sorting, the substrate within the shallow undulation section will be consist of 70% granular 'B' and 30% native material and the pools will consist of 60% granular 'B' and 40% native material for **Reach 1** and **Reach 2**.

Granular 'B' consists of a mix of stone where approximately 20 % - 50 % of the stone is greater than 0.005 m in diameter, but nothing larger than 0.15 m in diameter. These materials will always have a core of sediment that is not entrained under bankfull flow conditions. This material maintains the character of the native material, while providing slightly higher stability and opportunity for sediment sorting.

The granular 'B' is to be derived from pit-run material and contain no post-construction materials. This is particularly important as the supply of natural sediment from upstream will be limited due to development. This material maintains and enhances the character of the native material, while providing slightly higher stability and opportunity for sediment sorting. The gravel also provides opportunities for infiltration, filtration, and detention of water within the pore spaces to provide additional benefits by elongating the hydroperiod. These materials are also provided for stability and not for maintaining a "shallow" morphology. The proposed mix will also improve aquatic habitat by increasing diversity between the shallow and deep substrates.

Immediately after construction, the outside bank of meander bends (i.e., cutbanks) may experience relatively higher erosive flows, which could lead to meander bend migration. As such, all cutbanks will be bioengineered for additional stability. For immediate erosion protection, a biodegradable erosion control blanket will be installed along the banks in shallow and deep sections. The blanket will biodegrade over time and live stakes will be installed in the immediate overbank areas to provide long-term soil stability.

9.5 Channel Corridor Sizing

With regards to delineating the hazard associated with channel migration, the MNR treats confined and unconfined systems differently. Unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. In unconfined systems, the hazard is assumed to be from channel migration. Unconfined systems require a meander belt width. Given the size of the channel compared to the floodplain, this channel can be considered unconfined.

As part of the design, a meander belt width was calculated based on design bankfull dimensions of each design reach to ensure that the planform has a meander belt width that falls within the existing corridor requirements. Given the scale of the watercourse and limited migration potential for the system, the hazard limits calculated can be considered conservative. The meander belt widths provided are based on modelled relations from Williams (1986) (refer to Eq. 2 in **Section 6**). An additional 20% buffer, or factor of safety, was applied to the computed belt width values to address issues of under prediction.

The average width of the designed **Reach 1** and **Reach 2** is 1.80 m and the resulting meander belt width is 12 m. The proposed valley corridor bottom width for **Reach 1** and **Reach 2** is 19 m. It is anticipated that the channels through these sections will be stable given the proposed design was developed to be stable at bankfull conditions. The predicted meander belt widths outlined above fit well within the proposed valley bottom widths.

Once the channel planforms were finalized through the iterative process of determining bankfull widths, radius of curvatures and shallow-deep spacing the meander belt widths are overlain to ensure the channels fit within the bounds. For a stable channel the channel spacing, radius of curvature, gradient, flow and bankfull geometries would provide a design that fits within the proposed meander belt widths. The proposed design for **Reach 1** and **Reach 2** fits within the channel corridor bottom and therefore also within the proposed meander belt width.

9.6 Wetland Features

In addition to the low-flow channel, both online and offline wetland features are proposed within the corridor, and adjacent to the corridor. These features enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits such as short-term water retention and sediment banking. They will be irregularly shaped to maximize the perimeter for a given area, which increases the potential for edge effects. Submerged and dry mounds are proposed within the offline wetlands to increase habitat heterogeneity by providing a topographically complex bottom. These wetlands' short-term water retention function helps polish the water and moderate discharge into the channel.

It is understood that approximately 0.35 ha (3,500 m^2) m of existing wetland is proposed for removal adjacent to the corridor as part of the development. The total area of the online, offline wetland features and wet meadow area proposed within the corridor, and adjacent to the corridor is approximately 0.36 ha (3,600 m^2). We have provided variability to ensure that a range of water depths and hydroperiods are provided from year-to-year. The depressional storage provided within the proposed natural corridor designs elongates the hydroperiod. Given the storage areas, the channel directing flow to the depressional storage, and the low grade on the floodplains, depressional storage is anticipated to support wetland and wet meadow vegetation. Furthermore, the soils will likely have an extended hydroperiod.

The channel corridor will be restored using native plant species, including appropriate species for the seed mix. The plantings are intended to enhance the terrestrial habitat by providing species and habitat diversity, increasing floodplain soil stability, and increasing floodplain roughness and sedimentation.

9.7 Habitat Restoration

The design incorporates several habitat elements within the channel corridor to improve riparian habitat and promote wildlife biodiversity. To maximize potential for wildlife passage, forage and residency, the habitat design incorporates varying topographies and woody debris. The habitat elements proposed include, overwintering pools, brush mattresses, pallet type wood piles, raptor poles, rock piles, and terrestrial mounds.

Potential overwintering pools are proposed to provide critical habitat for resident fish. The overwintering pools are located within the tortuous meander pattern, which will increase scour and pool depth. This habitat feature will provide fish with potential refuge from freezing conditions in the winter and an ideal habitat during low flow periods and increase habitat heterogeneity within the channel.

Brush mattress is proposed along the outside meander bend of select meanders. This treatment consists of live brush cuttings installed parallel to the banks and tied in with coir twine and stakes. The brush mattress will provide bank stability and improve aquatic habitat through shading.

Pallet type wood piles consist of logs, snags and other wood debris, placed in a way that forms a stable interconnected mound, in the shape of a pallet. Additionally, the wood piles are planted with native fruit bearing vines, which provide forage opportunities for wildlife. A wood pile is placed along the floodplain.

Raptor poles are constructed from large conifer tree trunks, embedded into the ground and serve to provide perches for larger raptors.

Rock piles consist of a mix of stone of varying sizes, piled up to create small mounds. These features provide hibernation habitat for various terrestrial species. The base of the piles is partially buried to prevent rock falls. A rock pile is installed in the floodplain.

Terrestrial mounds consist of native material, piled up to create small mounds with a small dimple on the top. The bottom of the mound is seeded with the specified seed mix, while the top has limited soil and seed on it to provide foraging opportunities.

9.8 Natural Erosion Control

Newly constructed features can be vulnerable to erosion. This is particularly true before vegetation has been established along the channel banks. While low-flow events should not intensify erosion, the concern for erosion occurs when high flows or precipitation events occur during construction.

Immediately after construction, the outer banks of the meander bends (i.e., cutbanks) may experience relatively higher erosive flows, leading to meander bend migration. As such, all cutbanks are bioengineered for additional stability. A 100% biodegradable erosion control blanket, and live stakes are installed along the banks in the riffle and pool sections for immediate erosion protection. Over time, the blanket will biodegrade, while the live stakes establish in the immediate overbank areas to provide long-term soil stability.

For long-term stability, implementing planting plans within the corridor is recommended. This includes deep-rooting native grasses and other herbaceous species seeded along and within channel sections, prescription of flood-tolerant native shrub and tree species, and use of seed banks within the local soil. Shrubs should be planted close to the channel margins to maximize stabilization and channel cover benefit.

Potential erosion locations (i.e., along the outside meander bends, immediately downstream of wetland features, etc.) has been anticipated and reflected in the planting plans. Live staking should be used adjacent to the channel bank to provide immediate benefit and long-term infilling. If appropriate live staking methods are followed, this method should provide more significant benefits than simple potted or bare root shrub planting as there is potential for higher densities with live staking.

10 Natural Corridor Design Implementation

10.1 Interim and Long-Term Channel Conditions

After construction, it is anticipated that the channel will go through a period of adjustment. This is related to the growth rate of vegetation and long-term succession. In the short-term (< 5 years) we anticipate a level of vegetation encroachment into the channel given the proposed planting plan. When the channel is first landscaped, the vegetation will be immature with minimal canopy cover resulting in a higher percentage of grasses establishing and encroaching into the channel. As the vegetation matures and the canopy cover increases (10 – 25 years) we anticipate less grass encroachment into the channel due to reduced light penetration. The increased canopy cover will also benefit the system by reducing light penetration and increasing shading, which results in cooler channels. During this phase there will likely be limited changes in channel morphology.

In the long term (> 25 years) the canopy cover will increase, and it is anticipated that riparian vegetation will consist of less grasses and more shrubs, herbaceous, and tree species. This will likely result in greater habitat diversity due to increased woody debris. Willow and dogwood species are proposed along the channel banks which will increase woody debris within the channel. As the vegetation matures it will increase organic inputs and habitat diversity. The vegetation change over time will influence channel function. The proposed meandering channel is an appropriate planform design as the vegetation encroachment in the channel decreases. The proposed substrate will also provide stability to the channel bed once vegetation encroachment is minimized.

10.2 Construction Timing

Based on resident fish species and their respective life cycles, in-stream work is restricted to July 15 to March 15 unless otherwise directed by the MNR. Vegetation removals associated with clearing, site access and staging should occur outside the key breeding bird period identified by Environment Canada for migratory birds to ensure compliance with the *Migratory Birds Convention Act, 1994* (MBCA) and *Migratory Bird Regulations*. The breeding season for migratory birds in this part of the country typically extends from as early as April 1 to as late as August 31, and the bat roosting window is from as early as April 1 to as late as September 30. Should tree removals be required during critical breeding bird season, a qualified biologist should inspect those trees to ensure they do not contain nesting birds. It is understood that the MBCA is not limited to cutting woody vegetation but also applies to topsoil stripping and grubbing activities, as there are ground nesting bird species protected under the Act.

10.3 Best Management Practices

Site inspection should be performed by an inspector with experience overseeing channel works, as this type of work differs considerably from engineering projects. An experienced inspector will be able to provide quick and appropriate response to issues that may arise and ensure that construction proceeds in accordance with the approved design and contract.

The limits of construction will be delineated to prevent unanticipated impacts to natural surroundings, including trees and the existing watercourse. Flows will be conveyed around the work areas uninterrupted either through temporary diversion channels or with a cofferdam and pump system, such that the channels can be constructed fully isolated from the active flow area. This will limit downstream impacts such as sediment loading.

All isolated work areas will be dewatered to perform work under dry conditions. Water will be pumped to a sediment filtration system located at least 30 m from the receiving creek and be allowed to naturally flow over a well-vegetated surface and ultimately return to the channel downstream of the work area. This will allow particles to settle before reaching the watercourse.

All materials and equipment will be stored and operated in such a manner that prevents any deleterious substances from entering the water. Vehicle and equipment re-fuelling and/or maintenance will be conducted away from the watercourse and be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances.

11 Post-Construction Monitoring

11.1 Natural Corridor Design

A post-construction monitoring program is recommended to assess the performance of the implemented channel design. Monitoring observations can also be used to determine the need for remedial works, if required. The following activities should be undertaken by a fluvial geomorphologist and completed on a seasonal basis (i.e., spring and fall), unless otherwise indicated, for a period of three years following the year of construction. Biennial monitoring is recommended should the monitoring period extend beyond three years post-construction as most potential channel adjustments would occur in the first one to two years following construction.

The following monitoring and reporting activities are suggested for the realigned channel:

- General observations of the channel works should be documented after construction and after the first large flooding event to identify any potential areas of erosion concern
- An initial baseline survey should be completed after the channel has been constructed; subsequent surveys should be tied into this baseline survey
- A detailed photo record of the entire channel will be required. Photos should start at the upstream end of the channel and be sufficiently spaced to allow for coverage of the entire channel. During the initial photo record, GPS locations of the photos should be recorded, and these should be the locations from where subsequent photos are taken. Alternatively, a high

resolution orthorectified aerial photo of the entire channel length can be created using an unmanned aerial vehicle (UAV) to document the channel planform. This image should be generated in the spring prior to the on-set of vegetation growth
- Total station survey of the longitudinal profile and 8 - 10 cross sections following construction. Channel cross-section surveys should be an equal mix of geomorphic unit types. At least two of the cross-section should be monumented and georeferenced. The longitudinal profile and monumented channel cross sections would serve as the as-built reference condition for use in comparing surveys completed in subsequent years
- Re-survey of the longitudinal profile and cross sections in subsequent years after construction
- Installation of erosion pins at monumented cross sections after construction and monitoring of the erosion pins during subsequent years. Pins are to be placed in both banks within the low flow channel. Erosion pins need to be formally surveyed, including the end of the pins and their entry points into the banks to ensure their locations and exposure are accurately recorded. Erosion pins need to be resurveyed each year to ensure they have not moved due to flow, physically being hit or frost heave.
- Bed material characterization based on Wolman (1954) pebble counts
- General vegetation surveys completed annually after construction, for the duration of the monitoring period
- Annual reporting to summarize construction activities (i.e., design implementation), and subsequent year-end reports for the duration of the monitoring period
- Monitoring activities should be undertaken by a qualified fluvial geomorphologist

The monitoring would commence immediately after construction and the corridor should be reviewed annually to identify the natural variability of the system. Reporting would be provided annually prior to March 1st of the following year, with a summary report at the end of the monitoring period.

11.2 Instream Erosion

The erosion mitigation assessment completed in support of the proposed development indicates that instream erosion will not be exacerbated in the receiving tributary east of Mount Hope Road; however, geomorphological instream monitoring should be completed along **Reaches THRF-1** and **THRF-2** to ensure that erosion mitigation has been adequately addressed. Data collected in the post-development period can then be compared to baseline information collected in support of the LSS. The following annual post-construction monitoring activities are recommended along **Reaches THRF-1** and **THRF-2**:

- Re-survey of monumented cross sections and longitudinal profile established under baseline conditions
- Channel substrate characterization through a modified Wolman (1954) pebble count or sampling at each monumented cross-section
- Collection of monumented photographs
- Re-measurement of erosion pins
- Preparation of an annual report documenting results of the monitoring program, with a summary report provided at the end of the monitoring period

Monumented cross-sections were installed by GEO Morphix along **Reaches THRF-1** and **THRF-2** in 2025 and 2024, respectively. It is recommended that the cross-sections be re-surveyed within one year of the proposed SWM pond being operational to confirm existing conditions. The post-construction monitoring activities outlined above should be completed on an annual basis for a period of three years, once the SWM pond is operational. Annual reports and the summary report are to include a comparison of pre- and post-development instream conditions and evaluate any changes in the context of anticipated natural variability.

12 Summary

GEO Morphix was retained to complete a fluvial geomorphology assessment and prepare a conceptual natural corridor design as part of the LLS for the Mount Hope Secondary Plan Area in the Town of Caledon. The study focused on the central tributary within the subject lands (**Reaches THRE-1-1** to **THRE-1-3**) and the tributary on the east side of Mount Hope Road (**Reaches THRF-1** and **THRF-2**) that is proposed to receive stormwater discharge from future development. The following provides a summary of key findings and recommendations:

- Watercourse reaches within the subject lands have been significantly impacted by past agricultural land uses and generally lacked natural riffle and pool morphology and particularly along **Reach THRE-1-1**, a well-defined channel.

- Rapid geomorphological assessments were completed along all reaches of the central tributary within the subject lands and results indicated that **Reach THRE-1-2** was in transition, while **Reaches THRE-1-1** and **THRE-1-3** were relatively stable.

- Rapid geomorphological results for the tributary on the east side of Mount Hope Road indicated that the channel was in adjustment, with relatively high RGA scores of 0.33 (**THRF-2**) and 0.68, respectively (**THRF-1**).

- Detailed geomorphological assessments were conducted along **Reaches THRE-1-2**, **THRF-1** and **THRF-2** in support of the proposed natural corridor design and erosion mitigation assessment.

- Seasonal, event-based baseline surface water quality monitoring is being completed by GEO Morphix within **Reach THRF-1** between April and November of 2025 and to date, one spring wet weather event has been sampled. Surface water quality monitoring results will be reported in subsequent submissions of the LSS as laboratory results become available

- Meander belt widths of 18 m (**THRE-1-1**) and 33 m (**THRE-1-2** and **THRE-1-3**) were previously delineated by GEI (2025) and confirmed to be appropriate by GEO Morphix based on field observations, including measurements of meander amplitudes, and a review of aerial imagery.

- The erosion mitigation assessment focussed on **Reaches THRF-1** and **THRF-2**, which are to receive stormwater discharge as part of the proposed development. The assessment included the determination of an erosion threshold and the completion of erosion exceedance analyses using pre- and post-development hydrological modelling provided by Schaeffers Consulting Engineers

- Comparisons of post- to pre-development hydrological modelling indicate that the proposed SWM plan is effective in reducing erosion potential during storm events in **Reach THRF-1** and completely mitigates erosion risk in **Reach THRF-2** and as such, adequately addresses concerns relating to potential erosion impacts of the development on the receiving watercourse.

- Proposed realignment of **Reach THRE-1-1** provides an opportunity to replace the existing impacted channel with a naturalized corridor that will link the existing woodland with the downstream natural heritage system south of Columbia Way.

- Proposed corridor design contains an undulating channel sized to convey the 1.25 year return period event to promote interaction with the floodplain and will result in an overall increase in channel length when existing (253 m) and proposed (324 m) conditions are compared.

- Proposed corridor design includes approximately 0.36 ha of wetlands to compensate for the removal of approximately 0.35 ha of existing wetland along **Reach THRE-1-1**. It anticipated that the proposed wetlands, in combination with other proposed habitat features on the floodplain, will enhance terrestrial and aquatic habitat.

- A three year post-construction monitoring program is recommended along the naturalized corridor to identify any areas of potential instability and assure appropriate vegetation establishment. An annual report will be submitted prior to document the results of the previous year of monitoring and a summary report will be provided at the conclusion of the monitoring period.

- Erosion monitoring is recommended along **Reaches THRF-1** and **THRF-2** for a period of three years once the SWM pond is operational. Monumented cross-sections installed as part of the geomorphological assessments can be re-surveyed and assessed annually in the post-development condition to evaluate any potential cross-section adjustments in the context of natural variability

We trust this report satisfies your requirements at this time. Should you have any questions or concerns, please contact the undersigned.

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Appendix A:
Study Area and Reach Delineation

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Reach Delineation

Tributaries of Humber River

Mount Hope West Local Subwatershed Study

Town of Caledon

Legend

- Reach Break and ID
- ● Knickpoint
- Watercourse
- HDF
- Detailed Assessment
- Development Fabric
- 0.25 m Contour
- Proposed SWM Pond
- Subject Lands
- Green Belt Plan Boundary

N

0 125 250
Metres

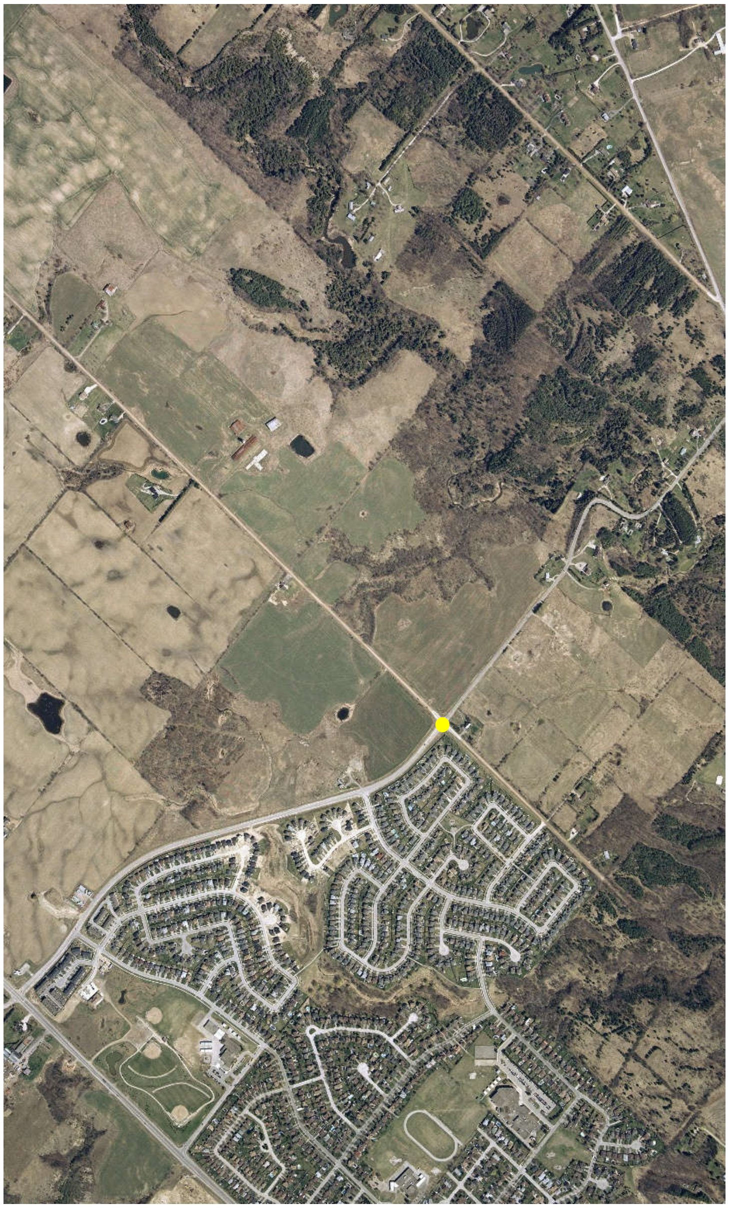
Imagery: Google Earth, 2022. Subject Lands, Green Belt
Watercourse, HDFs: GEI Consultants/GEO Morphix, 2025.
Development Fabric, SWMP, 0.25 m Contour: Schaeffers, 2025.
Waterbody: MNRF, 2024. Reach Break and ID, Knickpoint,
Detailed Assessment: GEO Morphix Ltd., 2024/2025.PN25026.
Print Date: June 2025. Drawn By: M.O., S.S.O., G.U.

Appendix B:
Historical Aerial Imagery

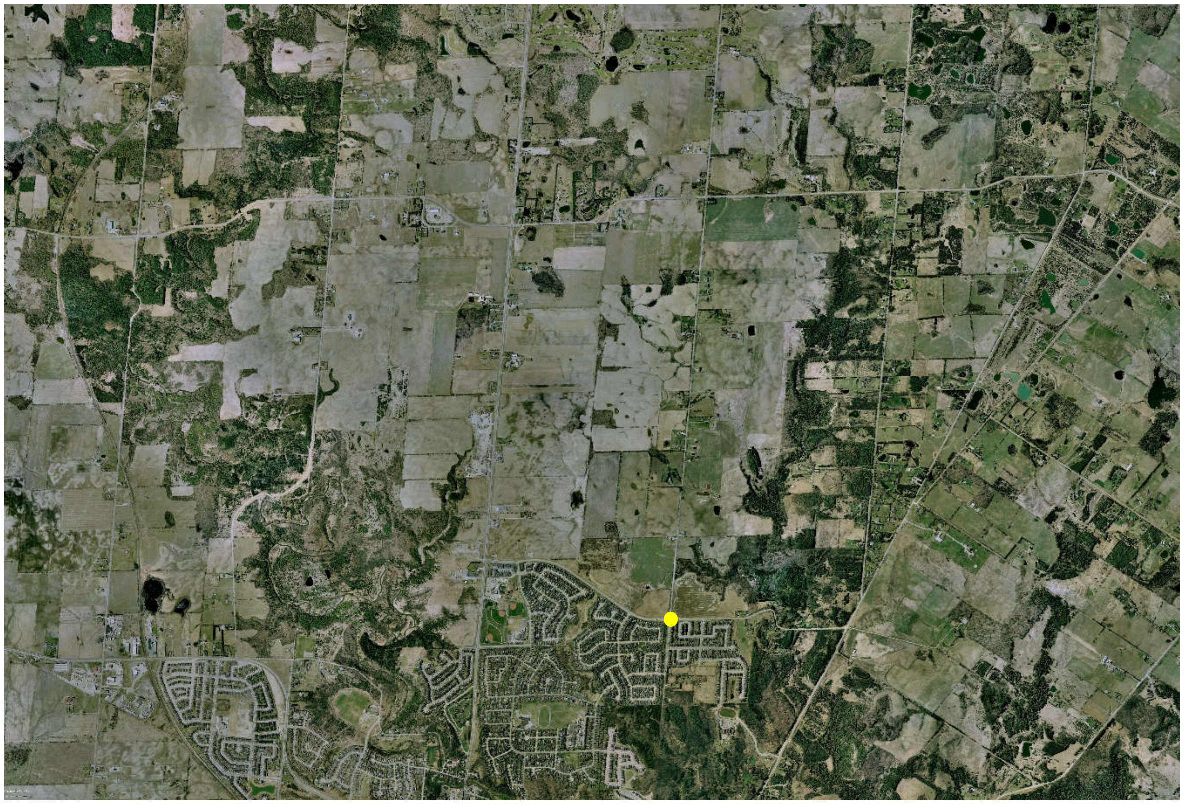
Location: Caledon, ON
Year: 1951
Scale: 1:40,000
Source: National Air Photo Library
Yellow Point: Intersection of Mount Hope Road and Columbia Way

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

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

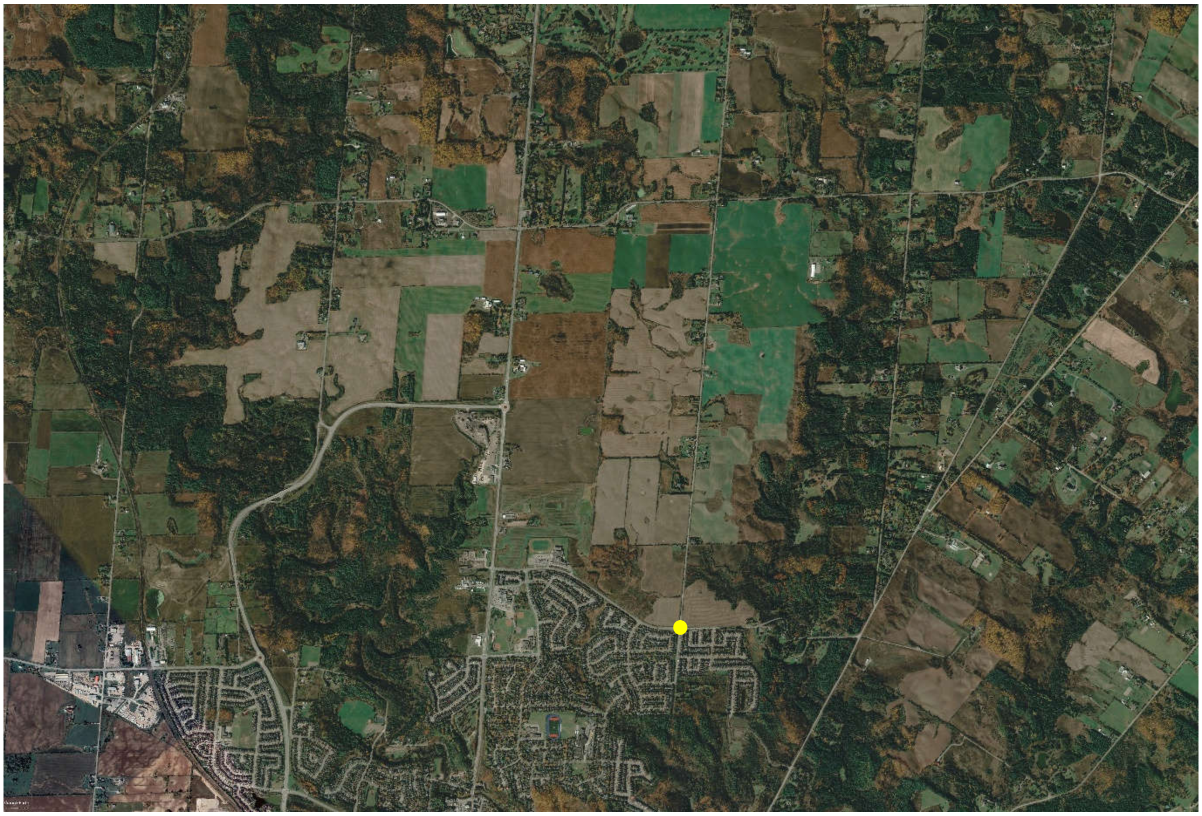


Location: Caledon, ON
Year: 1999
Scale: Digital Orthoimagery
Source: Ministry of Natural Resources
Yellow Point: Intersection of Mount Hope Road and Columbia Way



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

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



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

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

Appendix C: Photographic Record

Photo 1
Tributary of Humber River– Reach THRE-1-1
Caledon, Ontario

Photo of Reach **THRE-1-1** facing upstream from the culvert at Columbia Way. Note the limited valley form and riparian vegetation.

Photo 2
Tributary of Humber River– Reach THRE-1-1
Caledon, Ontario

Photo of Reach **THRE-1-1** taken facing upstream at an approximately 0.8 m knickpoint. Channel was eroded on both banks.

Photo 3 Tributary of Humber River– Reach THRE-1-1 Caledon, Ontario	 Photo of Reach **THRE-1-1** taken facing upstream at the knickpoint from **Photo 2.**
Photo 4 Tributary of Humber River– Reach THRE-1-1 Caledon, Ontario	 Photo of Reach **THRE-1-1** taken facing upstream. The edge of the treeline to the left represents the reach break between **THRE-1-1** and **THRE-1-2**. The reach appeared to be regularly ploughed to the edge of channel, which was poorly defined.

Photo 5 Tributary of Humber River– Reach THRE-1-2 Caledon, Ontario	 Photo of Reach **THRE-1-2** taken facing upstream at the first detailed assessment cross-section. Water was approximately 0.4 m deep and the wetted width was 1.66 m.
Photo 6 Tributary of Humber River– Reach THRE-1-2 Caledon, Ontario	 Photo of the left bank of Reach **THRE-1-2** taken upstream of **Photo 5**. Trees appeared to be leaning due to erosion of the bank. The channel widened at this location.

Photo 7
Tributary of Humber River– Reach THRE-1-2
Caledon, Ontario

No riffle morphology was identified and channel substrate consisted of silt, clay, and some organics.

Photo 8
Tributary of Humber River– Reach THRE-1-2
Caledon, Ontario

Photo of Reach **THRE-1-2** taken facing upstream just before the reach break, where the trees were denser and encroached the channel.

Photo 9
Tributary of Humber River– Reach THRE-1-3
Caledon, Ontario

Photo of Reach **THRE-1-3** taken facing upstream from the downstream extent of the reach, where trees heavily encroached the channel.

Photo 10
Tributary of Humber River– Reach THRE-1-3
Caledon, Ontario

Photo of Reach **THRE-1-3** taken facing upstream near the northern extent of the reach, where the watercourse originated in an agricultural field.

Photo 11
Tributary of Humber River, Reach– THRF-1
Caledon, Ontario

Photograph taken facing upstream at the downstream extent of **Reach THRF-1**. The channel flowed through a continuous, mature forest. Sand and gravel deposits were noted on the channel bed at the downstream extent of the reach.

Photo 12
Tributary of Humber River, Reach– THRF-1
B Caledon, Ontario

Banks were generally high and steep, and erosion was common. At this location banks were measured to be 1.8 m.

Photo 13
Tributary of Humber River, Reach– THRF-1
Caledon, Ontario

Photograph taken facing the left bank (facing downstream) of a terrace cut through older bar material.

Photo 14
Tributary of Humber River, Reach– THRF-1
Caledon, Ontario

Bed substrate ranged from silt to large boulders. Riffles were composed primarily of cobbles, with a low level of embeddedness. Substrate fowling was not observed.

Photo 15 Tributary of Humber River, Reach– THRF-1 Caledon, Ontario	 Photograph taken facing upstream of the first rooted knickpoint observed. The height was 0.30 m.
Photo 16 Tributary of Humber River,19each– THRF-1 Caledon, Ontario	 Exposed clay was noted throughout the channel, increasing in frequency upstream. Channel bed morphology was primarily comprised of riffles, with few deep pools. Measured riffle lengths were between 8.40 and 11.20 m.

Photo 17
Tributary of Humber River, Reach– THRF-2
Caledon, Ontario

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

Photo 18
Tributary of Humber River, Reach– THRF-2
Caledon, Ontario

Photograph taken facing downstream. The bed substrate consisted of gravel and cobbles and the bank substrate consisted of clay, silt, and gravel primarily.

Photo 19
Tributary of Humber River, Reach– THRF-2
Caledon, Ontario

Photograph taken facing upstream. The gradient along the reach was high and entrenchment increased at localized sections where knickpoints were present.

Photo 20
Tributary of Humber River, Reach– THRF-2
Caledon, Ontario

Photograph taken facing downstream. Woody debris, leaning and fallen trees, and exposed roots were common, with the highest concentration in the upstream section of the reach.

Appendix D:
Rapid Assessment Field Sheets

GEO MORPHIX™

General Site Characteristics

Project Number: 25026

Date:	2025-03-14	**Stream:**	Trib of Humber river
Time:	1:09	**Reach:**	THRE1-1
Weather:	7C sunny	**Location:**	Bolton, ON
Field Staff:	KC NBS	**Watershed/Subwatershed:**	Black creek-Humber river outlet

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
ѰѰѰ	Grasses
☁	Tree
▭	Instream log/tree
✳✳✳	Woody debris
⋘	Beaver dam
⊖	Vegetated island

Monitoring

-o-o-o-	Long-profile
⊢⊣	Monumented XS
⊡	Monumented photo
↓	Monumented photo direction
▼	Sediment sampling
▭	Erosion pins
8	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

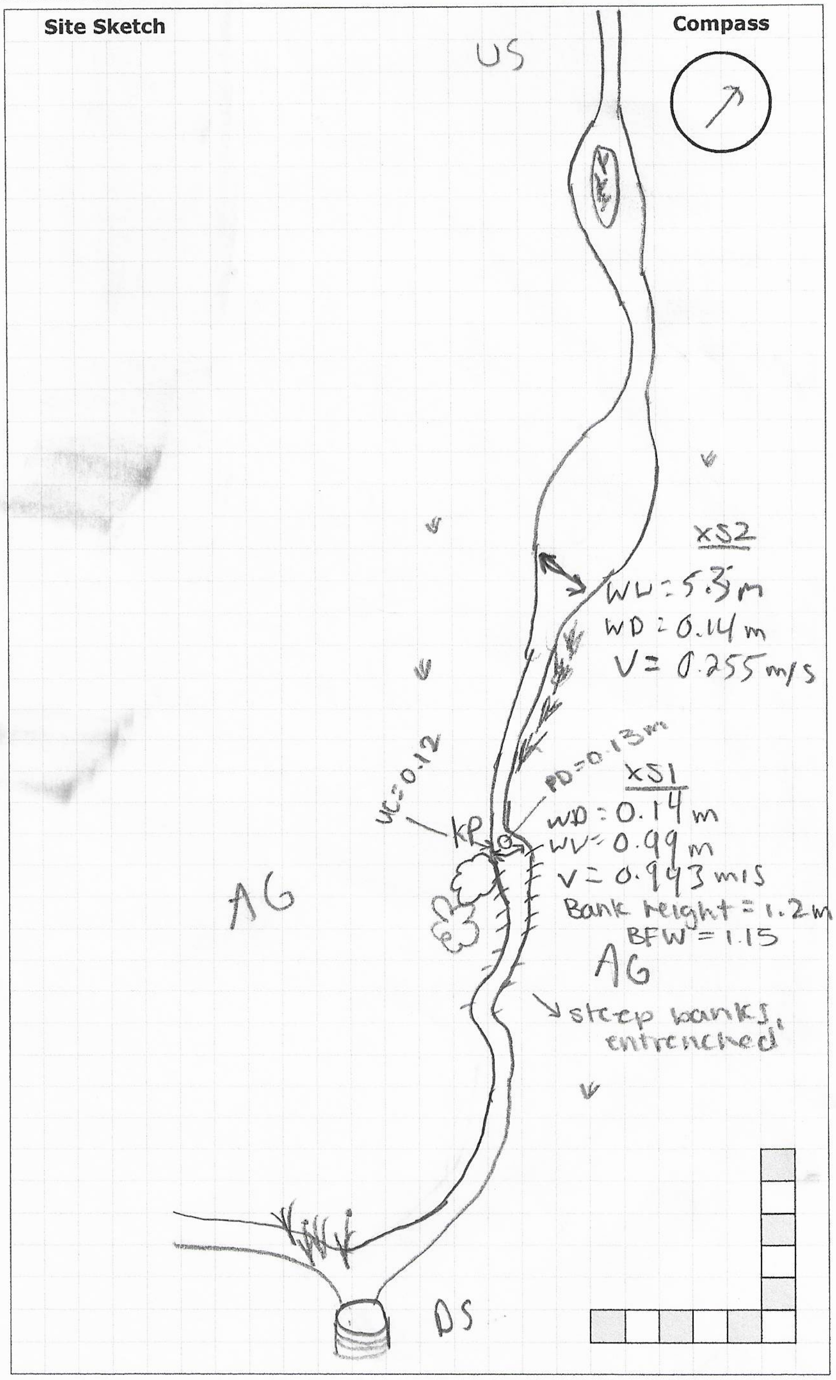
Substrate

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 **Compass**



Photos:

Notes: channel loses definition upstream of knick point, DS of KP channel becomes entrenched with high steep banks + more velocity, minimal riparian vegetation - some small grasses under snow
Bed substrate = clay, silt, sand.

Version #4
Last edited: 21/02/2023

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

Page 1 of 3

General Site Characteristics

Project Number: 25026

Date:	2025-03-14	**Stream:**	Trib of Humber river
Time:	1:20	**Reach:**	THRE1-1
Weather:	7°C sunny	**Location:**	Bolton, ON
Field Staff:	KC NBS	**Watershed/Subwatershed:**	Black creek - Humber river outlet

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

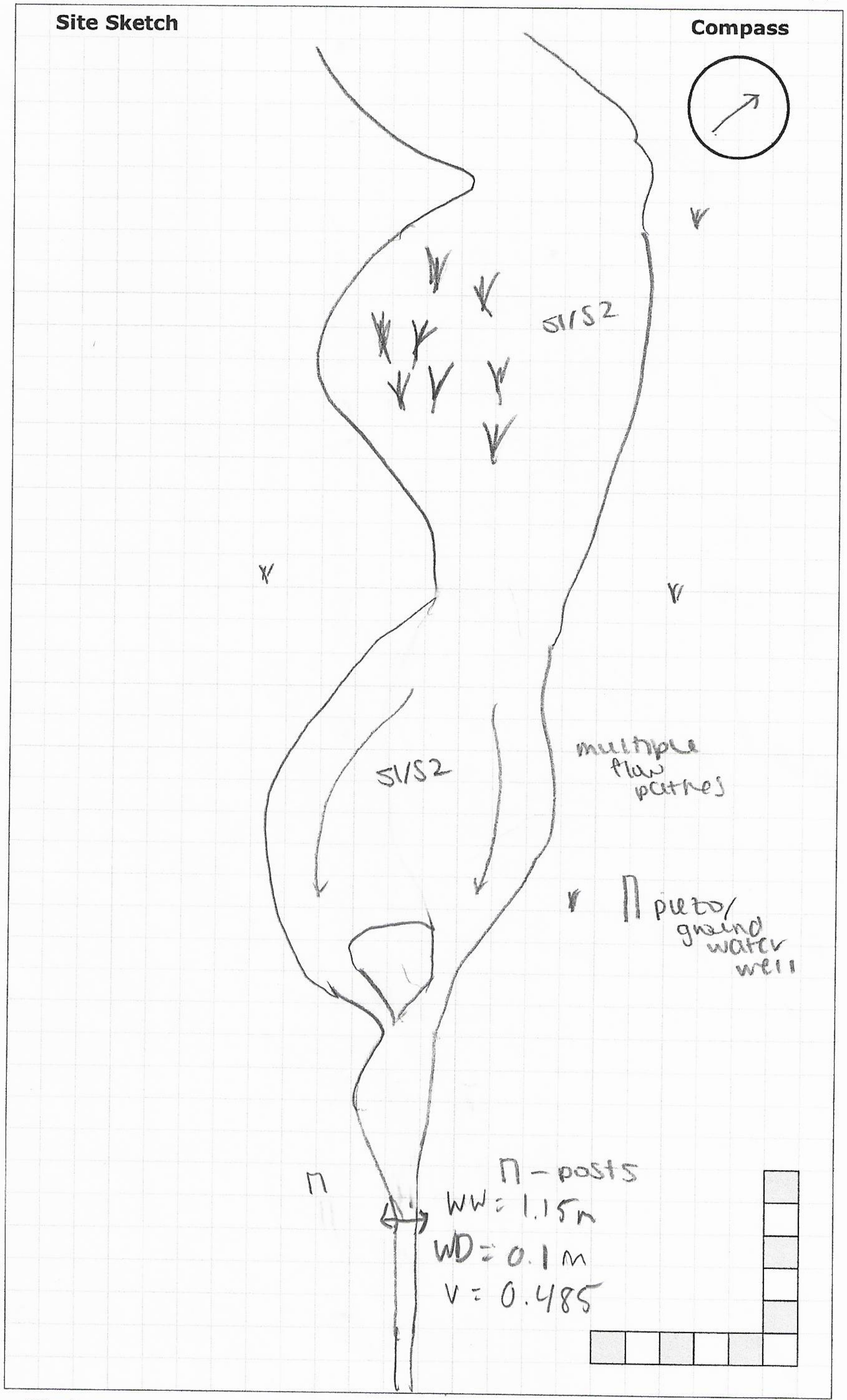
Substrate

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: upstream extent of drawing had no single defined flow pathway, no defined banks, multiple flow pathes (likely from snow melt). Channel observed during spring freshet.

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

General Site Characteristics

Project Number: 25026

Date:	2025-03-14	**Stream:**	Trib of Humber river
Time:	3:27	**Reach:**	THRE1-1
Weather:	7°C sunny	**Location:**	Bolton, ON
Field Staff:	KC NBS	**Watershed/Subwatershed:**	Black creek, Humber river outlet

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

- peizometer
- cattails

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

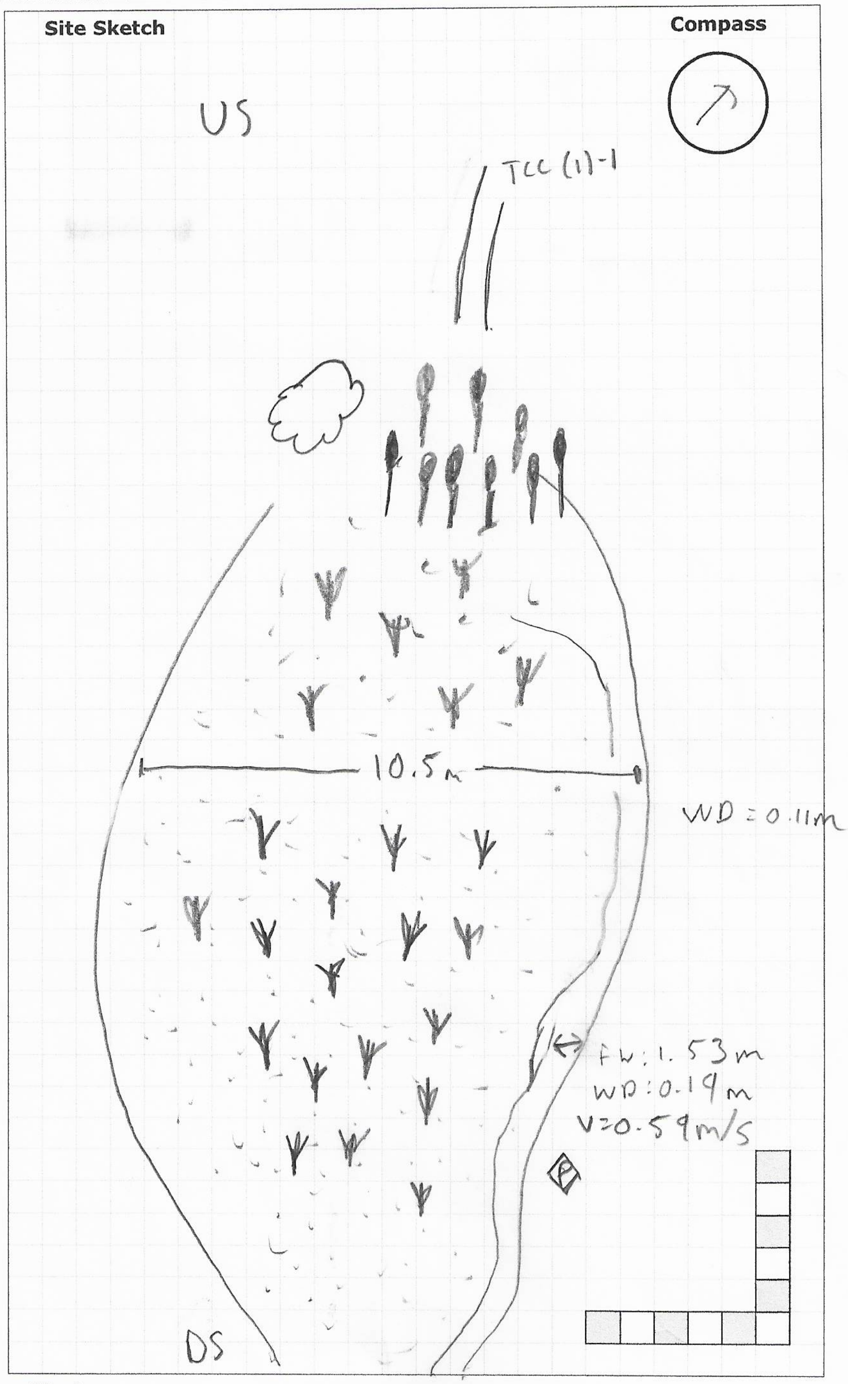
Substrate

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: Inundated wetland

Version #4
Last edited: 21/02/2023

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

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GEO
MORPHIX™

Reach Characteristics

Project Number: 25026

Date:	2025-03.14	**Field Staff:**	KC NBS	**Watershed/Subwatershed:**	Black Creek - Humber River wate
Time:	13:09	**Stream:**	Trib of Humber River	**UTM (Upstream):**	
Weather:	7°C sunny	**Reach:**	THRE-1-1	**UTM (Downstream):**	

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

Riparian Vegetation

Dominant Type (Table 6): 3

Encroachment (Table 7): 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 %: 15

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

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

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

entrenched @ DS extent →

no riffle/pools

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

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

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

Bankfull Width (m)	1.0	5.3	1.15
Bankfull Depth (m)	0.27	0.14	0.10
Undercuts (m)			
Pool Depth (m)	0.13		
Riffle Length (m)			

P.W.

Wetted Width (m)	0.99	5.3	1.15	10.5	1.53
Wetted Depth (m)	0.14	0.14	0.1	0.11	0.19
Velocity (m/s)	0.993	0.255	0.485		0.59
Velocity Estimate Method	WB	WB	WB		
Meander Amplitude (m)					

Notes: US extent - channel not defined, multi flow path, undefined banks, feature width = wetted width, likely higher ww due to snow melt
DS extent - defined, entrenched, steep, defined banks
Extremely narrow riparian buffer, minimal grasses, US extent is likely tilled over in the summer
DS culvert - 2.5m diameter
KP @ DS extent ~0.6m

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 25026

Date:	2025-03-14	**Stream:**	Trib of Humber River
Time:	13:09	**Reach:**	THRE-1-1
Weather:	7 c sunny	**Location:**	Bolton, ON
Field Staff:	KC NBS	**Watershed/Subwatershed:**	Black Creek-Humber River outlet

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		✓	1/5
	2	Coarse materials in riffles embedded -no riffles	—	—	
	3	Siltation in pools		✓	
	4	Medial bars		✓	
	5	Accretion on point bars -no point bars	—	—	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone	✓		
		Sum of indices =			0.20
Evidence of Degradation (DI)	1	Exposed bridge footing(s) N/A	—	—	1/6
	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		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =			0.167
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1/7
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots - only @ DS extent	✓		
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle -no riffles		✓	
	6	Outflanked gabion baskets / concrete walls / etc. N/A	—	—	
	7	Length of basal scour >50% through subject reach - only @ DS extent		✓	
	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 =			0.143
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		✓	
	7	Bar forms poorly formed / reworked / removed	✓		
		Sum of indices =			0.286

Notes: US extent undefined, likely tiled over. DS extent entrenched and defined

Channel observed during spring freshet

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.20
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: CT Completed by: KC

Channel observed during Spring freshet

Rapid Stream Assessment Technique

Project Number:

Date:	2025-03-14	**Stream:**	Trib of Humber River
Time:	—	**Reach:**	THRE-1-1
Weather:	7°C Sunny	**Location:**	Bolton, ON
Field Staff:	KC NBS	**Watershed/Subwatershed:**	Black Creek-Humber River outlet

Category	Poor	Fair	Good	Excellent
low angle banks, but mobile sediment	• < 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]
Channel Stability -exposed roots only @ DS	• 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
-no riffles	• > 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
Channel Scouring/ Sediment Deposition	• ~~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~~
S1/S2 –	• 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
-no pb	• 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: CT Completed by: NBS

Location: Bolton, ON

Date: 2025-03-14 **PN:** 25026

Category	Poor	Fair	Good	Excellent
-banks not defined @US	• 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)
-no riffles	• 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
Physical Instream Habitat	• 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) = 18	**Poor (<13)**	[✓ **Fair (13-24)**]	**Good (25-34)**	**Excellent (>35)**

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

Version #2
Last edited: 10/02/2023

General Site Characteristics

Project Number: 25026

Date:	27/02/2025	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-2
Weather:	3°C cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

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

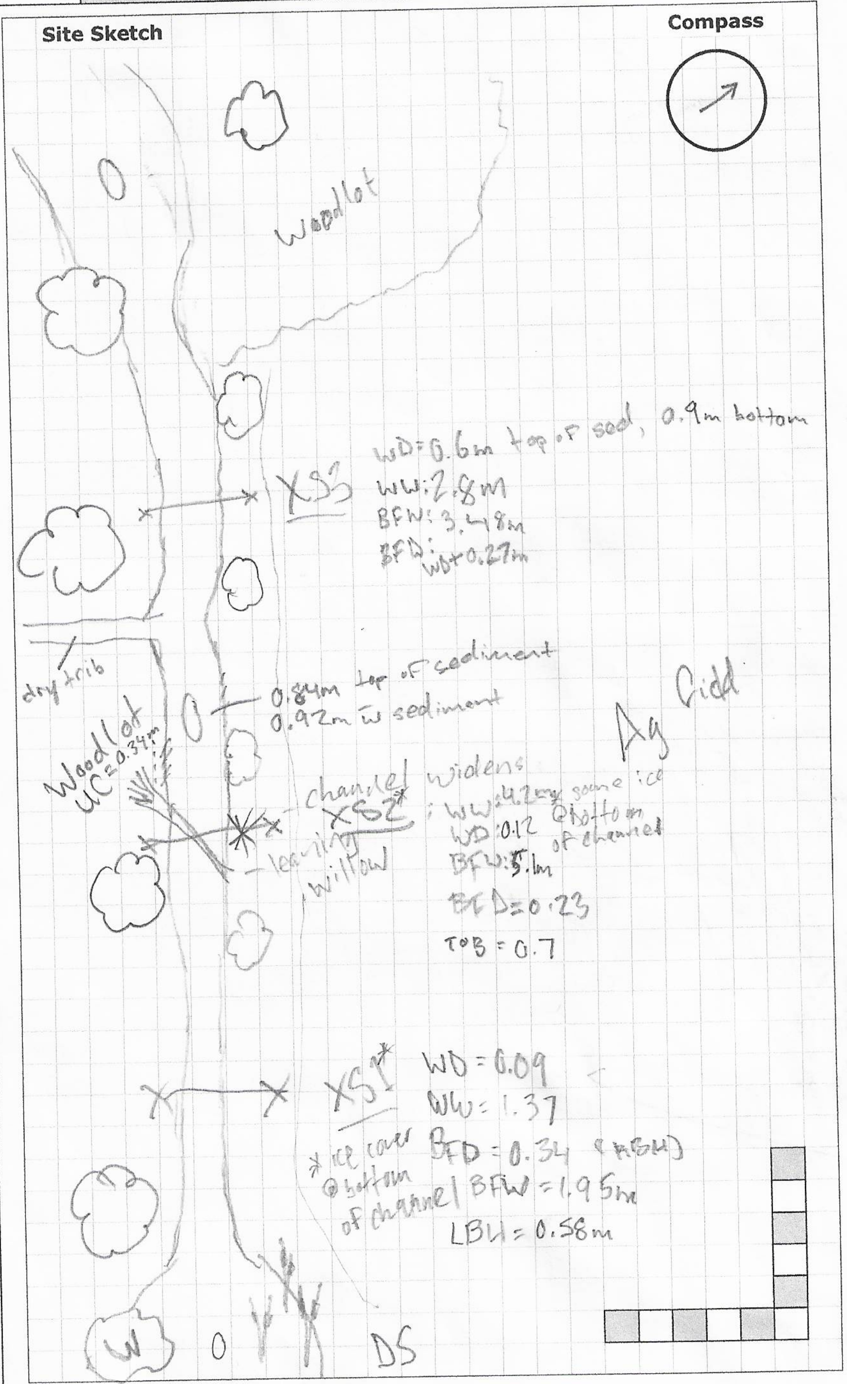
Substrate

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: CT

Page 1 of 2

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General Site Characteristics

Project Number: 25026

Date:	27/02/2025	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-2
Weather:	3°C cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

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
ѰѰѰ	Grasses
☁	Tree
▭	Instream log/tree
✱ ✱ ✱	Woody debris
⋇	Beaver dam
⬭	Vegetated island

Monitoring

-o-o-o-	Long-profile
├──┤	Monumented XS
⊡	Monumented photo
↓	Monumented photo direction
▼	Sediment sampling
▥	Erosion pins
8	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

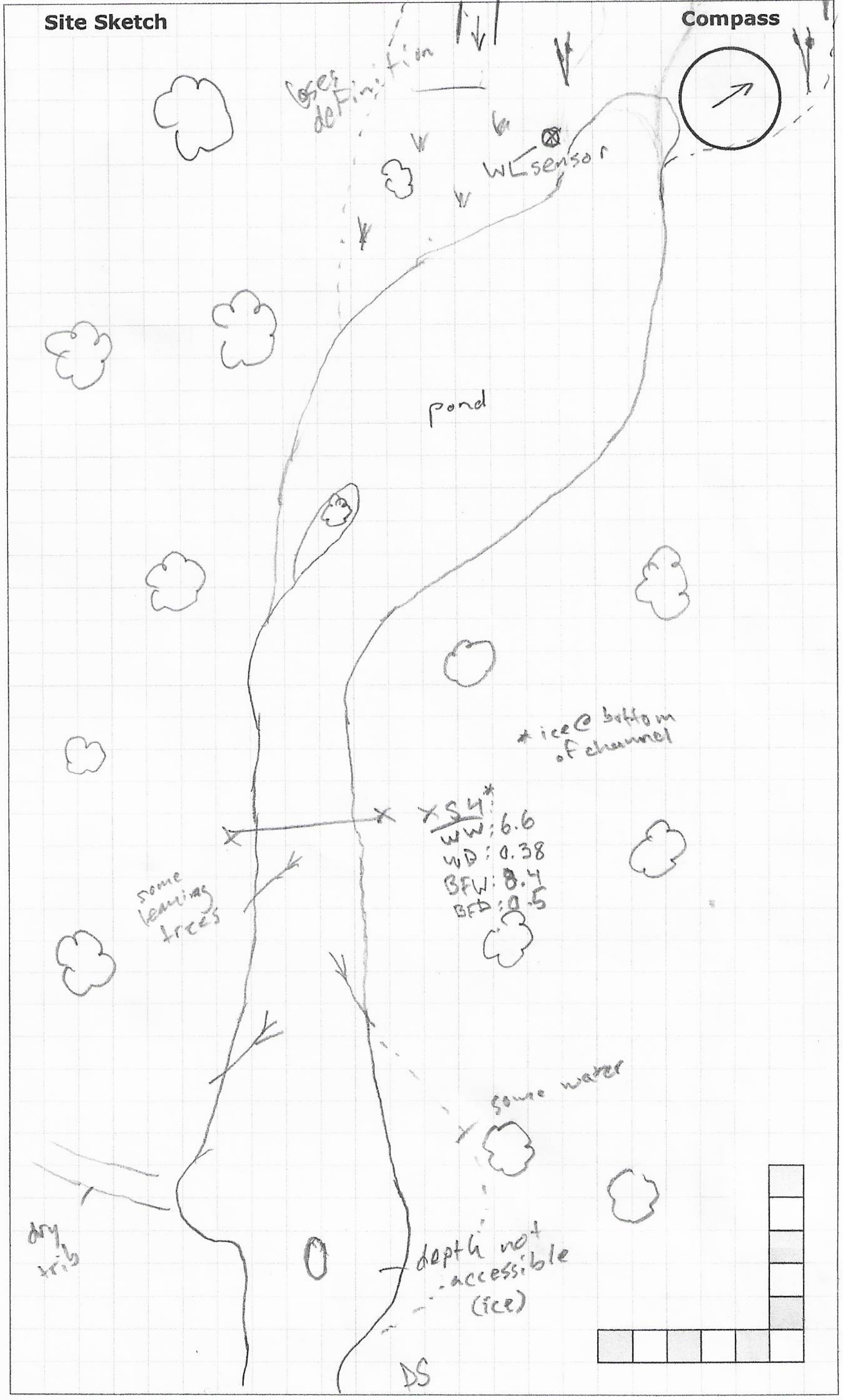
S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

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

Compass



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

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Reach Characteristics

Project Number: 25026

Date:	2025-02-27	**Field Staff:**	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet
Time:		**Stream:**	Trib of Humber River	**UTM (Upstream):**	
Weather:	3°C cloud/snow	**Reach:**	THRE-1-2	**UTM (Downstream):**	

Land Use (Table 1): 1&3
Valley Type (Table 2): 1
Channel Type (Table 3): 11/12
Channel Zone (Table 4): 2
Flow Type (Table 5): 1
☐ Evidence of Groundwater Location:______ Photo:______

Riparian Vegetation

Dominant Type (Table 6): 1&3
3@US extent
Encroachment (Table 7): 2

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

Aquatic & Instream Vegetation

* not visible

Type (Table 8): 1
@ US extent
Reach Coverage %: <10

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

WDJ/50m: 0

Water Quality

Odour (Table 16): 6) organic
Frozen
Turbidity (Table 17):

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 1
Down's Model (Table 15): m
Sed Sorting (Table 20): MS
not very visible
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 5/8/9
Riffle-Pool Spacing (m): n/a

Sinuosity Degree (Table 10): 2
# of Channels (Table 12): 1
Bank Failure (Table 14): 2
Bankfull Indicators (Table 18): 3/5
Sediment Transport Observed? ☐ Yes ☐ No ☒ Not Visible
% of Bed Active: N/a → frozen
Mass Movement (Table 23): 1+4
not seen
% Riffles:
% Pools: 75

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)	☑	☐	☐	☐	☐	☐	☐

	XS1	XS2	XS3	XS4
Bankfull Width (m)	1.95	5.1	3.48	8.4
Bankfull Depth (m)	0.34	0.23	0.87	0.5
Undercuts (m)	0.34			
Pool Depth (m)	0.84			
Riffle Length (m)	/	/	/	

	1	2	3	XS4
Wetted Width (m)	1.37	4.2	2.8	6.6
Wetted Depth (m)	0.09	0.12	0.6	0.38
Velocity (m/s)	0	0	0	
Velocity Estimate Method	n/a			
Meander Amplitude (m)	N/A			

Notes: Ice lined bottom of channel, will have minor impact on measurements.
Channel was wide in sections, inundated w/ water, wetland/grass area & ponding @ US
Likely seasonal wetland in forested area adjacent to channel

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): ______ Checked by: ______ Completed by: CT/NBS

GEO MORPHIX™

Rapid Stream Assessment Technique **Project Number:** 25026

Date:	2025-02-27	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-2
Weather:	3°C Cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet

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
straight / low sinuosity	• 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
not visible	• > 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
Channel Scouring/ Sediment Deposition	• 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
not visible	• 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
not seen	• 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: CT/NBS

Date:	2025-02-27	**PN:**	25026	**Location:**	Bolton

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)
not observed	~~- 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
lots of pools	[✓ - 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%)
Frozen brown ice	[✓ - 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
n/a (ice)	- Objects visible to depth < 0.15m below surface	- Objects visible to depth 0.15-0.5m below surface	- Objects visible to depth 0.5-1.0m below surface	- Objects visible to depth > 1.0m below surface
	- Moderate to strong organic odour	- Slight to moderate organic odour	[✓ - Slight organic odour]	- No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	- Narrow riparian area of mostly non-woody vegetation	[✓ - Riparian area predominantly wooded but with major localized gaps]	- Forested buffer generally > 31 m wide along major portion of both banks	- Wide (> 60 m) mature forested buffer along both banks
	- Canopy coverage: <50% shading (30% for large mainstem areas)	- Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	[✓ - Canopy coverage: 60-79% shading (45-59% for large mainstem areas)]	- Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☒ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 26	**Poor (<13)**	**Fair (13-24)**	[✓ **Good (25-34)**]	**Excellent (>35)**

Version #2
Last edited: 10/02/2023

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

*"NV" = not visible (n/a)

Rapid Geomorphic Assessment

Project Number: 25026

Date:	2025-02-27	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-2
Weather:	3°C cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar NV			1/3
	2	Coarse materials in riffles embedded NV			
	3	Siltation in pools	✓		
	4	Medial bars NV			
	5	Accretion on point bars NV			
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone NV		✓	
		Sum of indices =	1	2	0.33
Evidence of Degradation (DI)	1	Exposed bridge footing(s) n/a			0
	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
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		2/6
	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 n/a			
	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 =	2	4	0.33
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	1/5
	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) - in pool US	✓		
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed (NV)			
		Sum of indices =	1	4	0.2

Notes: Channel covered by snow, inundated by water, wetland-type ponding in sections

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.28
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: CT/NBS

General Site Characteristics

Project Number: 25026

Date:	27/02/2025	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-3
Weather:	3°C cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

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

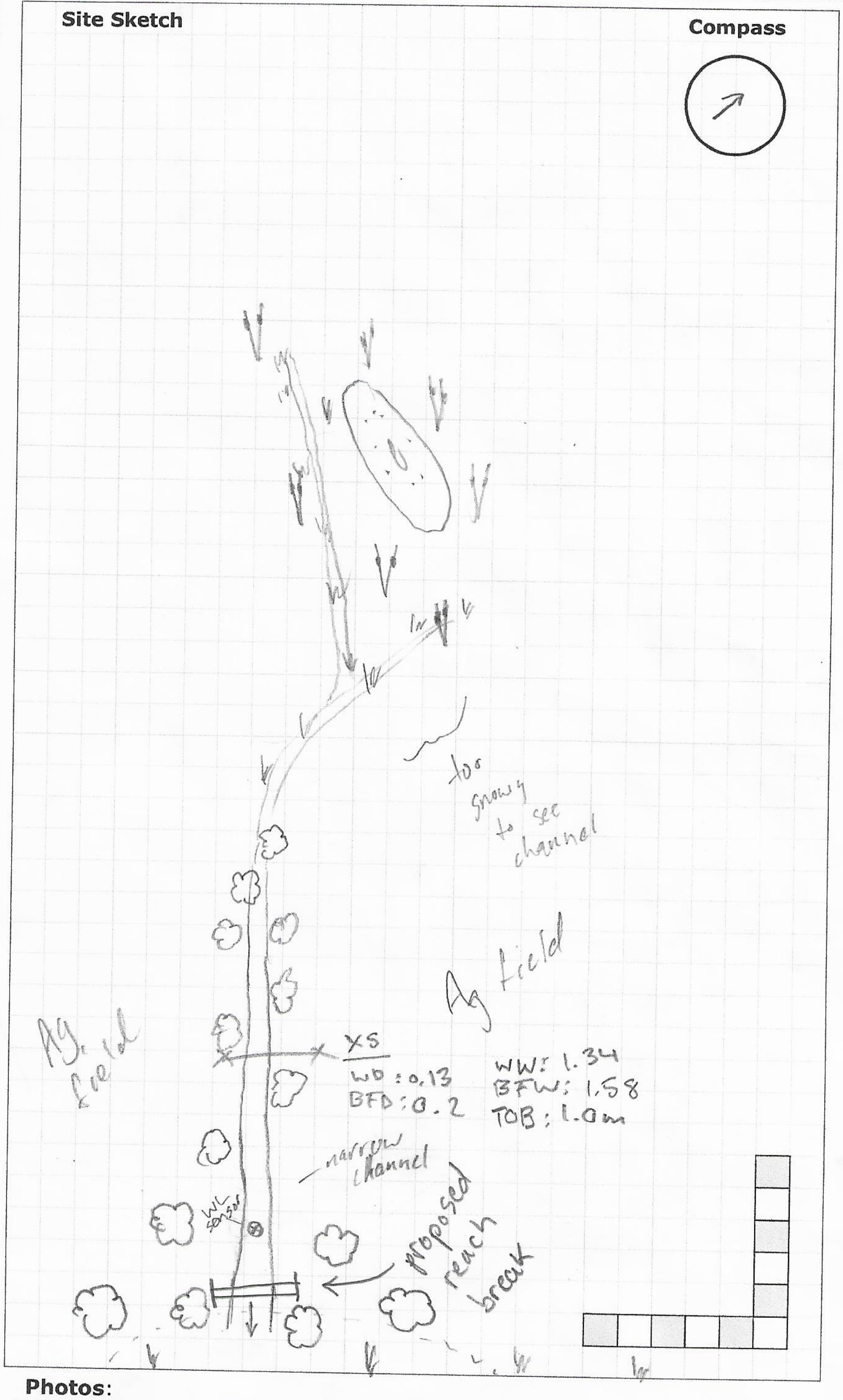
S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

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

Compass



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

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GEO
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Reach Characteristics **Project Number:** 25026a

Date:	2025-02-27	**Field Staff:**	CT NBS	**Watershed/Subwatershed:**	Humber River
Time:		**Stream:**	Trib. Humber River	**UTM (Upstream):**	
Weather:	3°C cloud/snow	**Reach:**	THRE-1-3	**UTM (Downstream):**	

Land Use (Table 1): 3 **Valley Type** (Table 2): 1 **Channel Type** (Table 3): 11 **Channel Zone** (Table 4): 1 **Flow Type** (Table 5): 3 ☐ Evidence of Groundwater Location:__________ Photo:______

Riparian Vegetation

Dominant Type (Table 6): 1+3

Encroachment (Table 7): 4

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

Reach Coverage %: 50

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

WD Density
- ☑ Low
- ☐ Mod
- ☐ High

WDJ/50m: 0

Water Quality frozen

Odour (Table 16): — **Turbidity** (Table 17):

Channel Characteristics

Sinuosity Type (Table 9)	1	**Sinuosity Degree** (Table 10)	1		
Gradient (Table 11)	1	**# of Channels** (Table 12)	1		
Entrenchment (Table 13)	1	**Bank Failure** (Table 14)	1		
Down's Model (Table 15)	m	**Bankfull Indicators** (Table 18)	5+3		
Sed Sorting (Table 20)	WS	**Sediment Transport Observed?**	☐ Yes ☐ No ☒ Not Visible		
Transport Mode (Table 21)	3	**% of Bed Active**	0		
Geomorphic Units (Table 22)	8	**Mass Movement** (Table 23)	4 → ds		
Riffle-Pool Spacing (m):	N/a	**% Riffles:**	n/a	**% Pools:**	N/a

snow/ice

pond@ US extent

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

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

} snow covered

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

Bankfull Width (m)	1.58			**Wetted Width (m)**	1.34		
Bankfull Depth (m)	0.2			**Wetted Depth (m)**	0.13		
Undercuts (m)	/			**Velocity (m/s)**	0		
Pool Depth (m)	/			**Velocity Estimate Method**	/		
Riffle Length (m)	/			**Meander Amplitude (m)**	/		

Notes: Reach covered in snow, partially dry

Photos:

Version #4
Last edited: 04/04/2023

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

* NV = not visible (snow)

GEO
MORPHIX™

Rapid Geomorphic Assessment **Project Number:** 25026

Date:	2024-02-27	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-3
Weather:	3°C cloud/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		✓	2/7
	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 likely @ US →	✓		
		Sum of indices =	2	5	0.286
Evidence of Degradation (DI)	1	Exposed bridge footing(s) n/a			0
	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
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		1/4
	2	Occurrence of large organic debris - small O.D.		✓	
	3	Exposed tree roots - NV			
	4	Basal scour on inside meander bends - n/a (straight)			
	5	Basal scour on both sides of channel through riffle - n/a			
	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 =	1	8	0.25
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	0
	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 - NV			
		Sum of indices =	0	1	0

Notes: Short reach located in narrow wooded section bordered by agri. Grasses + wetland/pond connected US (HDF) Covered in snow.

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.134
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: CT /NBS

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Rapid Stream Assessment Technique   Project Number: 25026

Date:	2025-02-27	**Stream:**	Trib of Humber River
Time:		**Reach:**	THRE-1-3
Weather:	3°C cloudy/snow	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

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: CT/NBS

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Date:	2025-02-27	**PN:**	25026	**Location:**	Bolton

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat not visible US –	• 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)
n/a	~~• 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~~
No riffles/pools, minimal water instream none	~~• 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 (Frozen)	• 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: CT/NBS

GEO
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General Site Characteristics

Project Number: 25026

Date:	2025-03-26	**Stream:**	
Time:	2:00 pm	**Reach:**	THRF-1
Weather:	0°C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet

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

- exposed roots

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

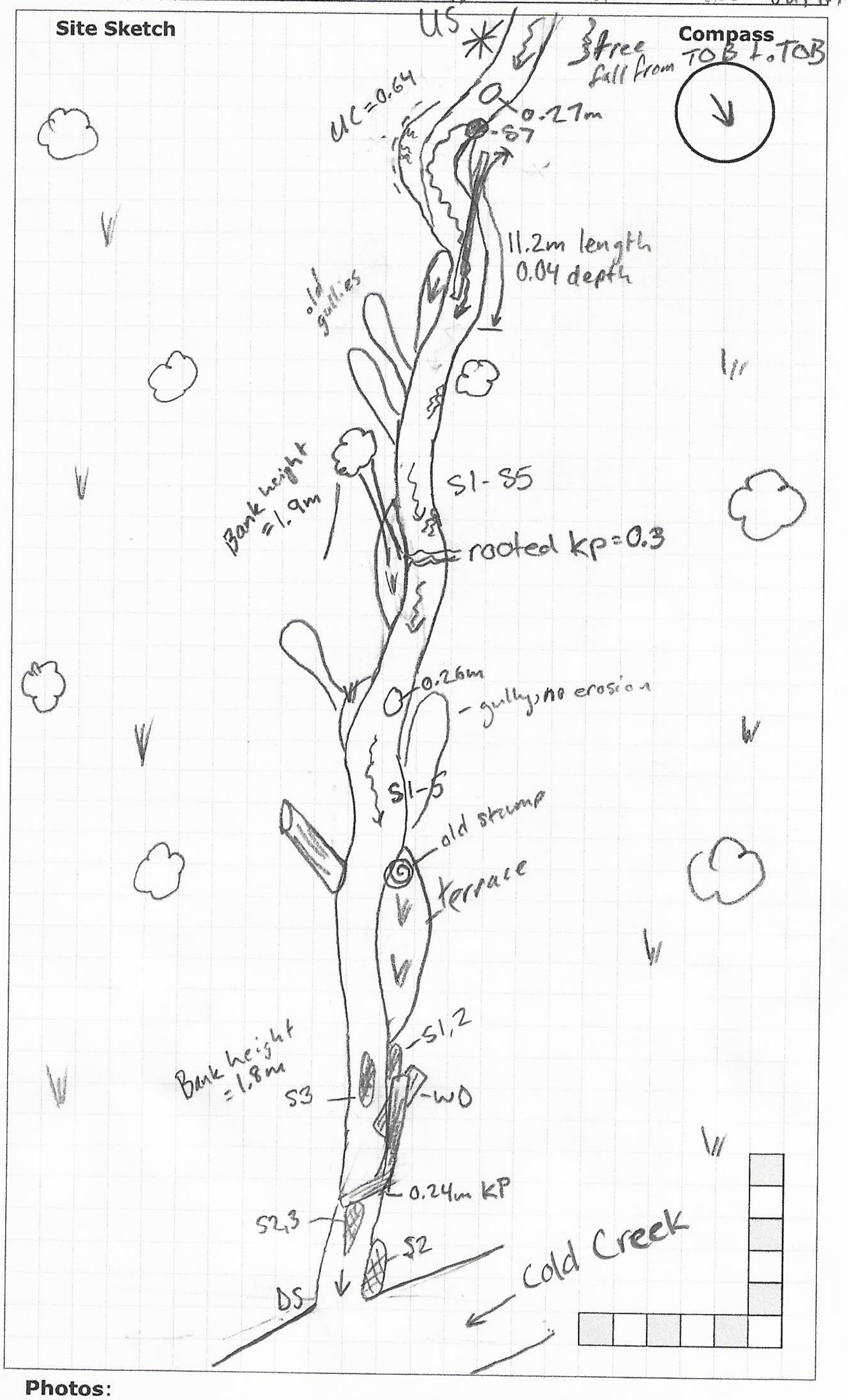
Substrate

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: Exposed soil, highly entrenched, erosion on most banks for all of the reach. Grain size ranged silt to large boulders. US portion of reach became very exposed hard clay bed with less unconsolidated material.

Version #4
Last edited: 21/02/2023

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

GEO
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General Site Characteristics

Project Number: 25026

Date:	2025-03-26	**Stream:**	
Time:		**Reach:**	THRF-1
Weather:	0°C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet

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

Flow Type

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

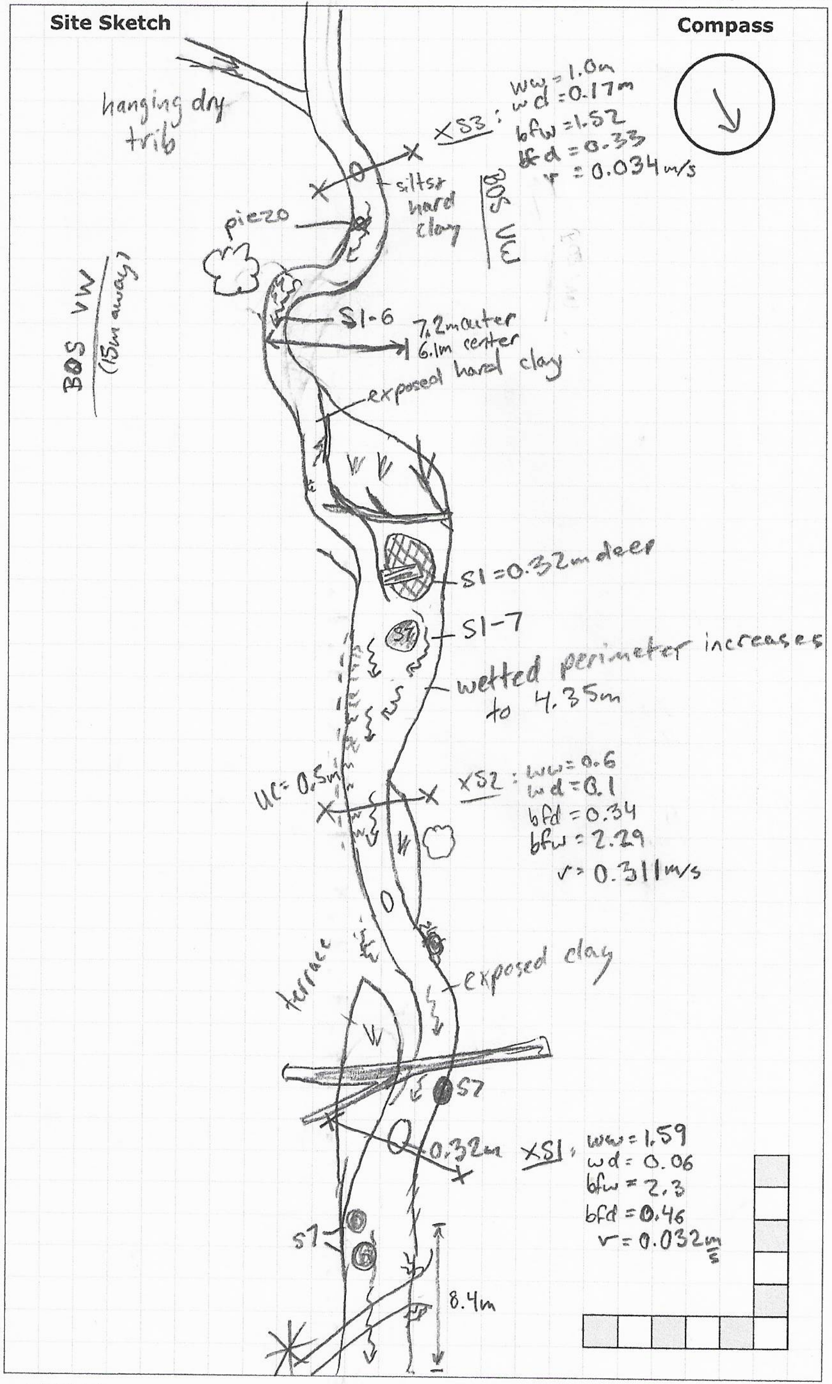
Substrate

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

Other

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

Site Sketch



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

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General Site Characteristics

Project Number: 25026

Date:	2025-03-26	**Stream:**	
Time:		**Reach:**	THRF-1
Weather:	0'C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek Humber River Outlet

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

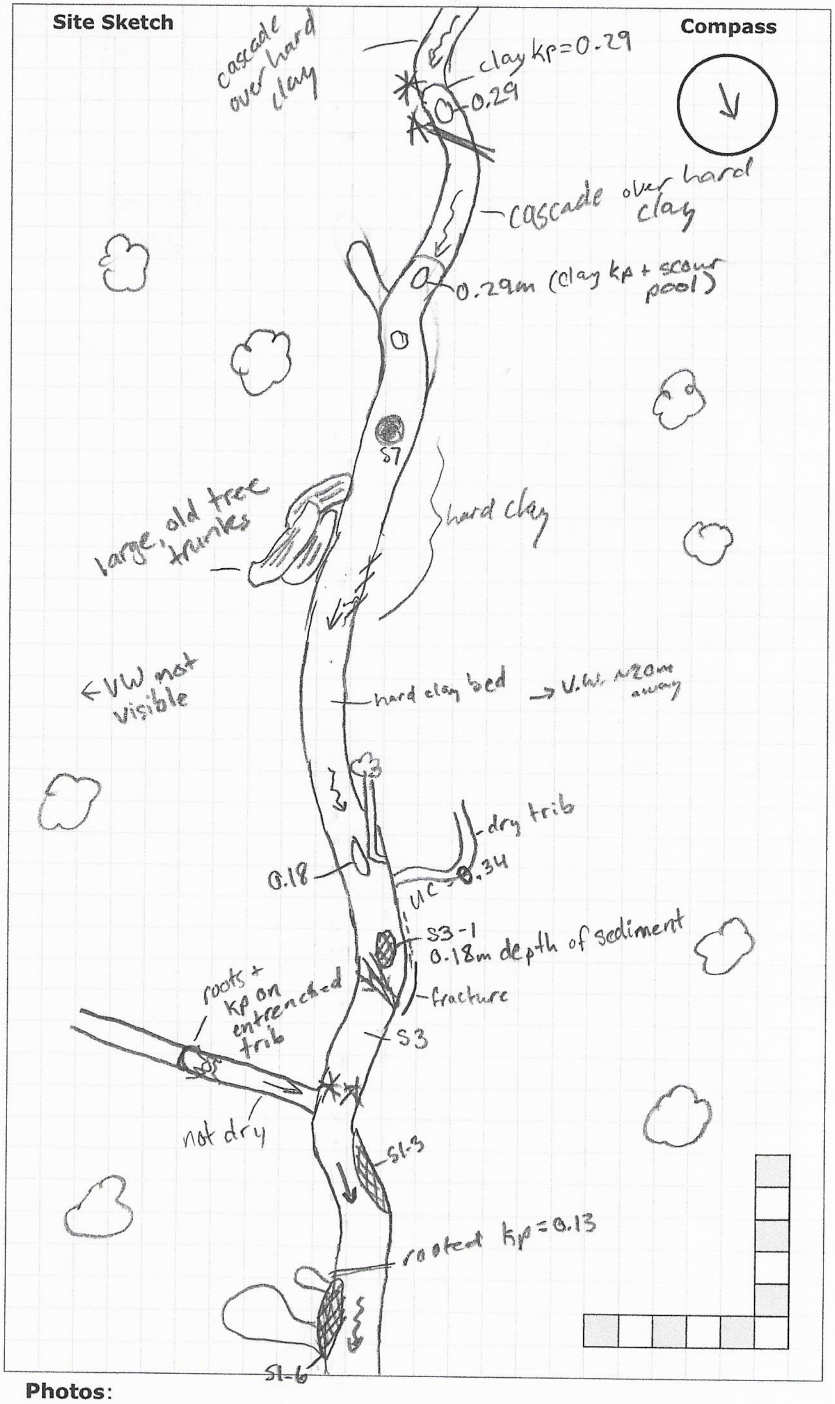
Substrate

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: SSO Completed by: CT

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General Site Characteristics

Project Number: 25026

Date:	2025-03-26	**Stream:**	
Time:		**Reach:**	THRF-1
Weather:	0°C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek - Humber River Outlet

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

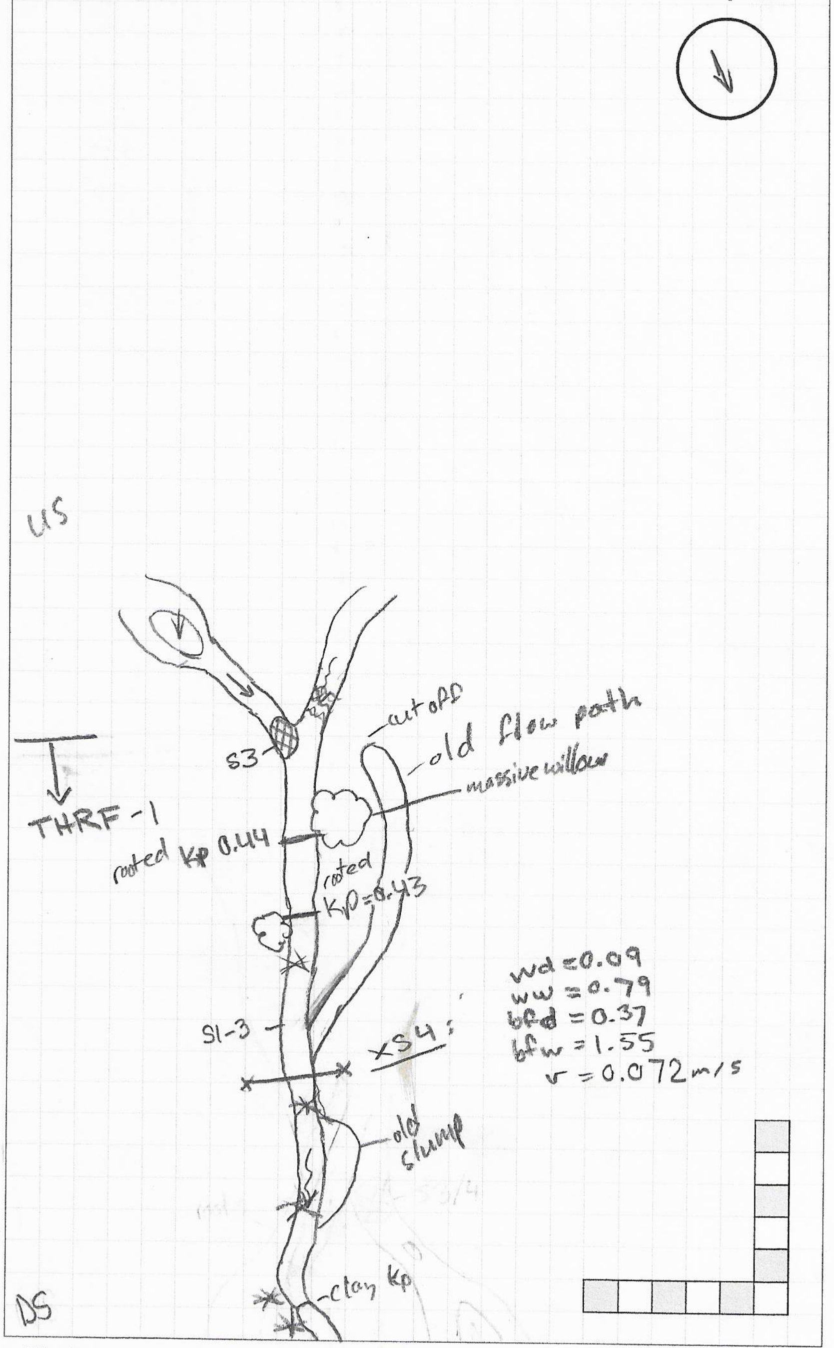
S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

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

Compass



Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

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GEO MORPHIX™

Reach Characteristics

Project Number: 25026

Date:	2025-03-26	**Field Staff:**	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet
Time:	2:00 pm	**Stream:**	Trib of Cold Creek	**UTM (Upstream):**	
Weather:	0°C Sun	**Reach:**	THRF-1	**UTM (Downstream):**	

Land Use (Table 1): 3
Valley Type (Table 2): 2
Channel Type (Table 3): 7
Channel Zone (Table 4): 2
Flow Type (Table 5): 2
☒ Evidence of Groundwater Location: — Some iron staining Photo: 3

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 2

Coverage
- ☐ None
- ☐ Fragmented
- ☒ Continuous

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

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

Aquatic & Instream Vegetation — Some rootlets

Type (Table 8): Na
Reach Coverage %: 0

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

WD Density
- ☒ Low
- ☐ Mod
- ☐ High

WDJ/50m: 1

Water Quality

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

Channel Characteristics

banks ~2m tall

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

Sinuosity Degree (Table 10): 2
# of Channels (Table 12): 1
Bank Failure (Table 14): 6 + gullying
Bankfull Indicators (Table 18): 4,5,7
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 1
Mass Movement (Table 23): 6 (most similar to gully)
% Riffles: 80
% Pools: 5

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

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

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

Bankfull Width (m)	2.3	2.29	1.52
Bankfull Depth (m)	0.46	0.34	0.33
Undercuts (m)	0.64	0.5	0.34
Pool Depth (m)	0.26	0.27	0.32
Riffle Length (m)	11.2	8.4	

Wetted Width (m)	1.59	0.6	1.0
Wetted Depth (m)	0.06	0.1	0.17
Velocity (m/s)	0.032	0.311	0.034
Velocity Estimate Method	WB	WB	WB
Meander Amplitude (m)	7.2		

Notes: Very entrenched, high banks, exposed soil eroding but not extensive undercutting, lots of traces of past large gullies, confined within valley, mixed bed materiel, majority riffles, increased exposed hard parent clay moving US, some old terraces visible, trapezoidal channel shape, with steep banks.

Photos:

Version #4
Last edited: 04/04/2023

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

GEO MORPHIX™

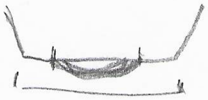
Rapid Stream Assessment Technique **Project Number:** 25026

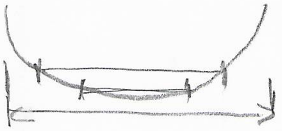
Date:	2025-03-26	**Stream:**	
Time:	2:00pm	**Reach:**	THRF-1
Weather:	0°C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet

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
3/4 of reach	[✓ • 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 US 1/4 of reach had bottom 1/3 made of hard clay	• 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 not embeded in riffles	• > 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 pools, ranged clay-cobble	• 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: SSO Completed by: CT/NBS





GEO
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Date:	2025-03-26	**PN:**	25026	**Location:**	Bolton

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]
too shallow	~~• Objects visible to depth < 0.15m below surface~~	~~• Objects visible to depth 0.15-0.5m below surface~~	~~• Objects visible to depth 0.5-1.0m below surface~~	~~• Objects visible to depth > 1.0m below surface~~
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• [✓ No odour]
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☒ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	[✓ • Wide (> 60 m) mature forested buffer along both banks]
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	[✓ • Canopy coverage: >80% shading (> 60% for large mainstem areas)]
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☒ 7

Total overall score (0–42) = 24	**Poor (<13)**	[✓ **Fair (13-24)**]	**Good (25-34)**	**Excellent (>35)**

Senior staff sign-off (if required): ________ Checked by: SSO Completed by: CT/NBS

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Rapid Geomorphic Assessment

Project Number: 25026

Date:	2025-03-26	**Stream:**	
Time:	2:00pm	**Reach:**	THRF-1
Weather:	0°C sun	**Location:**	Bolton
Field Staff:	CT NBS	**Watershed/Subwatershed:**	Black Creek-Humber River Outlet

Process	No.	Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	3/6
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars	✓		
	~~5~~	~~Accretion on point bars~~ no/few point bars			
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone		✓	
		Sum of indices =	3	3	0.5
Evidence of Degradation (DI)	1	Exposed bridge footing(s) n/a			4/5
	2	Exposed sanitary / storm sewer / pipeline / etc. n/a			
elevated tributary	3	Elevated storm sewer outfall(s) n/a			
	4	Undermined gabion baskets / concrete aprons / etc. n/a			
some scour DS of Kps	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 =	6	1	0.8
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		7/7
	2	Occurrence of large organic debris	✓		
	3	Exposed tree roots	✓		
	4	Basal scour on inside stream ~~meander~~ bends - yes, minor, no pt. bars	✓		
	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 =	7	0	1.0
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 - no clear meanders		✓	
	7	Bar forms poorly formed / reworked / removed	✓		
		Sum of indices =	3	4	0.429

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.68
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: SSO Completed by: CT/NBS

GEO MORPHIX™

General Site Characteristics

Project Number: PN24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	14:00	**Reach:**	THRF-2
Weather:	18°C sunny	**Location:**	Bolton, ON
Field Staff:	SC JV	**Watershed/Subwatershed:**	Bolton Dam-Humber River

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

- exposed roots

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

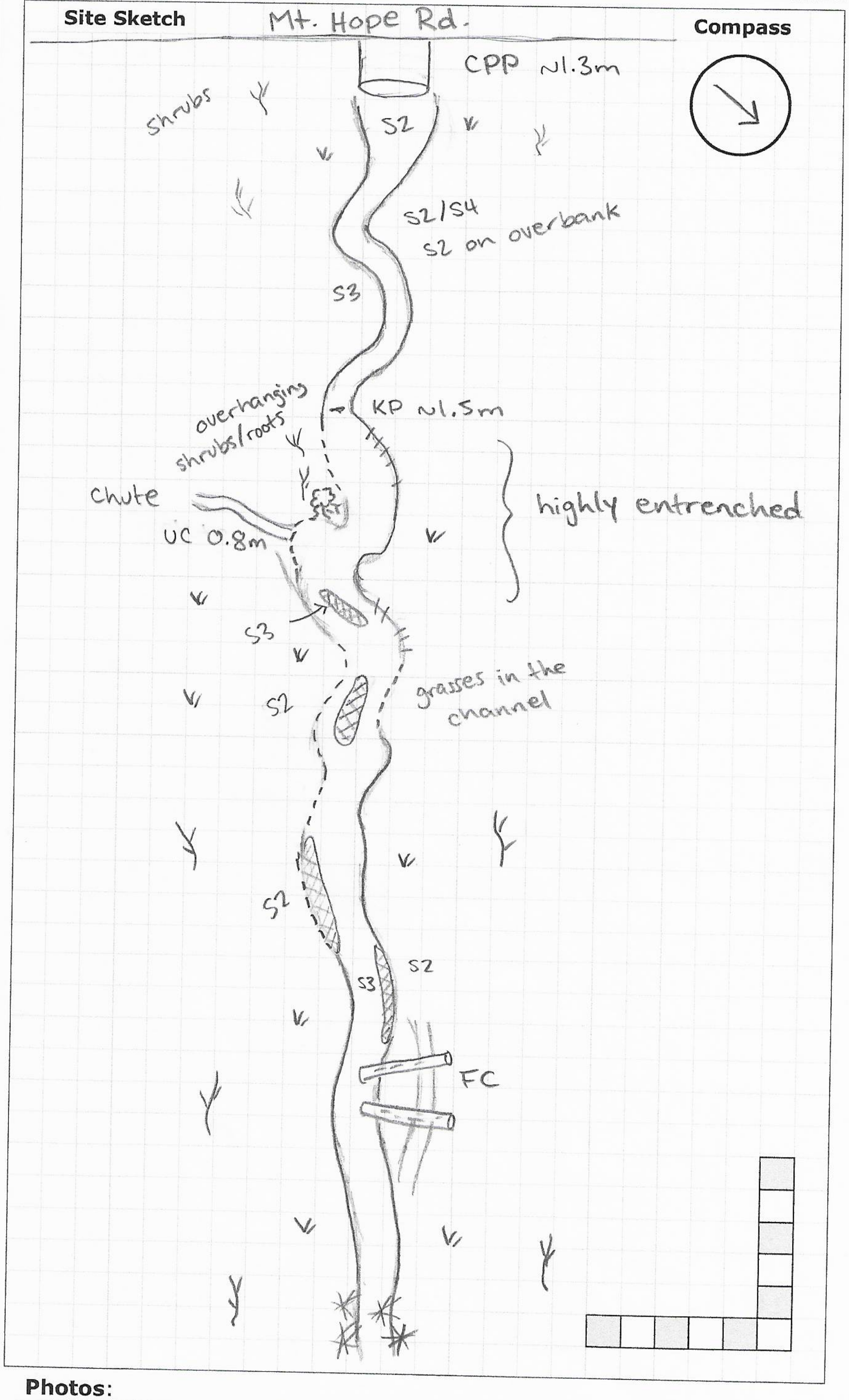
Substrate

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: SC

Page 1 of 5

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General Site Characteristics

Project Number: PN24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	14:00	**Reach:**	THRF-2
Weather:	18°C sunny	**Location:**	Bolton, ON
Field Staff:	SC JV	**Watershed/Subwatershed:**	Bolton Dam-Humber River

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

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S5	Large cobble		

Other

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BOS	Bottom of slope	**FP**	Flood plain
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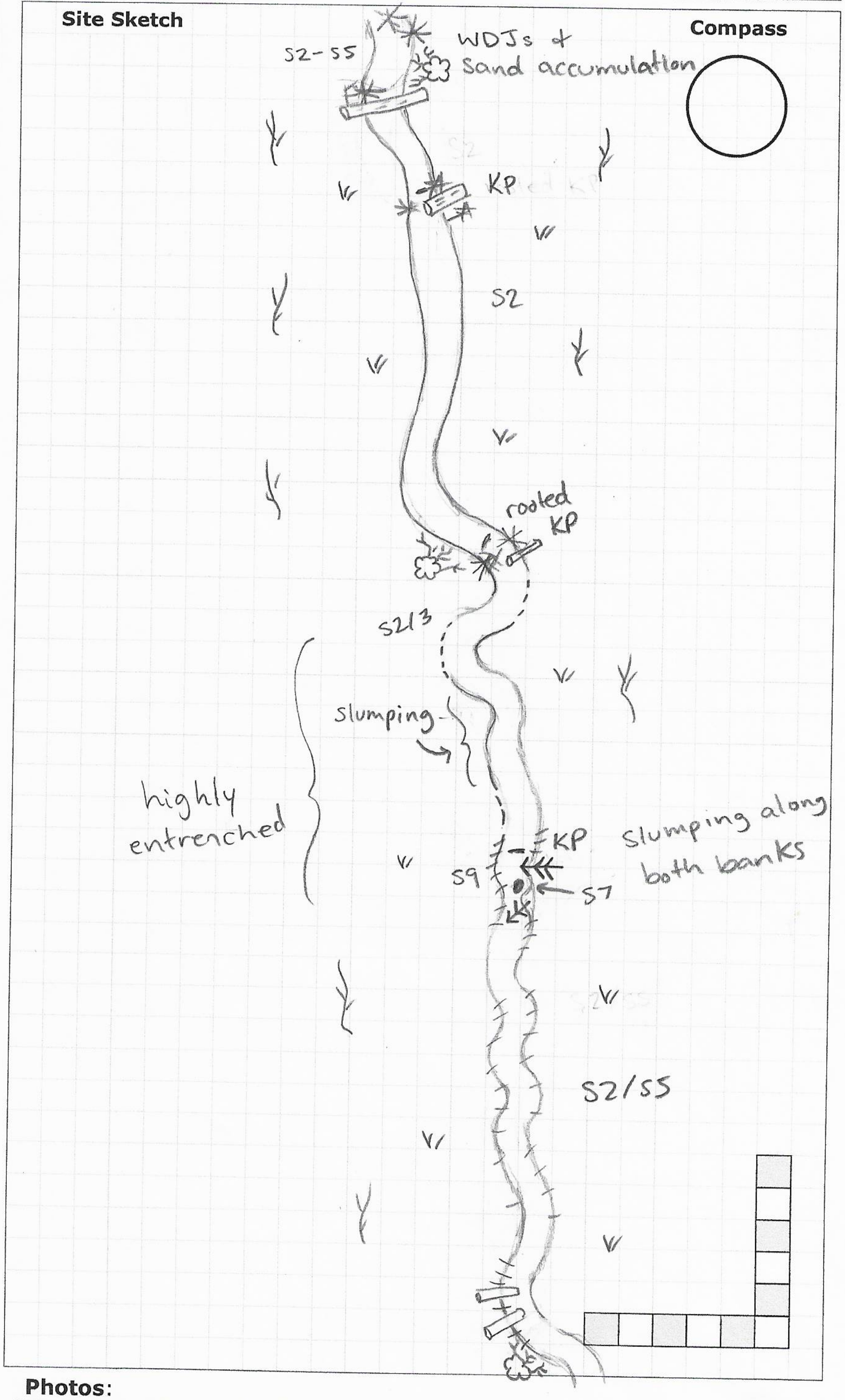
Site Sketch



Photos:

Notes:

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

Page 2 of 5

General Site Characteristics

Project Number: PN24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	14:00	**Reach:**	THRF-2
Weather:	18°C sunny	**Location:**	Bolton, ON
Field Staff:	SC JV	**Watershed/Subwatershed:**	Bolton Dam - Humber River

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		
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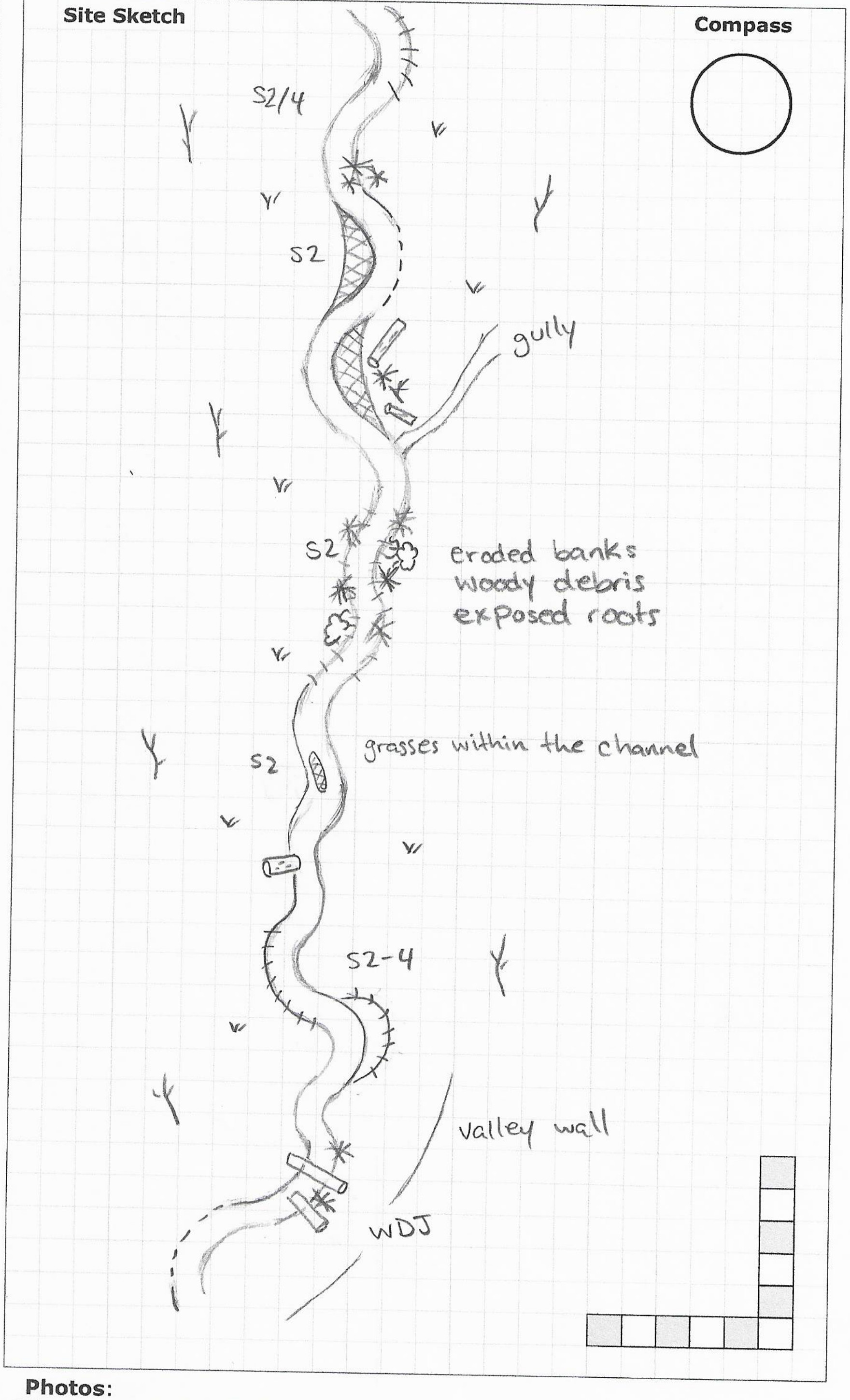

Photos:

Notes:

Version #4
Last edited: 21/02/2023

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

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General Site Characteristics

Project Number: PN24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	14:00	**Reach:**	THRF-2
Weather:	18°C sunny	**Location:**	Bolton, ON
Field Staff:	SC JV	**Watershed/Subwatershed:**	Bolton Dam-Humber River

Features	**Monitoring**
├─┤ Reach break	-o-o-o- 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
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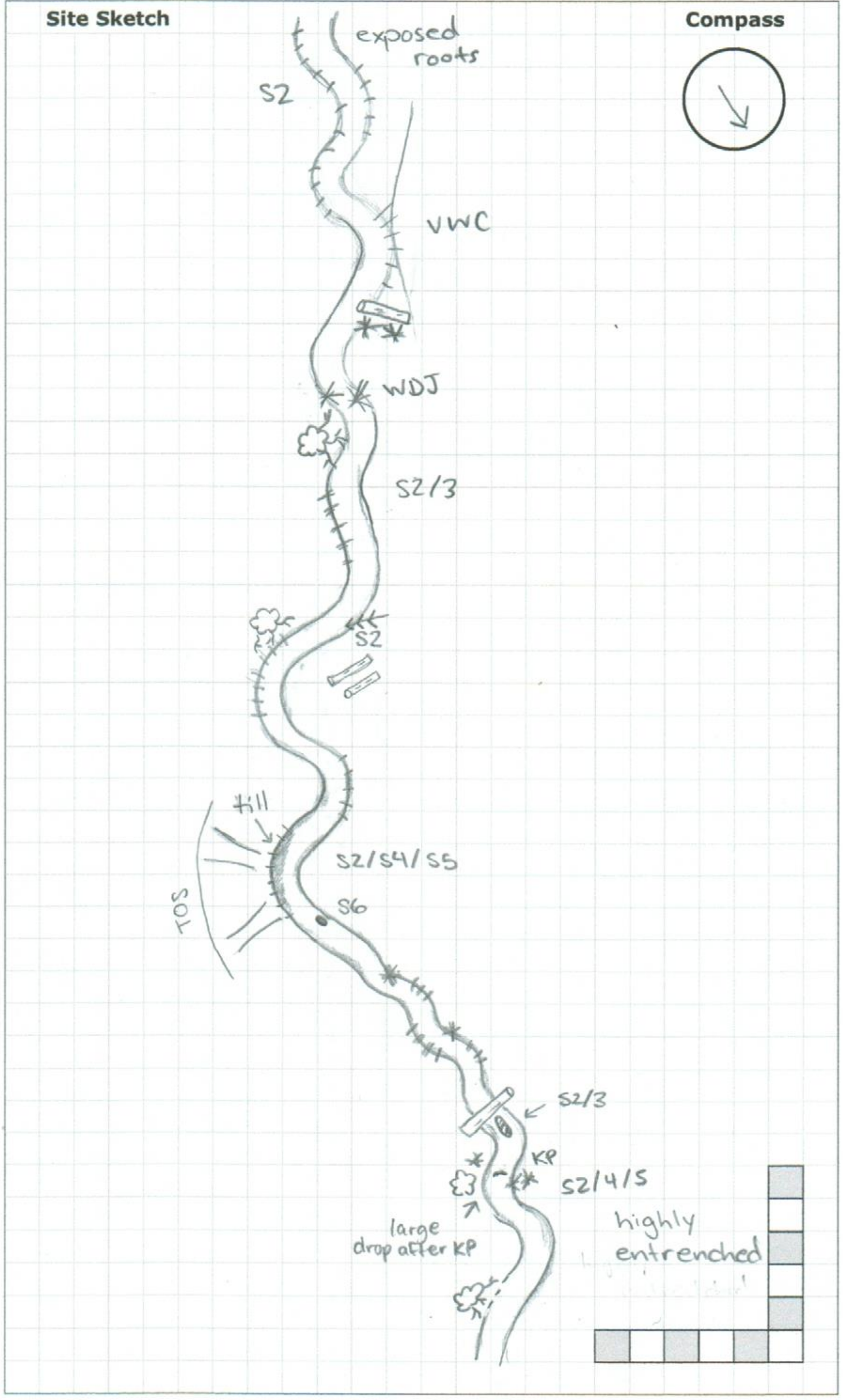
Site Sketch

Compass



Photos:

Notes:

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

GEO MORPHIX™

General Site Characteristics

Project Number: PN24043

Date:	2024-04-22	**Stream:**	Humber River Trib
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Field Staff:	SC JV	**Watershed/Subwatershed:**	Bolton Dam- Humber Rive

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
ѰѰѰ	Grasses
☁	Tree
▭	Instream log/tree
✳ ✳ ✳	Woody debris
⋇	Beaver dam
⬭	Vegetated island

Monitoring

-o-o-o-	Long-profile
⊢—⊣	Monumented XS
◙	Monumented photo
↓	Monumented photo direction
▼	Sediment sampling
▥	Erosion pins
8	Scour chains

Additional Symbols

▨	till

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
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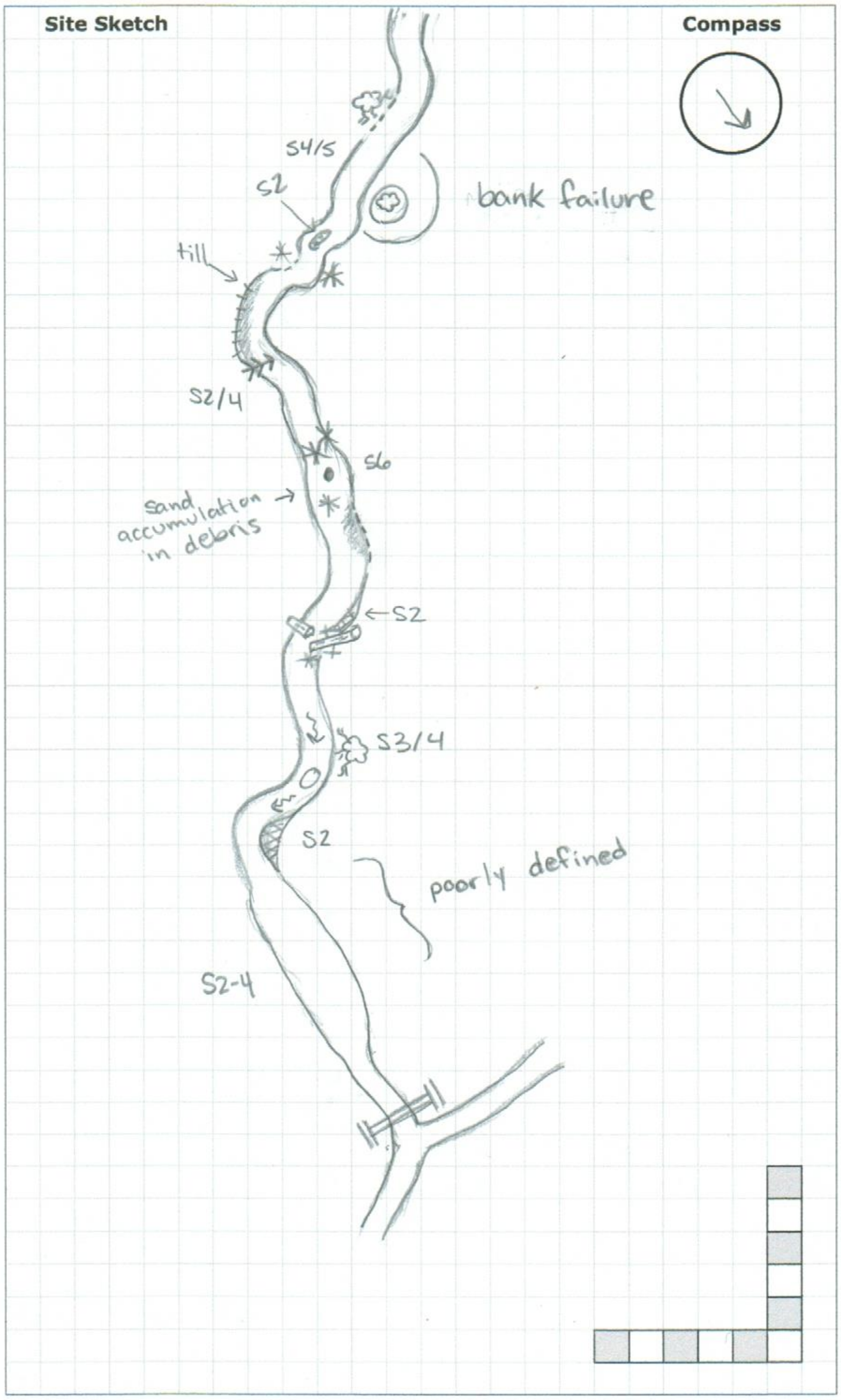
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point



Photos:

Notes:

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

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Rapid Geomorphic Assessment **Project Number:** 24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	13:52	**Reach:**	THRF-2
Weather:	Sunny 16°C	**Location:**	Bolton ON
Field Staff:	JV SC	**Watershed/Subwatershed:**	Humber River

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		X	3/7
	2	Coarse materials in riffles embedded	X		
	3	Siltation in pools	X		
	4	Medial bars		X	
	5	Accretion on point bars	X		
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =	3	4	0.429
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		1/6
	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		X	
	6	Cut face on bar forms		X	
	7	Head cutting due to knickpoint migration	X		
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	1	5	0.167
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		5/7
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle	X		
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.	N/A		
	9	Fracture lines along top of bank	X		
	10	Exposed building foundation	N/A		
		Sum of indices =	5	2	0.714
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	0/7
	2	Single thread channel to multiple channel		X	
	3	Evolution of pool-riffle form to low bed relief form		X	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		X	
	7	Bar forms poorly formed / reworked / removed		X	
		Sum of indices =	0	7	0.328

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0
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: ________

Rapid Stream Assessment Technique **Project Number:** 24043

Date:	2024-04-22	**Stream:**	Humber River Trib
Time:	13:52	**Reach:**	THRF-2
Weather:	Sunny 16°C	**Location:**	Bolton ON
Field Staff:	JV SC	**Watershed/Subwatershed:**	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: ________

Date:	2024-04-22	**PN:**	24043 THRF-2	**Location:**	Bolton ON

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
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
	• 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) = 20	**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: ________

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Reach Characteristics **Project Number:**

Date:	2024-04-22	**Field Staff:**	JV SC	**Watershed/Subwatershed:**	Humber River
Time:	13:52	**Stream:**	Trib of Humber Riv	**UTM (Upstream):**	Road
Weather:	Sunny 16°C	**Reach:**	THRF-2	**UTM (Downstream):**	415

Land Use (Table 1): 1
Valley Type (Table 2): 2
Channel Type (Table 3): 13
Channel Zone (Table 4): 2
Flow Type (Table 5): 2
☐ Evidence of Groundwater Location:__________ Photo:______

Riparian Vegetation

Dominant Type (Table 6): 1/2
Encroachment (Table 7): 3

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

Aquatic & Instream Vegetation

Type (Table 8): 1
Reach Coverage %: 5

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

WDJ/50m: 1

Water Quality

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

Channel Characteristics

Sinuosity Type (Table 9): 5
Sinuosity Degree (Table 10): 3
Gradient (Table 11): 2
# of Channels (Table 12): 1
Entrenchment (Table 13): 2
Bank Failure (Table 14): 1/6
Down's Model (Table 15): e
Bankfull Indicators (Table 18): 1/7
Sed Sorting (Table 20): poorly
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
Transport Mode (Table 21): 3
% of Bed Active: \
Geomorphic Units (Table 22): \
Mass Movement (Table 23): \ \
Riffle-Pool Spacing (m): 5.7
% Riffles: \
% Pools: \

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

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

Bankfull Width (m)	2.4	1.4	1.9	**Wetted Width (m)**	0.39	0.48	0.47	
Bankfull Depth (m)	0.93	0.38	0.62	**Wetted Depth (m)**	0.06	0.05	0.04	
Undercuts (m)	0.3	0.23	0.48	0.43 0.43 **Velocity (m/s)**	0	0	0	0
Pool Depth (m)	0.13	0.09	0.18	**Velocity Estimate Method**	WB	WB	WB	
Riffle Length (m)	3.72	2.6	/	**Meander Amplitude (m)**	10.2	/	/	

Notes: Not flowing at this time lots of intermittent pools
Confined in valley
2 waterfall areas occurred.
Channel highly eroded w̄ lots of downed trees & slumps present

WW	0.18	1.15
BW	1.85	2.3
BD	0.44	0.48
WD	0.02	0.18

Photos:

Version #4
Last edited: 04/04/2023

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

Appendix E:
Detailed Geomorphological Assessment Summaries

Detailed Geomorphological Assessment Summary

Reach THRF-1

Project Number:	PN25027	**Date:**	2025-04-14
Client:	United Holdings Inc.	**Length Surveyed (m):**	237.7
Location:	Caledon	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	0.6 km^2	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	5d Till (clay to silt texture)	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest/Agriculture	**Width of Riparian Cover:**	>10m LB, >10m RB
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature (>30 years)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	0	**Density of Woody Debris:**	Moderate

Hydrology

Estimated Discharge (m^3/s):	--	**Estimated Bankfull Discharge (m^3/s):**	1.29
Modelled 2-year Discharge (m^3/s):	--	**Estimated Bankfull Velocity (m/s):**	1.50
Modelled 2-year Velocity (m/s):	--		

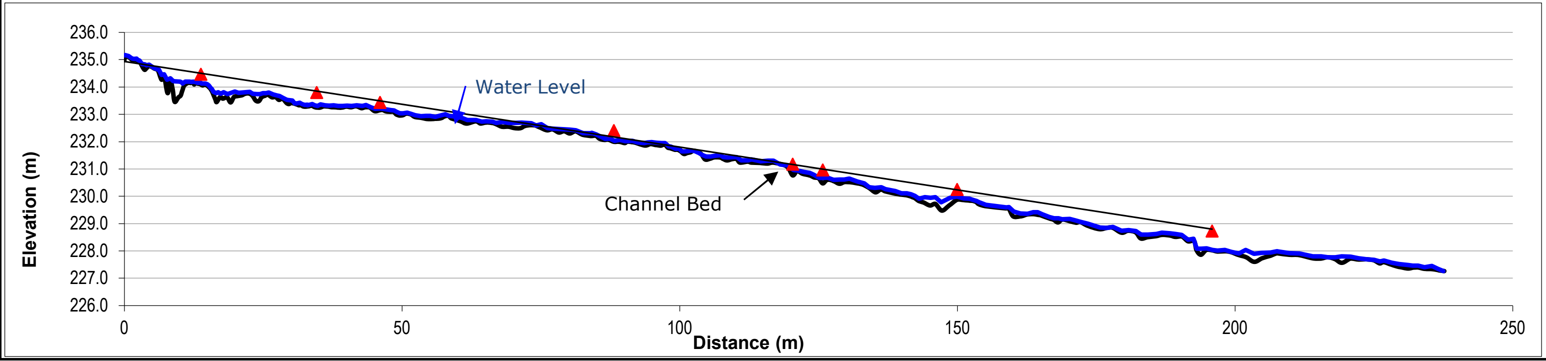
Profile Characteristics

Bankfull Gradient (%):	3.06
Channel Bed Gradient (%):	2.97
Riffle Gradient (%):	2.09
Riffle Length (m):	4.84
Riffle-Pool Spacing (m):	0.00

Planform Characteristics

Sinuosity:	1.23
Meander Belt Width (m):	--
Radius of Curvature (m):	--
Meander Amplitude (m):	--
Meander Wavelength (m):	--

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.26	1.76	1.29
Bank Angle (deg):	30	90	68
Root Depth (m):	0.16	1.58	0.87
Root Density (%):	0.05	0	0
Bank Undercut (m):	0.14	0.48	0.26

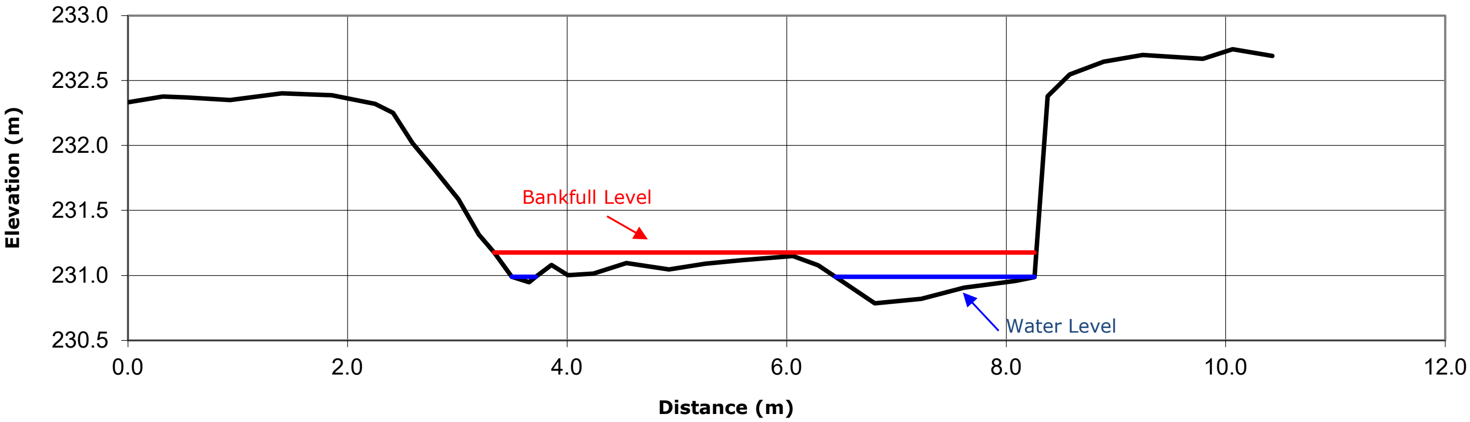
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	0	1	0.4
Bank Material (range):		Sand to Gravel	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.39	4.92	3.07
Average Bankfull Depth (m):	0.16	0.52	0.28
Bankfull Width/Depth (m/m):	5	30	13
Wetted Width (m):	0.36	4.76	1.54
Average Water Depth (m):	0.01	0.07	0.03
Wetted Width/Depth (m/m):	12	159	65
Entrenchment Ratio (m/m):	1.4 - 2.2 (Moderately Entrenched)		
Maximum Water Depth (m):	0.02	0.21	0.08
Manning's *n*:		0.050	

Photograph at cross section 4 (looking downstream)

Representative Cross-Section 4

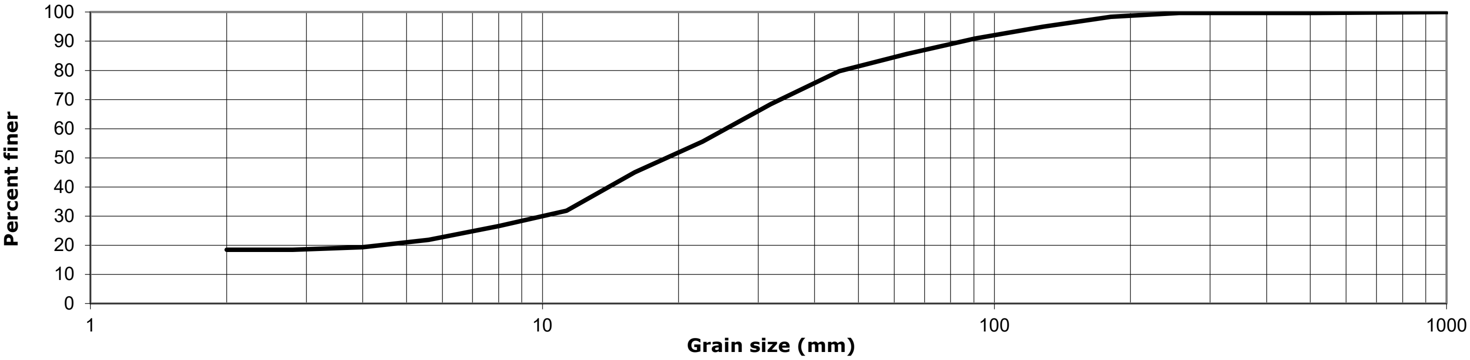


Substrate Characteristics

Particle Size (mm)	
D_{10} :	<0.2
D_{50} :	19.1
D_{84} :	58.9

Subpavement:	Till
Particle Shape:	Platy/Sub-Rounded
Embeddedness (%):	0
Particle Range (riffle):	Clay-Small Cobble
Particle Range (pool):	Clay-Small Cobble

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	83.90
for D_{50}:	0.77	**Tractive Force at 2-year flow (N/m^2):**	--
for D_{84}:	1.29	**Critical Shear Stress (D_{50}) (N/m^2):**	13.92
Unit Stream Power at Bankfull (W/m^2):	126		

General Field Observations

Channel Description

The subject reach was characterized by a channel with a low sinousity set within a confined, wooded valley. Agricultural fields bordered the forest on either side of the channel. Instream vegetation was predominantly absent for the full extent of the reach. Channel bed morphology was characterized by occasional riffle-pool sequences and had a moderate gradient. The channel exhibited evidence of systematic widening. Bank soil was additionally loose and exposed to flow, with bank erosion being visible throughout the reach. Flow in the channel was minimal, and was largely only observed in riffles. Bank substrate was primarily consisted of sand, silt, and clay materials, while bed substrate was defined by sand, gravel, cobble, and boulders. Notably, a rooted knickpoint was observed at the downstream extent of the reach.

Cross Section 3 - Facing Upstream

Detailed Geomorphological Assessment Summary

Reach THRF-2

Project Number:	PN24084	**Date:**	2024-11-29
Client:	Bolton North Hill Landowners Group	**Length Surveyed (m):**	113.5
Location:	Caledon	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	0.131 km^2	**Dominant Riparian Vegetation Type:**	Deciduous forest, shrubs
Geology/Soils:	Till (clay-silt textured clay)	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Agriculture	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	>30 years
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	0	**Density of Woody Debris:**	Moderate

Hydrology

Estimated Discharge (m^3/s):	--	**Estimated Bankfull Discharge (m^3/s):**	1.77
Modelled 2-year Discharge (m^3/s):	--	**Estimated Bankfull Velocity (m/s):**	2.33
Modelled 2-year Velocity (m/s):	--		

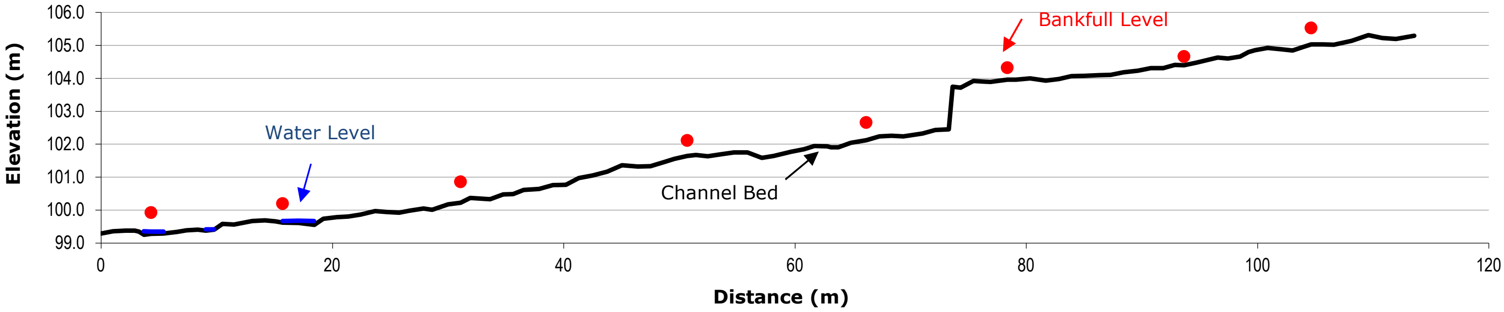
Profile Characteristics

Bankfull Gradient (%):	5.79
Channel Bed Gradient (%):	5.99
Riffle Gradient (%):	N/A
Riffle Length (m):	N/A
Riffle-Pool Spacing (m):	N/A

Planform Characteristics

Sinuosity:	1.20
Meander Belt Width (m):	--
Radius of Curvature (m):	--
Meander Amplitude (m):	--
Meander Wavelength (m):	--

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.40	2.50	1.10
Bank Angle (deg):	25	90	59
Root Depth (m):	0.15	1.00	0.35
Root Density (%):	5	25	13
Bank Undercut (m):	0.00	0.34	0.09

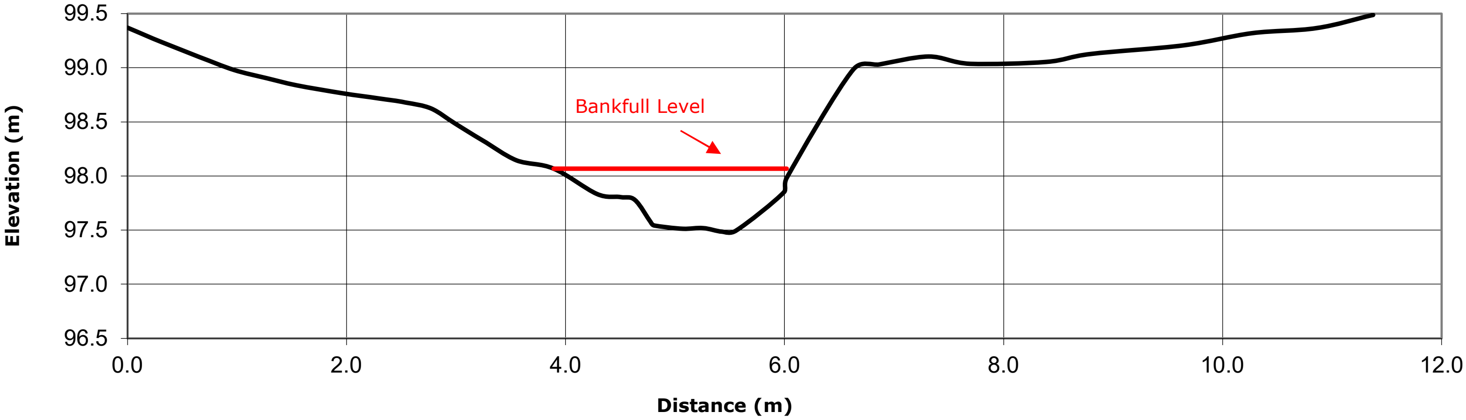
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):		Not measured - frozen banks	
Bank Material (range):		Clay/silt to cobble	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.49	3.22	2.26
Average Bankfull Depth (m):	0.25	0.46	0.34
Bankfull Width/Depth (m/m):	4	9	7
Wetted Width (m):		Mostly dry	
Average Water Depth (m):		Mostly dry	
Wetted Width/Depth (m/m):		Mostly dry	
Entrenchment Ratio (m/m):		>2.2 (Slight/Low Entrenchment)	
Maximum Water Depth (m):		Mostly dry	
Manning's *n*:		0.050	

Photograph at cross-section 2

Representative Cross-Section #2



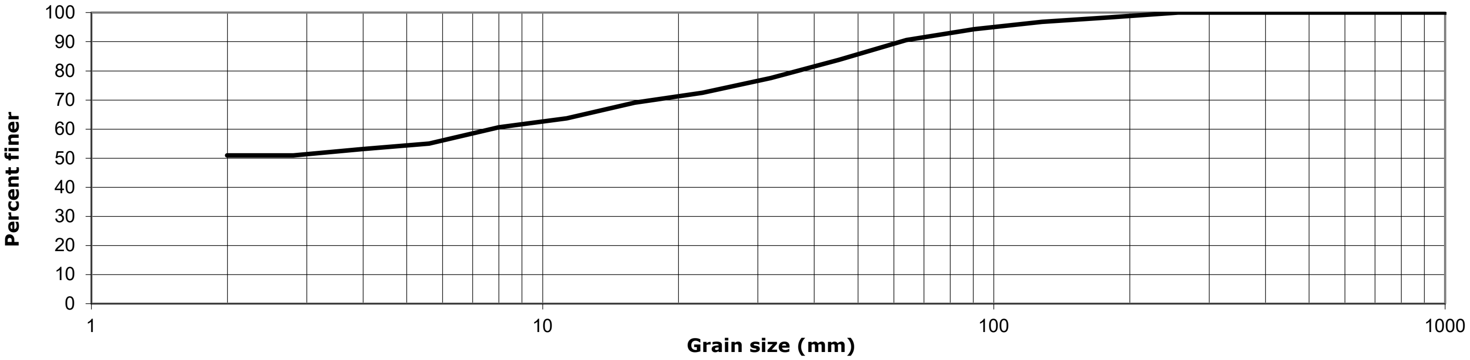
Substrate Characteristics

Particle Size (mm)

D_{10} :	2.0
D_{50} :	2.0
D_{84} :	46.0

Subpavement:	clay-silt textured till
Particle Shape:	Platy, sub-angular, angular, sub-rounded, rounded, well rounded
Embeddedness (%):	5-50
Particle Range (riffle):	<0.2 - 20.9 cm
Particle Range (pool):	<0.2 - 13 cm

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	191.27
for D_{50}:	--	**Tractive Force at 2-year flow (N/m^2):**	--
for D_{84}:	1.15	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	446		

General Field Observations

Channel Description

The subject reach was characterized by a sinuous channel set within an confined, forested valley. Dominant riparian vegetation consisted of deciduous trees and shrubs, which provided good cover over the channel. Channel bed morphology was characterized by runs near the upstream survey extent, and became dominated by riffles following a knickpoint, then pools at the furthest downstream extent. The channel exhibited evidence of systematic degradation with signs of recent knickpoint migration, and planform adjustment into the valley wall. Gullies on the banks were frequent. Channel banks were generally vegetated with young herbaceous plants and exposed to flow, with both young and old tree root exposure. The channel displayed multiple indicators associated with fair channel health. For example, instream woody debris would provide refuge and differences in bed morphology were observed, however the channel was dry at the time of the survey and channel degradation/erosion would result in poor water quality.

Representative channel conditions at the time of the survey

Detailed Geomorphological Assessment Summary

Reach: THRE-1-2

Project Number:	PN25026	**Date:**	2025-03-14
Client:	United Holdings Inc.	**Length Surveyed (m):**	95.1
Location:	Caledon	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	1.592 km2	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Clay to silt textured till	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Agricultural	**Width of Riparian Cover:**	1-4 on LB, >10 on RB
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Established (5-30 yrs)
Dominant Instream Vegetation Type:	Rooted Emergent	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	15	**Density of Woody Debris:**	Low

Hydrology

Estimated Discharge (m^3/s):	0.03	**Estimated Bankfull Discharge (m^3/s):**	1.51
Modelled 2-year Discharge (m^3/s):	0.12	**Estimated Bankfull Velocity (m/s):**	0.97
Modelled 2-year Velocity (m/s):	0.1		

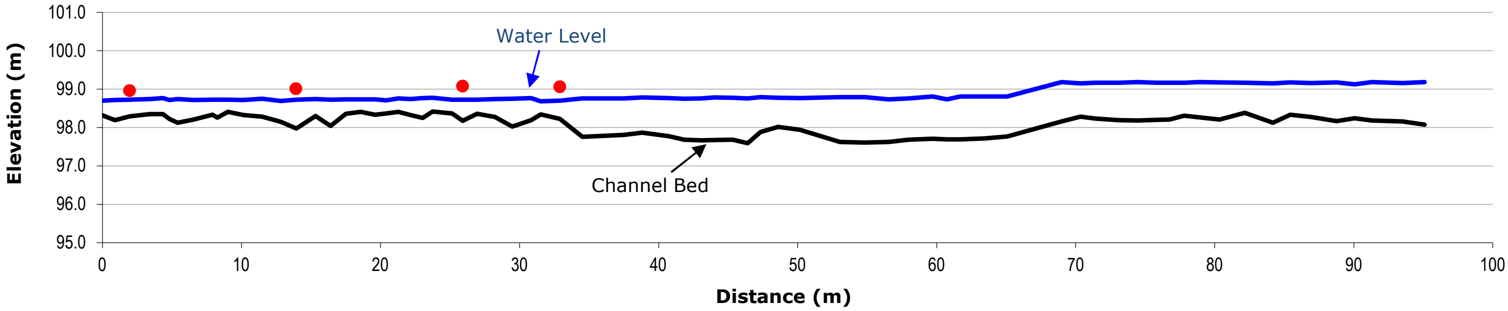
Profile Characteristics

Bankfull Gradient (%):	0.37
Channel Bed Gradient (%):	0.22
Riffle Gradient (%):	N/A - no riffles present
Riffle Length (m):	N/A - no riffles present
Riffle-Pool Spacing (m):	N/A - no riffles/pools present

Planform Characteristics

Sinuosity:	1.05
Meander Belt Width (m):	See Report
Radius of Curvature (m):	N/A - straight channel
Meander Amplitude (m):	N/A - straight channel
Meander Wavelength (m):	N/A - straight channel

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.44	2.15	1.24
Bank Angle (deg):	20	90	45
Root Depth (m):	0.20	3.00	0.53
Root Density (%):	0.2	30	15
Bank Undercut (m):	0.00	0.34	0.02

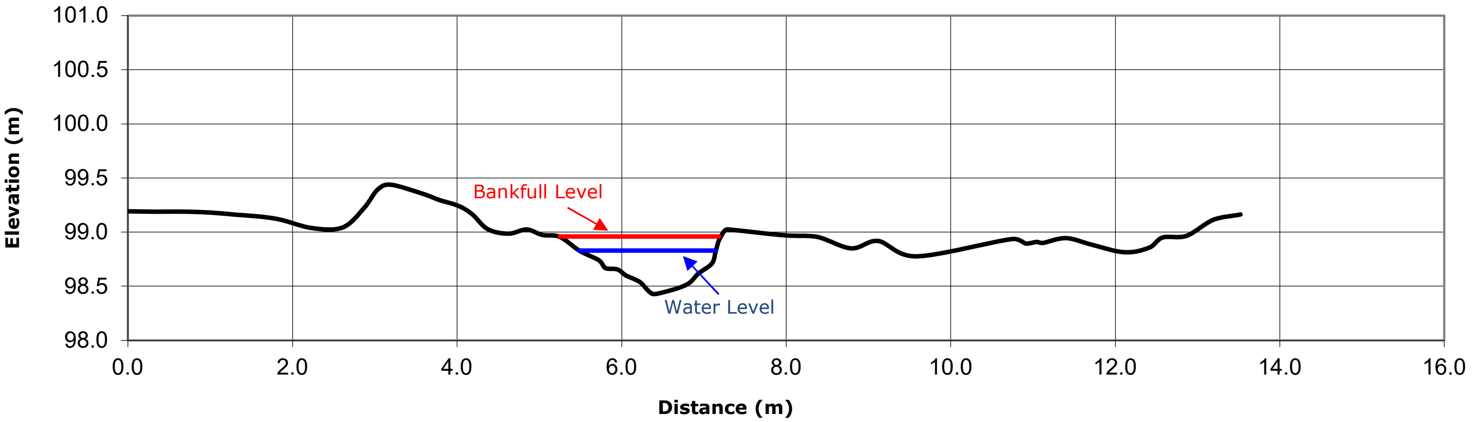
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	Did not measure - frozen banks		
Bank Material (range):	Silt to gravel		

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.94	4.67	3.66
Average Bankfull Depth (m):	0.29	0.65	0.42
Bankfull Width/Depth (m/m):	7	12	9
Wetted Width (m):	1.50	4.40	3.11
Average Water Depth (m):	0.21	0.65	0.39
Wetted Width/Depth (m/m):	6	11	8
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.40	1.09	0.72
Manning's *n*:		0.035	

Photograph at cross section 1 (looking upstream)

Representative Cross-Section 1



Substrate Characteristics

Particle Size (mm)

D_{10} :	< 2 mm
D_{50} :	< 2 mm
D_{84} :	< 2 mm

Subpavement: N/A

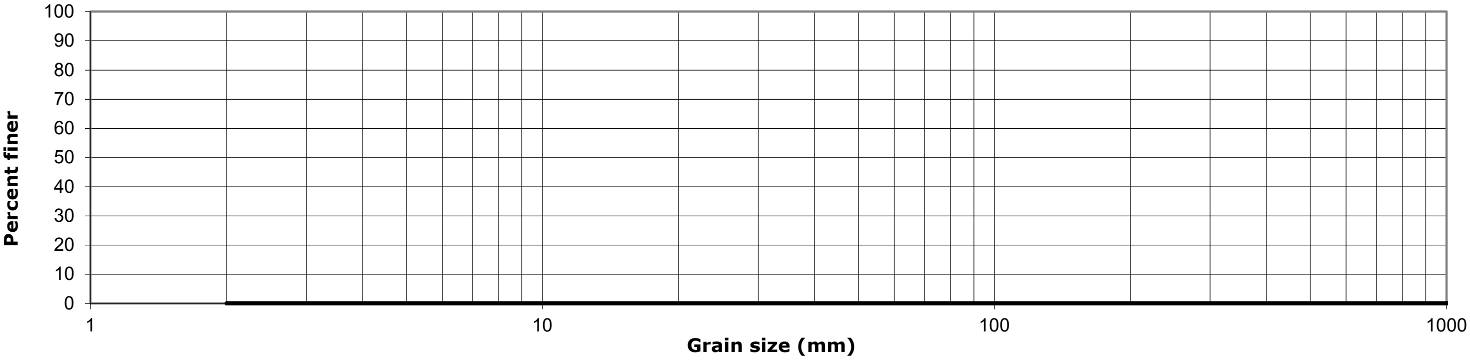
Particle Shape: N/A - fine-grained substrate

Embeddedness (%): N/A - fine-grained substrate

Particle Range (riffle): N/A - no riffles, fine-grained substrate

Particle Range (pool): N/A - no pools, fine grained substrate

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	15.18
for D_{50}:	---	**Tractive Force at 2-year flow (N/m^2):**	78.00
for D_{84}:	---	**Critical Shear Stress (D_{50}) (N/m^2):**	---
Unit Stream Power at Bankfull (W/m^2):	15		

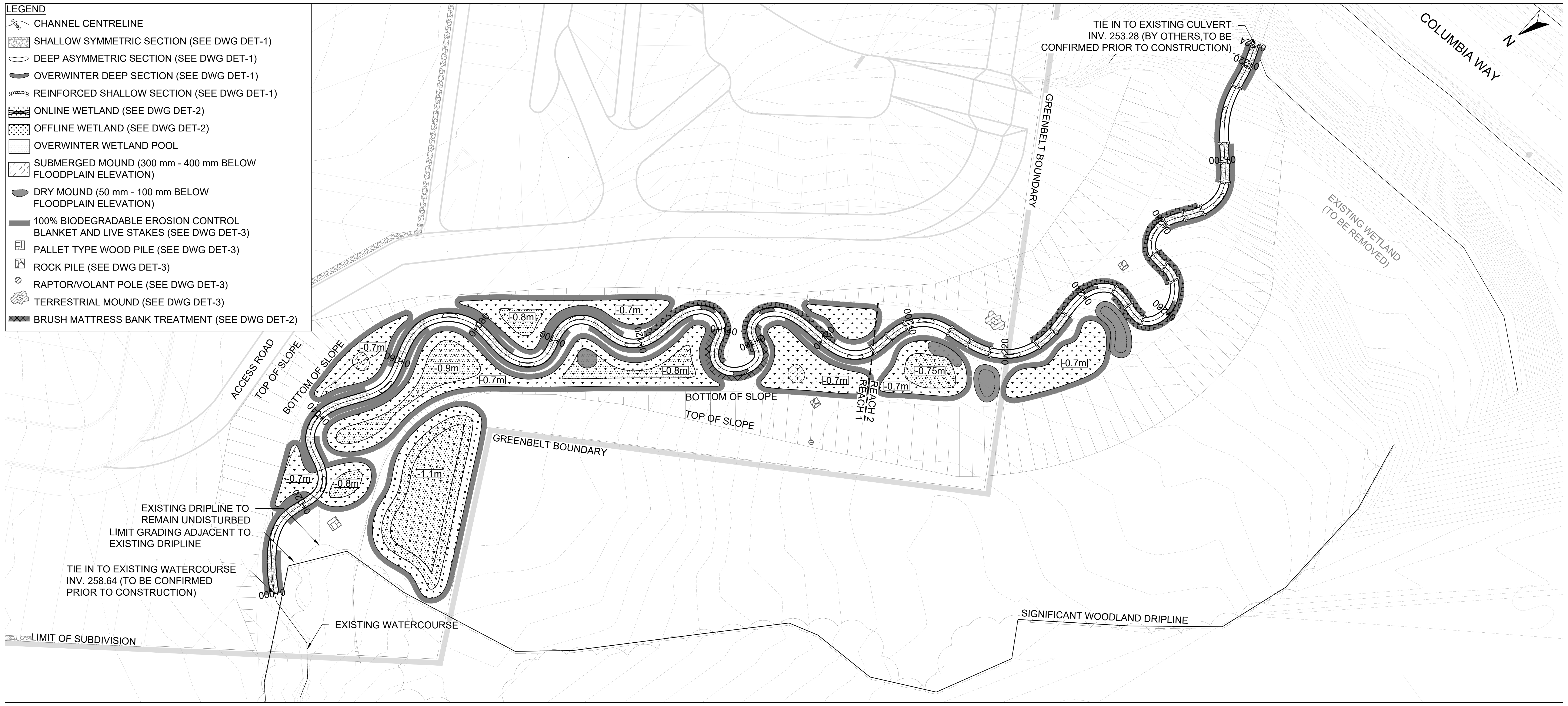
General Field Observations

Channel Description

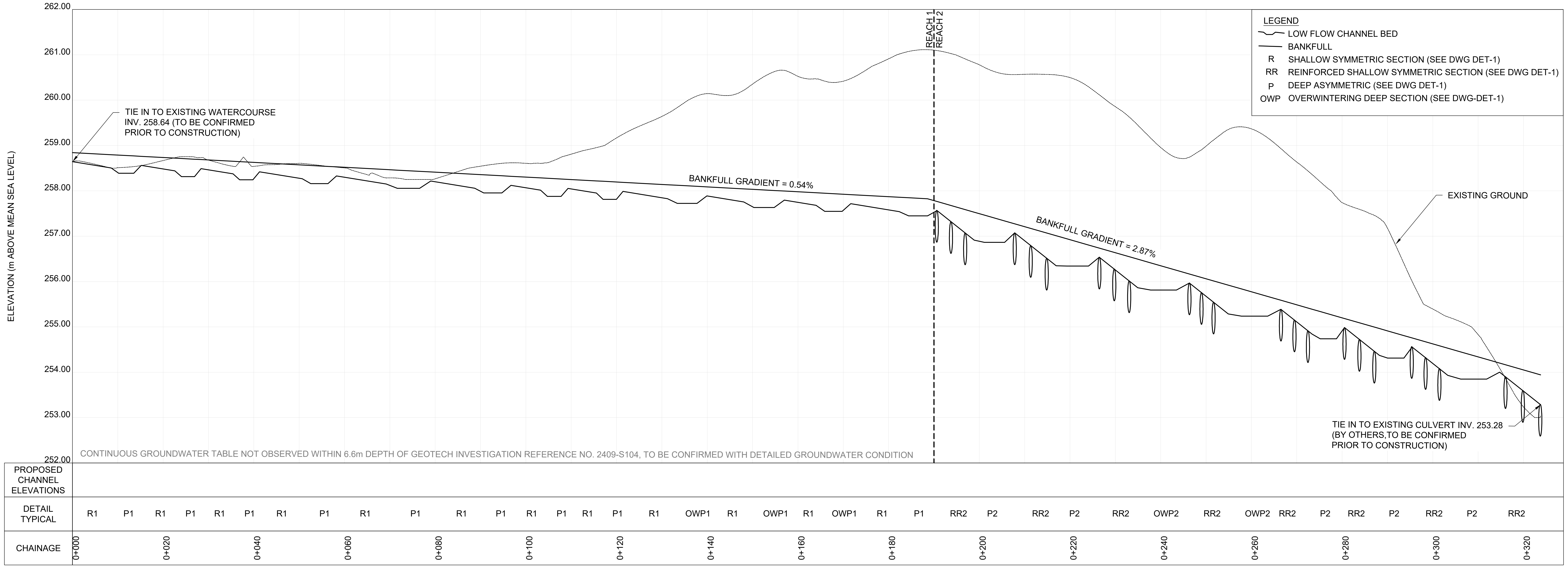
The subject reach was characterized by a generally straight channel set within an unconfined forested area between two agricultural fields. Dominant riparian vegetation consisted of trees and shrubs, which provided good cover over the channel. Instream vegetation covered approximately 15% of the channel, generally consisting of rooted emergent vegetation. Channel bed morphology was relatively planar, primarily dominated by one habitat type, and one depth and velocity condition. Generally, no flow was observed. The water level appeared high at the time of observation as inundated riparian vegetation was common. Bed substrate was primarily silt and clay, with organics. Woody debris was noted more frequently at the upstream extent. Bank angles generally ranged from 30 to 60 degrees and bank erosion was observed along less than 30% of the reach.

Cross Section 4 - Facing Downstream

Appendix F:
Conceptual Natural Corridor Design Drawings

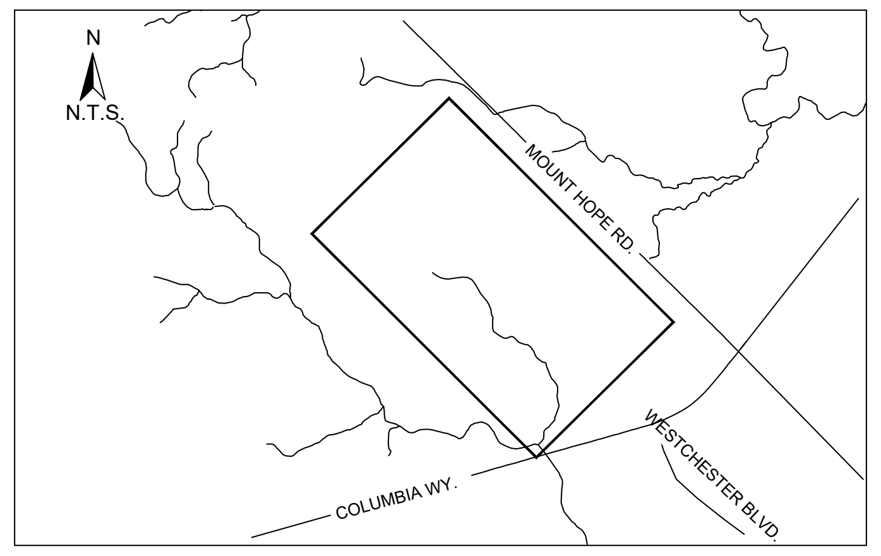


PLANFORM
1:500



PROFILE
H = 1:500; V=1:50

SCALED FOR PLOT ON 'ARCH D'



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

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3. THE WEATHER FORECAST SHOULD BE CONTINUALLY MONITORED TO ENSURE THAT WORKS ARE UNDERTAKEN ONLY DURING FAVOURABLE WEATHER CONDITIONS.
4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
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3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW.
5. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE. ALL DISTURBED GROUND LEFT INACTIVE FOR MORE THAN 30 DAYS SHALL BE STABILIZED USING APPROPRIATE EROSION CONTROL MEASURES AND AN APPROPRIATE SEED MIX AS NOTED WITHIN THE FINAL APPROVED RESTORATION PLAN.
6. ALL VEGETATION, ADJACENT TO THE WORK AREA, MUST BE PROTECTED AND DELINEATED WITH CONSTRUCTION FENCING OR TREE PROTECTION BARRIERS.
7. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.
8. AN AFTER-HOURS CONTACT NUMBER IS TO BE VISIBLY POSTED ONSITE FOR EMERGENCIES. ALL THE PLANS SHOULD HAVE NAME AND CONTACT INFO OF THE PERSON RESPONSIBLE FOR ESC MEASURES.

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3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
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7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.
8. THE PROJECT PROPONENT OR THEIR REPRESENTATIVE IS ULTIMATELY RESPONSIBLE FOR CONTROLLING SEDIMENT AND EROSION WITHIN THE CONSTRUCTION SITE FOR THE TOTAL PERIOD OF THE CONSTRUCTION.
9. IF EXCESSIVE SILTATION RESULTS FROM THE CONSTRUCTION ACTIVITIES, THE ONSITE SUPERVISOR/INSPECTOR AND/OR THE LOCAL REGULATORY BODY RESERVE THE RIGHT TO REQUEST ADDITIONAL ESC MEASURES WHICH WOULD BE INSTALLED PRIOR TO FURTHER CONSTRUCTION ACTIVITIES.

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1. PREVENT THE RELEASE OF SEDIMENT, SEDIMENT-LADEN WATER, RAW CONCRETE, CONCRETE LEACHATE OR ANY OTHER DELETERIOUS SUBSTANCES INTO ANY WATERBODY, RAVINE OR STORM SEWER SYSTEM.
2. ENSURE EQUIPMENT AND MACHINERY ARE IN GOOD OPERATING CONDITION (POWER WASHED), FREE OF LEAKS, EXCESS OIL, AND GREASE.
3. NO EQUIPMENT REFUELLING OR SERVICING SHOULD BE UNDERTAKEN WITHIN 30 m OF ANY WATERCOURSE OR SURFACE WATER DRAINAGE.
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3. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 m FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
4. FISH MUST BE REMOVED FROM THE WORK AREA ONCE ISOLATED. FISH SALVAGE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES.

	DATE	BY	REVISIONS

DESIGNED BY: LD
CHECKED BY: PV
DRAWN BY: SE
DATE: MAY 2025

DRAFT FOR INTERNAL DISCUSSION

NOT FOR CONSTRUCTION

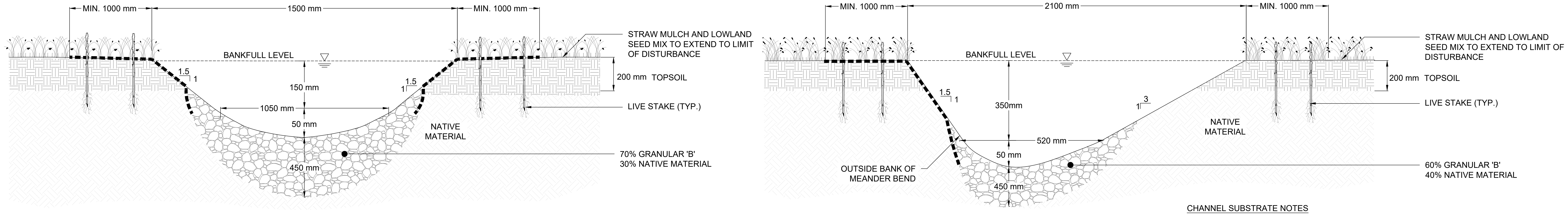
GEO
MORPHIX™
36 Main St N., P.O. Box 205
Campbellville, Ontario L0P 1B0

T: 416.920.0926
www.geomorphix.com

MOUNT HOPE WEST
HUMBER RIVER TRIBUTARIES
TOWN OF CALEDON

COLD CREEK
CONCEPTUAL CHANNEL DESIGN
PLANFORM AND PROFILE

PROJECT No.: PN25026
DRAWING No.: GEO-1
SCALE: AS NOTED
SHEET 1 OF 4



TYPICAL SHALLOW SYMMETRIC SECTION

TYPICAL DEEP ASYMMETRIC SECTION

CHANNEL CROSS SECTIONS - REACH 1

N.T.S.

CHANNEL SUBSTRATE NOTES

1. SUBSTRATES TO BE COMPACTED TO 90% SPD TO PREVENT PIPING/FLOW-THROUGH.
2. FINE NATIVE MATERIAL TO BE ADDED TO SUBSTRATE MIX TO FILL INTERSTITIAL VOIDS, AS REQUIRED.
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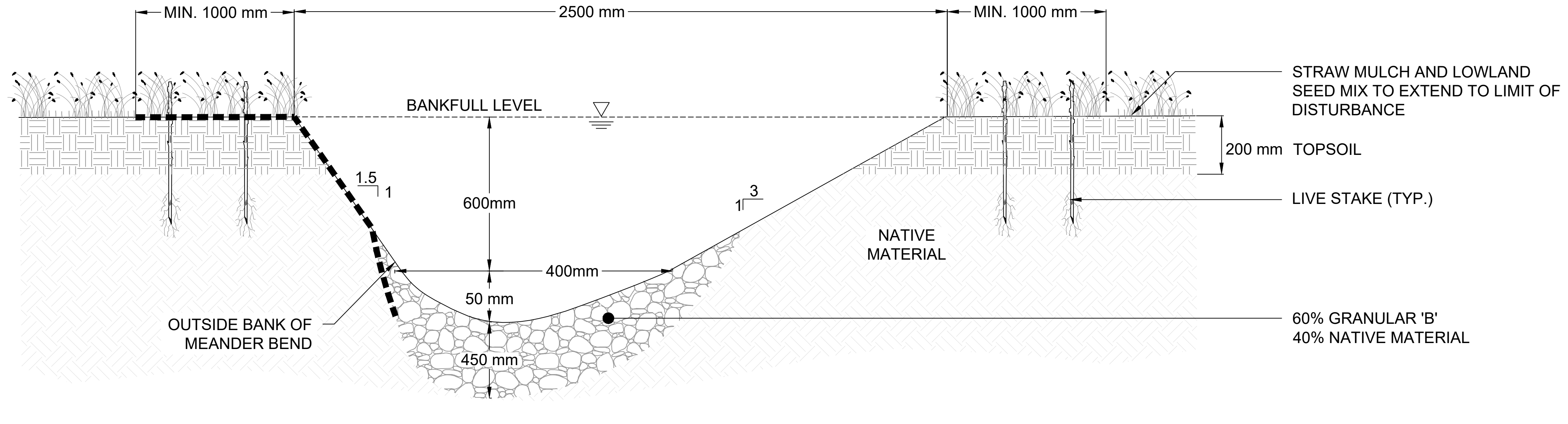
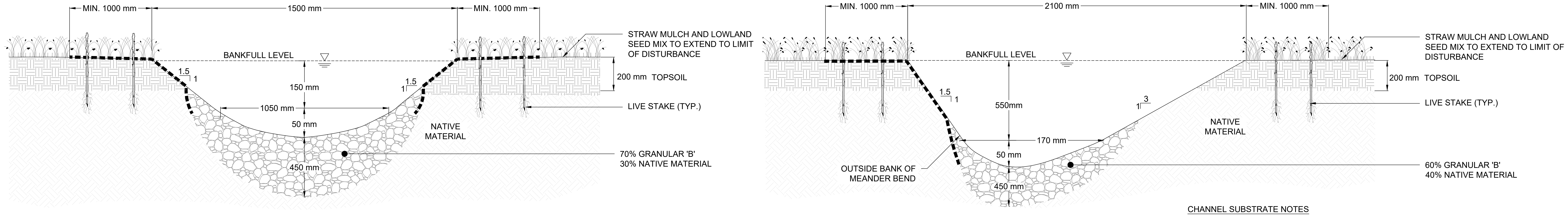


OVERWINTERING DEEP SECTION - REACH 1

N.T.S.



TYPICAL SHALLOW SYMMETRIC SECTION

TYPICAL DEEP ASYMMETRIC SECTION

CHANNEL CROSS SECTIONS - REACH 2

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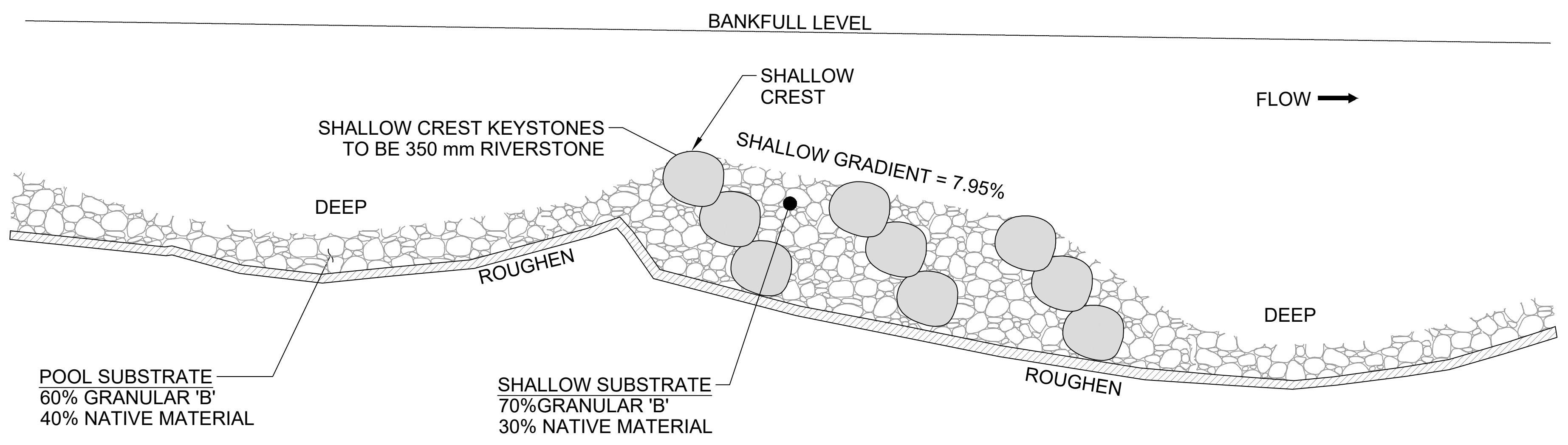
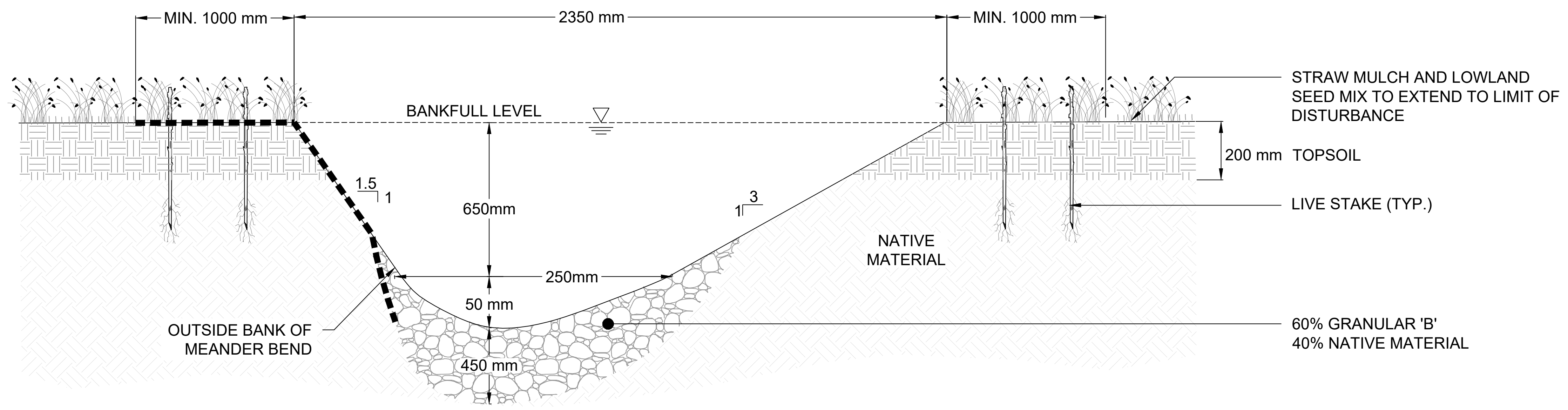


TYPICAL SHALLOW-DEEP SEQUENCE - REACH 2

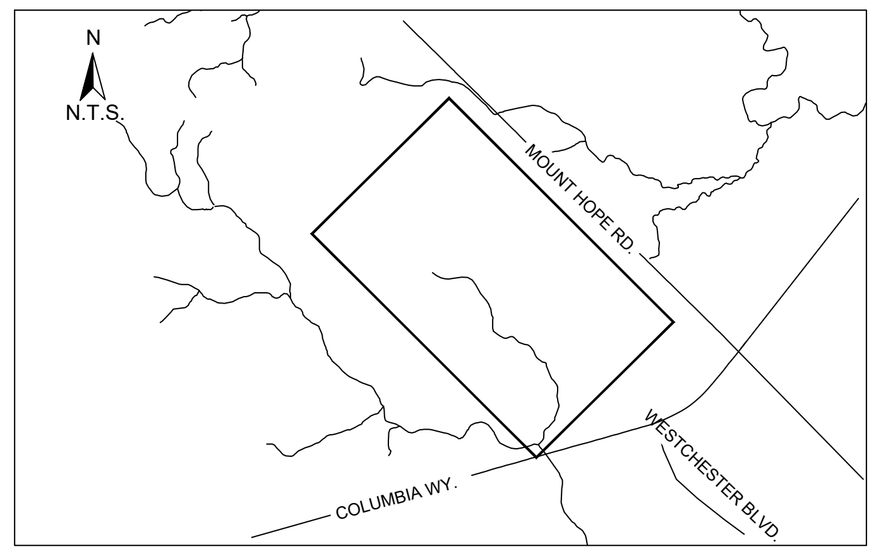
N.T.S.



OVERWINTERING DEEP SECTION - REACH 2

N.T.S.

SCALED FOR PLOT ON 'ARCH D'



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4. FISH MUST BE REMOVED FROM THE WORK AREA ONCE ISOLATED. FISH SALVAGE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES.

	DATE	BY	REVISIONS

DESIGNED BY: LD
CHECKED BY: PV
DRAWN BY: SE
DATE: MAY 2025

DRAFT FOR INTERNAL DISCUSSION

NOT FOR CONSTRUCTION

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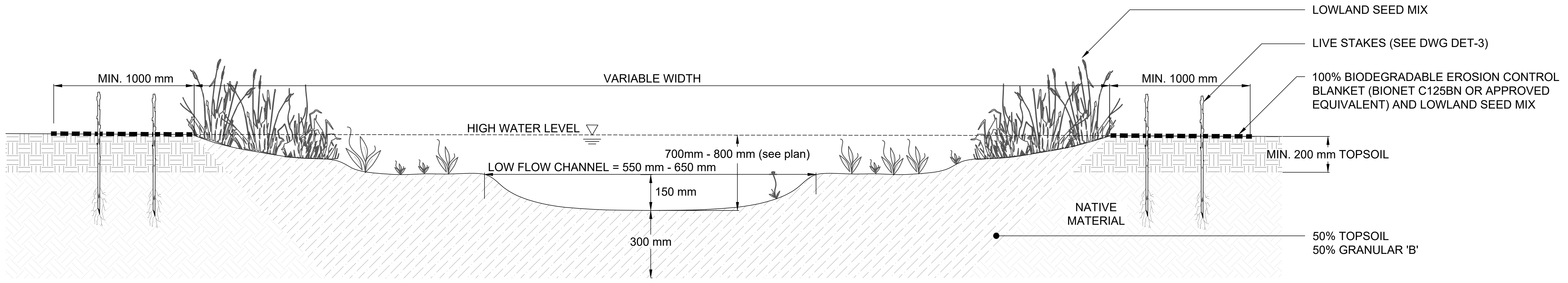
MOUNT HOPE WEST
HUMBER RIVER TRIBUTARIES
TOWN OF CALEDON

COLD CREEK
CONCEPTUAL CHANNEL DESIGN
CHANNEL DETAILS

PROJECT No.: PN25026
DRAWING No.: DET-1
SCALE: AS NOTED
SHEET 2 OF 4

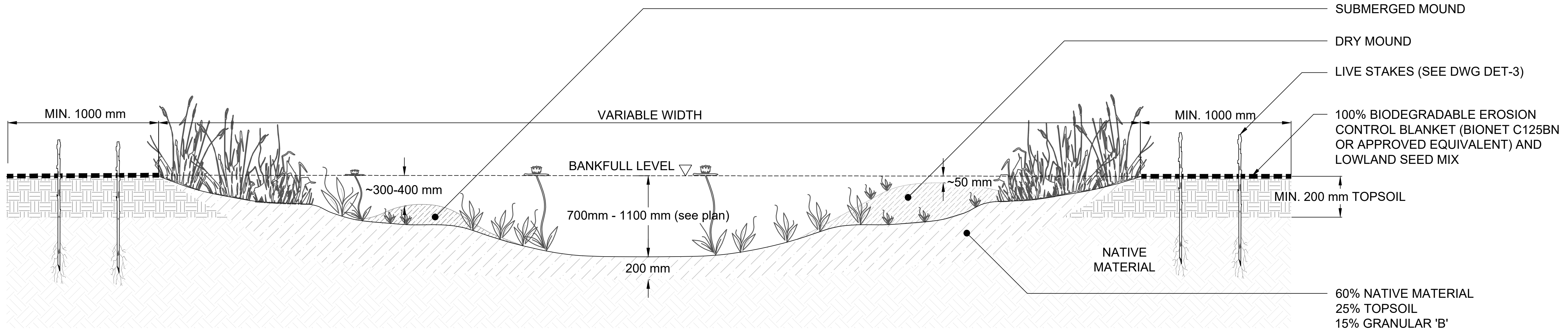


NOTES

1. SUBSTRATES TO BE COMPACTED TO 90% SPD TO PREVENT PIPING/FLOW-THROUGH.
2. FINE NATIVE MATERIAL TO BE ADDED TO SUBSTRATE MIX TO FILL INTERSTITIAL VOIDS, AS REQUIRED.
3. GRANULAR 'B' TO BE SOURCED FROM PIT-RUN MATERIAL AND ROUNDED IN NATURE. NO CRUSHED ROCK, LIMESTONE OR POST-CONSTRUCTION MATERIALS ARE TO BE USED WITHIN THE CHANNEL. MATERIAL TO BE REVIEWED BY THE DESIGNER OR REPRESENTATIVE PRIOR TO INSTALLATION.
4. SEED IS TO BE PLACED PRIOR TO THE INSTALLATION OF EROSION CONTROL BLANKET. SEED DWG DET-1 FOR SEED MIX SPECIFICATIONS.

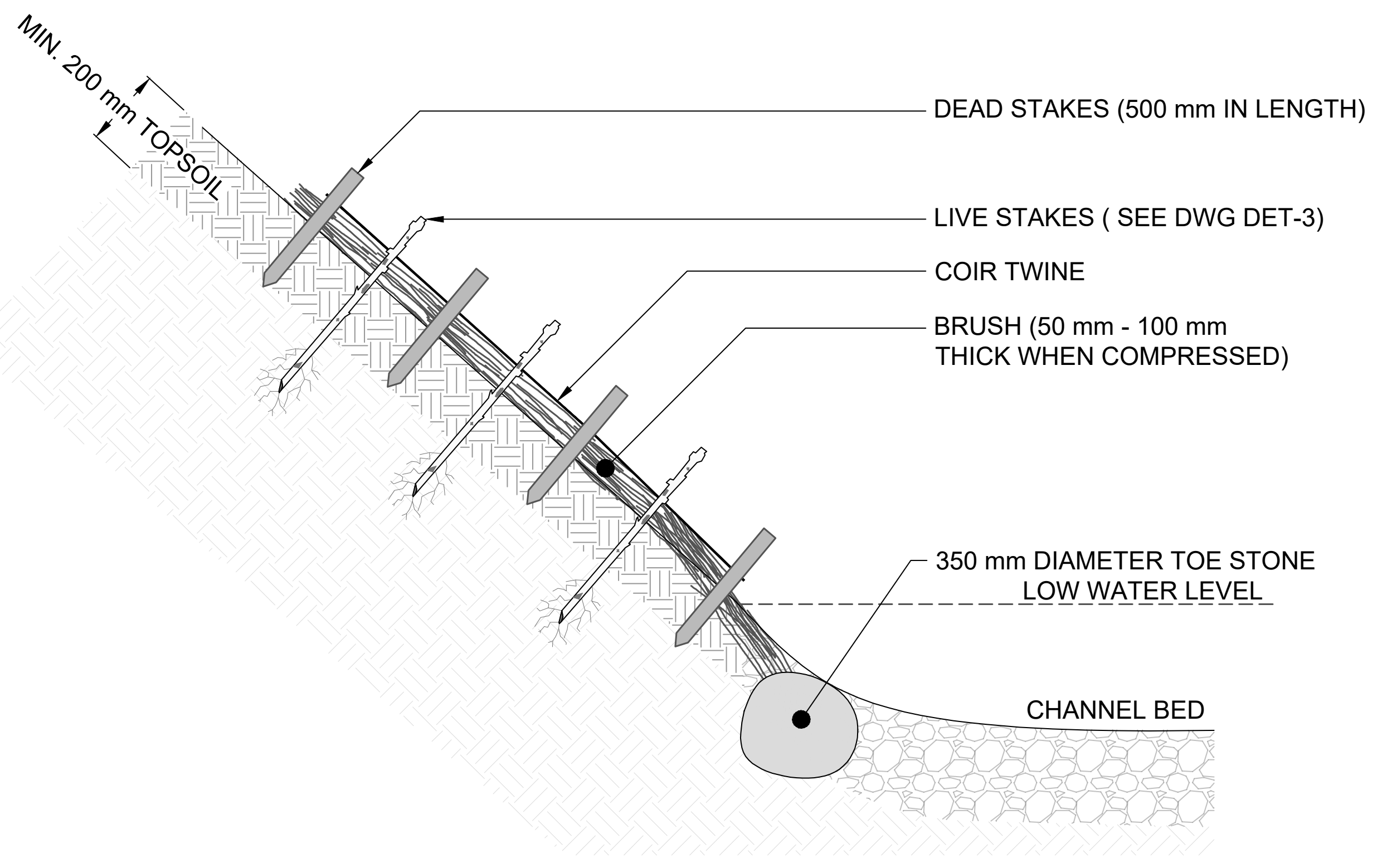
ONLINE WETLAND CROSS SECTION

N.T.S.

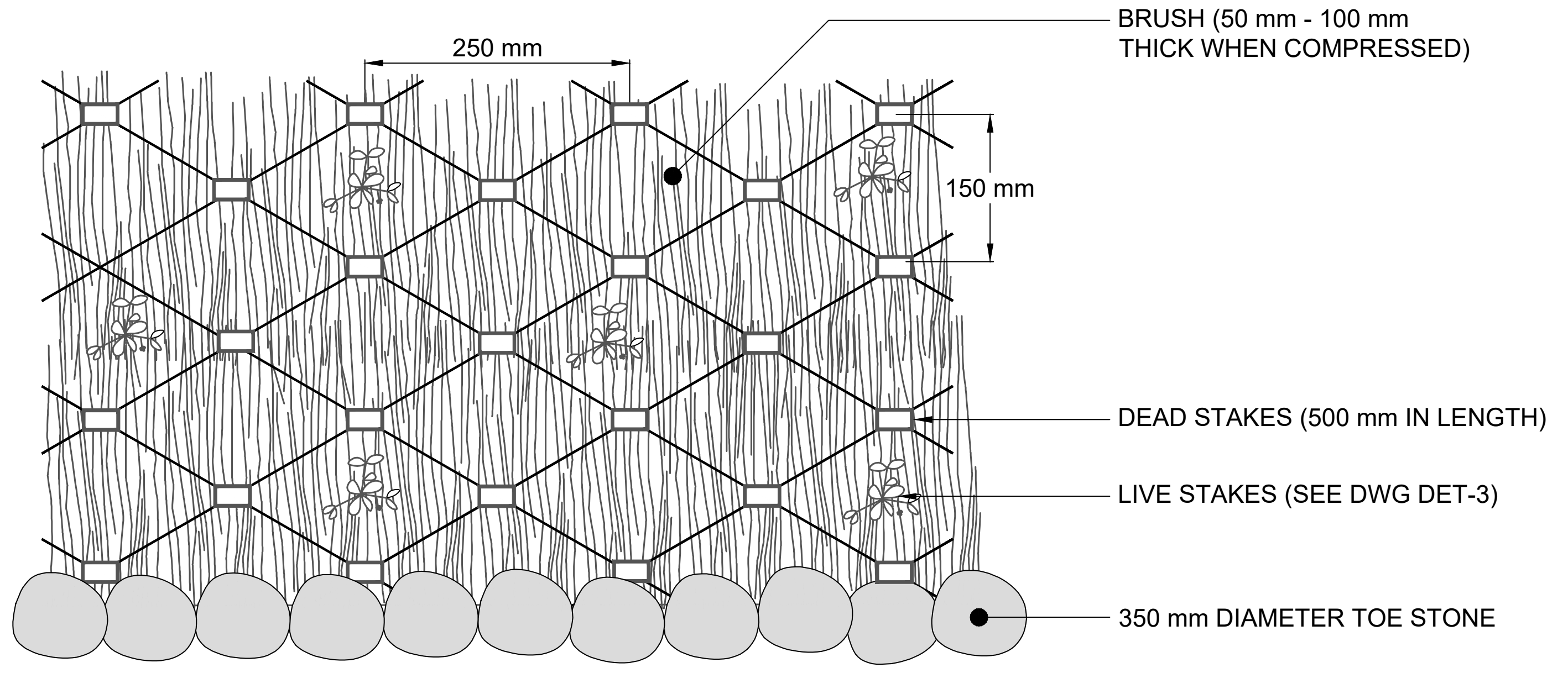


OFFLINE WETLAND CROSS SECTION

N.T.S.



CROSS SECTION



PLAN

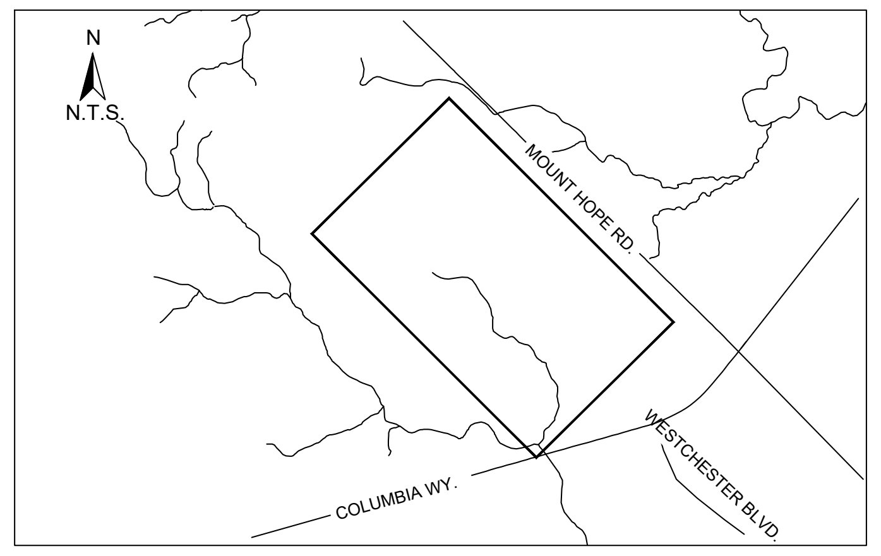
NOTES

1. LIVE BRANCHES TO CONSIST OF WILLOW AND DOGWOOD SPECIES, APPROXIMATELY 1 m IN LENGTH AND 50 mm - 100 mm IN WIDTH.
2. BRANCHES TO BE KEPT IN MOIST AND COLD CONDITION UNTIL INSTALLATION.
3. BRUSH MATTRESS TO BE INSTALLED WHILE BRANCHES ARE DORMANT.
4. BRANCHES TO BE PLACED ON SLOPE WITH BUTT END TOWARDS VALLEY FLOOR AND PUSHED INTO SOIL.
5. BRANCHES MUST BE FLEXIBLE ENOUGH TO CONFORM TO THE SLOPE SURFACE IRREGULARITIES.
6. POUND DEAD STAKES TO HALF THEIR LENGTH INTO SOIL BETWEEN BRANCHES. TIE COIR TWINE AROUND DEAD STAKES AND TIGHTLY OVER BRANCHES. USE A CLOVE HITCH TO SECURE STAKES. POUND STAKES INTO SLOPE TO COMPRESS BRANCHES AGAINST GROUND.
7. TAMP LIVE STAKES BETWEEN DEAD STAKES.
8. FILL VOIDS BETWEEN BRANCHES OF THE BRUSH MATTRESS WITH SOIL TO PROMOTE ROOTING.

BRUSH MATTRESS

N.T.S.

SCALED FOR PLOT ON 'ARCH D'



KEY MAP

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2. ALL CONTRACT DRAWINGS, SPECIFICATIONS AND APPLICABLE PERMITS MUST BE KEPT ON SITE DURING CONSTRUCTION FOR REFERENCE.
3. THE CONTRACTOR MUST NOTIFY THE DESIGNER AND CONTRACT ADMINISTRATOR OF THE INTENT TO COMMENCE WORK AT LEAST 48 HOURS IN ADVANCE.
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5. LAYOUT MUST BE REVIEWED AND APPROVED BY THE DESIGNER / DESIGNER REPRESENTATIVE, DESIGNATED ENGINEER, AND THE CONTRACT ADMINISTRATOR.
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TIMING OF WORKS

1. WORKS SHALL BE COMPLETED DURING THE DESIGNATED IN-WATER WORKS WINDOW SET OUT BY MNR/DFO.
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4. COMPLETE THE WORKS WITH MINIMAL AVOIDABLE INTERRUPTIONS ONCE THEY COMMENCE.

SITE AND MATERIAL MANAGEMENT

1. ALL CONSTRUCTION EQUIPMENT AND MATERIALS (IMPORTED OR EXCAVATED) MUST BE STORED AT LEAST 30 m AWAY FROM ANY WATERBODY IN A STABLE AREA ABOVE THE ACTIVE FLOODPLAIN, OR IN A DESIGNATED STAGING/STORAGE AREA.
2. IN THE EVENT OF AN UNEXPECTED STORM, ALL UNFIXED ITEMS THAT HAVE THE POTENTIAL TO CAUSE A SPILL OR AN OBSTRUCTION TO FLOW MUST BE MOVED A STABLE AREA ABOVE ACTIVE FLOODPLAIN.
3. STOCKPILES MUST BE LOCATED OUTSIDE THE ISOLATED WORK AREAS.
4. STABILIZE, TEMPORARILY OR PERMANENTLY, ANY DISTURBED AREAS AS WORK PROGRESSES, OR SOON AS CONDITIONS ALLOW.
5. MINIMIZE THE AREA OF DISTURBANCE TO THE EXTENT POSSIBLE. ALL DISTURBED GROUND LEFT INACTIVE FOR MORE THAN 30 DAYS SHALL BE STABILIZED USING APPROPRIATE EROSION CONTROL MEASURES AND AN APPROPRIATE SEED MIX AS NOTED WITHIN THE FINAL APPROVED RESTORATION PLAN.
6. ALL VEGETATION, ADJACENT TO THE WORK AREA, MUST BE PROTECTED AND DELINEATED WITH CONSTRUCTION FENCING OR TREE PROTECTION BARRIERS.
7. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.
8. AN AFTER-HOURS CONTACT NUMBER IS TO BE VISIBLY POSTED ONSITE FOR EMERGENCIES. ALL THE PLANS SHOULD HAVE NAME AND CONTACT INFO OF THE PERSON RESPONSIBLE FOR ESC MEASURES.

EROSION AND SEDIMENT CONTROL

1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
2. FOLLOWING INSTALLATION OF THE PROPOSED ESC MEASURES, A QUALIFIED AGENT OF THE PROPONENT (E.G. CAN-CISEC CERTIFIED MONITOR) WILL CONDUCT REGULAR SITE VISITS TO MONITOR ALL WORKS, PARTICULARLY THE CONDITION OF THE ESC MEASURES, DEWATERING, AND IN- OR NEAR-WATER WORKS. SHOULD CONCERNS ARISE; THE ENVIRONMENTAL MONITOR WILL CONTACT THE PROPONENT, THE CONSERVATION AUTHORITY, AND ANY OTHER APPROPRIATE PARTIES.
3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
5. ANY CHANGES TO THE EROSION AND SEDIMENT CONTROL PLAN BEYOND MINOR ADJUSTMENTS MUST BE APPROVED BY THE CONTRACT ADMINISTRATOR.
6. ADDITIONAL EROSION AND SEDIMENT CONTROL SUPPLIES MUST BE KEPT ON SITE IN ORDER TO FACILITATE IMMEDIATE REPAIRS AND/OR UPGRADES AS NEEDED.
7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.
8. THE PROJECT PROPONENT OR THEIR REPRESENTATIVE IS ULTIMATELY RESPONSIBLE FOR CONTROLLING SEDIMENT AND EROSION WITHIN THE CONSTRUCTION SITE FOR THE TOTAL PERIOD OF THE CONSTRUCTION.
9. IF EXCESSIVE SILTATION RESULTS FROM THE CONSTRUCTION ACTIVITIES, THE ONSITE SUPERVISOR/INSPECTOR AND/OR THE LOCAL REGULATORY BODY RESERVE THE RIGHT TO REQUEST ADDITIONAL ESC MEASURES WHICH WOULD BE INSTALLED PRIOR TO FURTHER CONSTRUCTION ACTIVITIES.

DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

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

WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. CROSSING AN ACTIVE WATERCOURSE OR WETLAND BY EQUIPMENT, VEHICLES, PERSONNEL, ETC. IS NOT PERMITTED UNLESS APPROVED BY THE CONSERVATION AUTHORITY. ALL ACCESS TO WORK SITES SHALL BE FROM EITHER SIDES OF THE WATERCOURSE OR WETLAND.
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	DATE	BY	REVISIONS

DESIGNED BY: LD
CHECKED BY: PV
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DATE: MAY 2025

DRAFT FOR INTERNAL DISCUSSION

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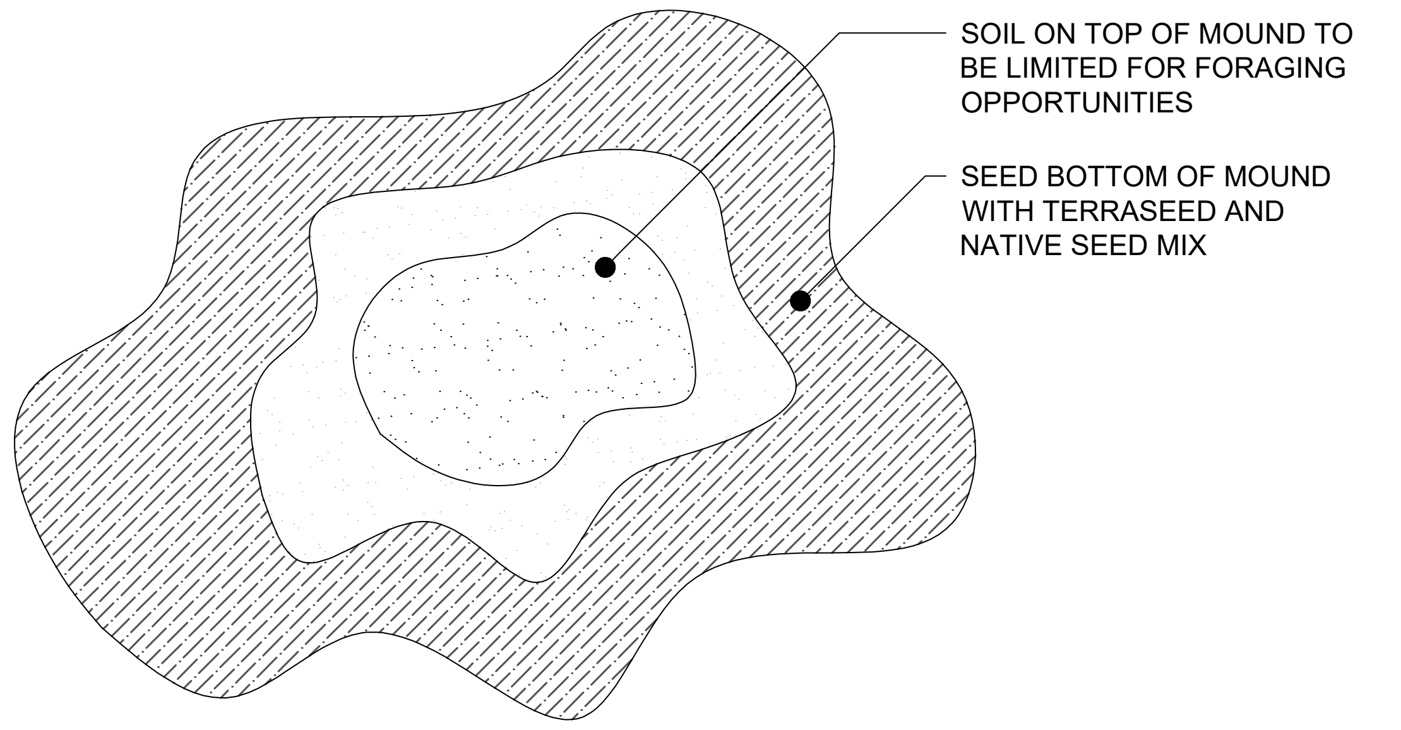
MOUNT HOPE WEST
HUMBER RIVER TRIBUTARIES
TOWN OF CALEDON

COLD CREEK
CONCEPTUAL CHANNEL DESIGN
WETLAND AND BANK TREATMENT DETAILS

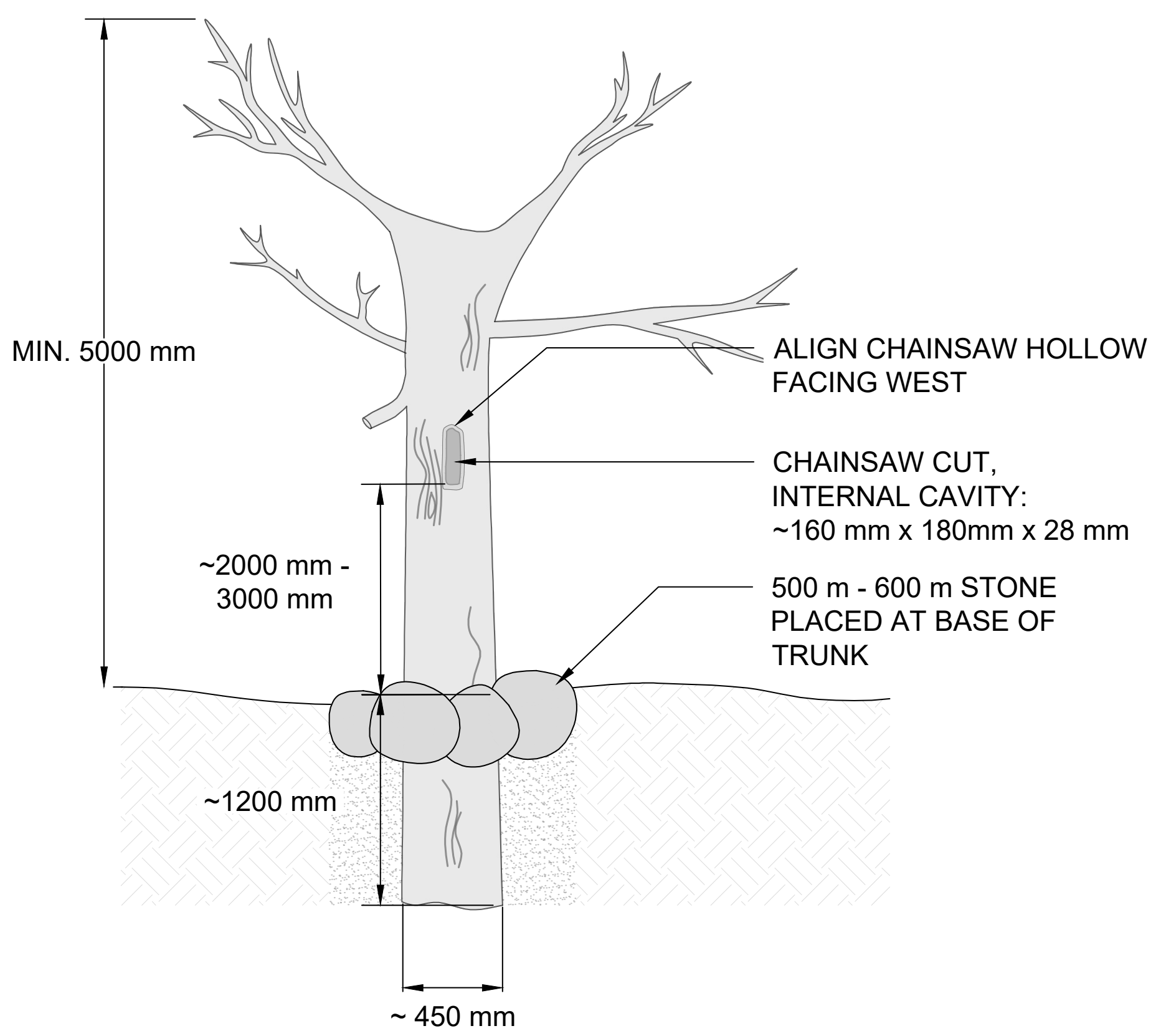
PROJECT No.: PN25026
DRAWING No.: DET-2
SCALE: AS NOTED
SHEET 3 OF 4



NOTES
1. HEIGHT OF TERRESTRIAL MOUND SHALL BE 500 mm TO 1000 mm.
2. LOCATION OF VEGETATED TERRESTRIAL MOUND IS TO BE DETERMINED BY THE DESIGNER IN FIELD, IN DRY AREAS ONLY.
3. CONSTRUCTION OF MOUND TO BE COMPLETED IN CONJUNCTION WITH VERNAL POOL EXCAVATION.
4. TERRESTRIAL MOUNDS TO BE GRADED TO MATCH EXISTING GROUND AND/OR TIE INTO EXISTING SLOPES.
5. TERRESTRIAL MOUND TO BE SLIGHTLY CONCAVE/DIMPLED ON TOP.
6. TERRESTRIAL MOUND TO BE SEEDED AND COVERED WITH 100% BIODEGRADABLE EROSION CONTROL BLANKET (BioNET C125BN OR APPROVED EQUIVALENT) IMMEDIATELY FOLLOWING SHAPING. EROSION CONTROL BLANKET TO BE SECURED WITH WOOD STAKES.
7. SEED MIX TO BE COMPRISED OF WOODLAND SPECIES. SEE DET-1 DRAWINGS FOR SEED MIX SPECIFICATIONS.

TERRESTRIAL MOUND

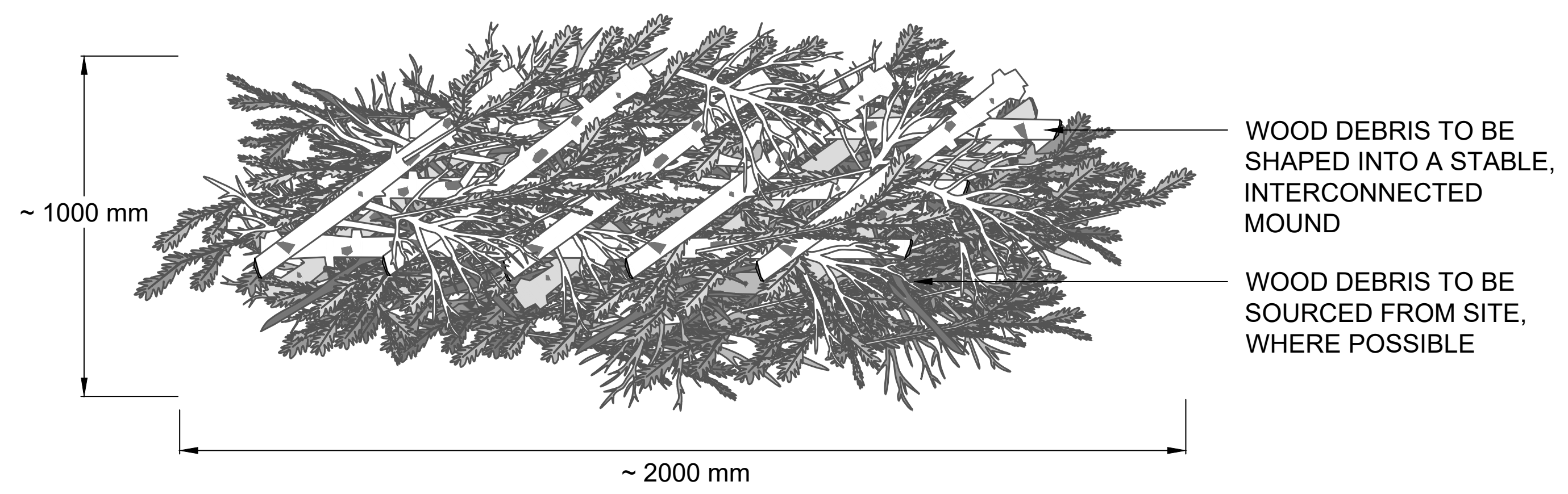
N.T.S



NOTES
1. CONSTRUCT WITH MATURE CONIFER TRUNKS WITH TWO OR MORE NATURAL BRANCHES.
2. AT LEAST 75% OF THE BARK SHOULD BE INTACT.
3. AUGER HOLE TO A DEPTH OF ~1000 m INSTALL TRUNK AND TAMP IN SAND AROUND BASE.
4. ~1000 m OF TRUNK IS TO BE BURIED.
5. PLACE 500 m - 600 m STONE AROUND BASE FOR ADDITIONAL SUPPORT. ~ 90% OF STONE TO BE BURIED.
6. IF ROOT WAD IS USED PLACE ROOT AT TOP.
7. LOGS SHOULD BE SOURCED ON SITE (WHERE POSSIBLE).

RAPTOR/VOLANT POLE

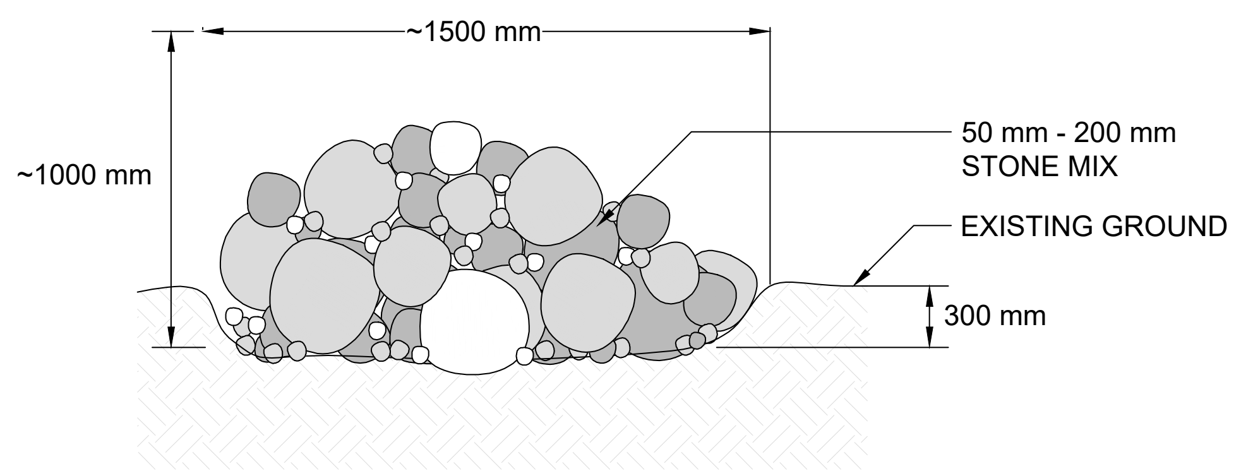
N.T.S.



NOTES
1. LARGEST AND HEAVIEST LOG MATERIAL SHOULD BE PLACED ON THE BASE OF THE BRUSH PILE. THE SMALLEST BRUSH MATERIAL SHOULD BE PLACED AT THE TOP.
2. LOGS SHOULD BE FORMED INTO A PALLET SHAPE.
3. HEIGHT OF BRUSH PILE IS NOT TO EXCEED 1000 mm.
4. A MIX OF HARDWOOD AND SOFTWOOD SHOULD BE USED.
5. PLANT WITH NATIVE FRUIT BEARING VINES.

PALLET TYPE WOOD PILE

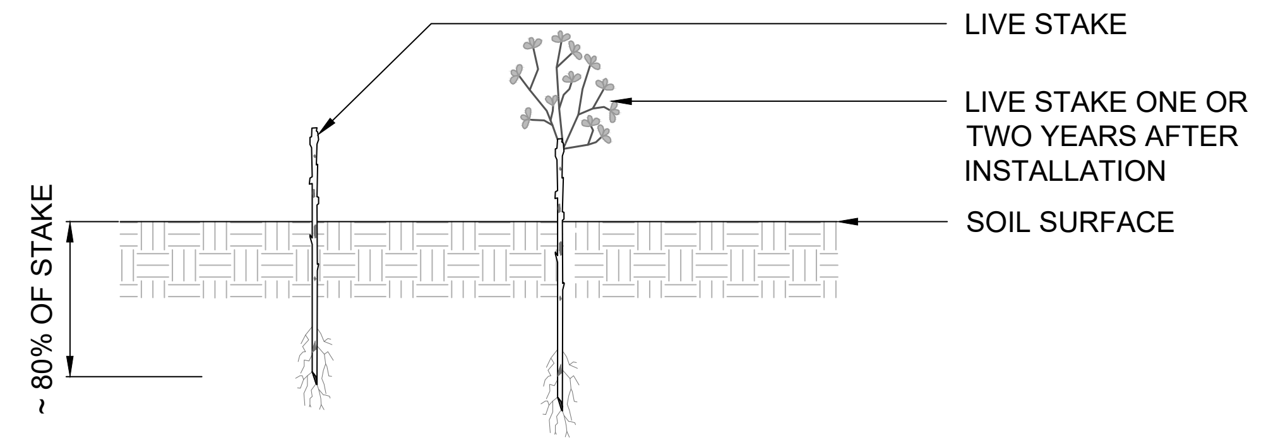
N.T.S



NOTES
1. 50 mm - 200 mm STONE MIX WITH SOME ANGULAR STONES.
2. THE STONE MIX SHOULD PROVIDE A VARIETY OF INTERSTITIAL SPACES.
3. PILES ARE AT LEAST 1500 mm IN DIAMETER AND ~1000 mm HIGH.
4. EMBED ROCK PILE 300 mm TO AVOID ROCKFALL.

ROCK PILE

N.T.S.



SCIENTIFIC NAME	COMMON NAME	QTY	CONDITION
CORNUS STOLONIFERA	RED OSIER DOGWOOD	875	1 m, LIVE STAKE
SALIX BEBBIANA	BEBB'S WILLOW	875	1 m, LIVE STAKE
SALIX DISCOLOR	PUSSY WILLOW	875	1 m, LIVE STAKE
SALIX INTERIOR	SANDBAR WILLOW	875	1 m, LIVE STAKE
SALIX LUCIDA	SHINING WILLOW	875	1 m, LIVE STAKE

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

LIVE STAKING

N.T.S.

CVC 2 – LOWLAND MIX

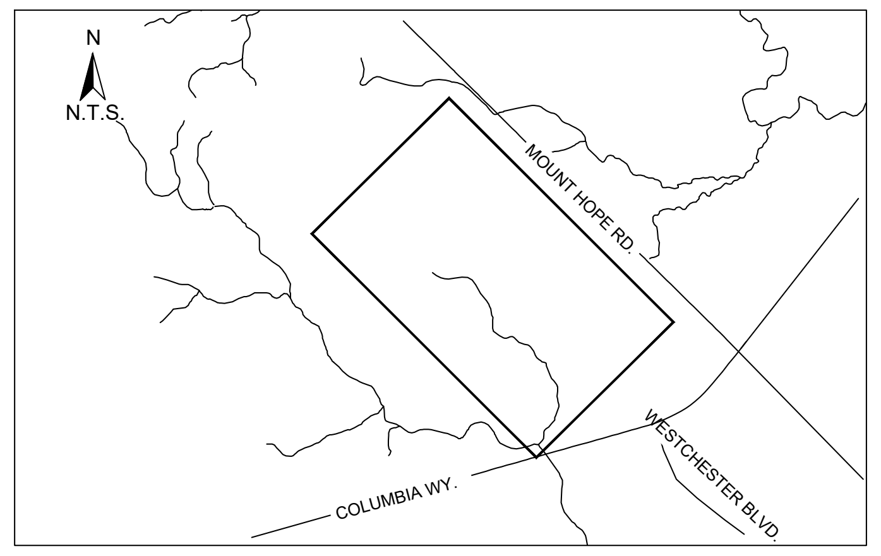
SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
CAREX VULPINOIDEA	FOX SEDGE	25
ELYMUS VIRGINICUS VAR. VIRGINICUS	VIRGINIA WILD RYE	35
JUNCUS TENUIS	PATH RUSH	5
POA PALUSTRIS	FOWL BLUEGRASS	25
SCIRPUS ATROVIRENS	DARK GREEN BULRUSH	5
VERBENA HASTATA	BLUE VERVAIN	5

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

EROSION CONTROL BLANKET SPECIFICATIONS

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

SCALED FOR PLOT ON 'ARCH D'



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7. ALL GRADES IN THE AREA REGULATED BY THE CONSERVATION AUTHORITY MUST BE MAINTAINED OR MATCHED, UNLESS OTHERWISE AUTHORIZED IN THE APPLICABLE PERMIT.
8. AN AFTER-HOURS CONTACT NUMBER IS TO BE VISIBLY POSTED ONSITE FOR EMERGENCIES. ALL THE PLANS SHOULD HAVE NAME AND CONTACT INFO OF THE PERSON RESPONSIBLE FOR ESC MEASURES.

EROSION AND SEDIMENT CONTROL

1. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES MUST BE INSTALLED PRIOR TO START OF WORKS.
2. FOLLOWING INSTALLATION OF THE PROPOSED ESC MEASURES, A QUALIFIED AGENT OF THE PROPONENT (E.G. CAN-CISEC CERTIFIED MONITOR) WILL CONDUCT REGULAR SITE VISITS TO MONITOR ALL WORKS, PARTICULARLY THE CONDITION OF THE ESC MEASURES, DEWATERING, AND IN- OR NEAR-WATER WORKS. SHOULD CONCERNS ARISE; THE ENVIRONMENTAL MONITOR WILL CONTACT THE PROPONENT, THE CONSERVATION AUTHORITY, AND ANY OTHER APPROPRIATE PARTIES.
3. EROSION AND SEDIMENT CONTROLS MUST BE MAINTAINED DURING CONSTRUCTION, AND ANY REQUIRED REPAIRS OR REPLACEMENTS MUST BE COMPLETED WITHIN 24 HOURS AFTER THEY HAVE BEEN IDENTIFIED DURING THE MONITORING.
4. EROSION AND SEDIMENT CONTROLS MAY REQUIRE PERIODIC ADJUSTMENTS TO REFLECT CHANGING SITE CONDITIONS. THE CONTRACTOR WILL BE RESPONSIBLE FOR THESE ADJUSTMENTS TO ENSURE PROPER FUNCTION.
5. ANY CHANGES TO THE EROSION AND SEDIMENT CONTROL PLAN BEYOND MINOR ADJUSTMENTS MUST BE APPROVED BY THE CONTRACT ADMINISTRATOR.
6. ADDITIONAL EROSION AND SEDIMENT CONTROL SUPPLIES MUST BE KEPT ON SITE IN ORDER TO FACILITATE IMMEDIATE REPAIRS AND/OR UPGRADES AS NEEDED.
7. ALL TEMPORARY SEDIMENT CONTROLS MUST BE REMOVED AFTER THE CONTRACT ADMINISTRATOR DEEMS THE SITE TO BE STABLE.
8. THE PROJECT PROPONENT OR THEIR REPRESENTATIVE IS ULTIMATELY RESPONSIBLE FOR CONTROLLING SEDIMENT AND EROSION WITHIN THE CONSTRUCTION SITE FOR THE TOTAL PERIOD OF THE CONSTRUCTION.
9. IF EXCESSIVE SILTATION RESULTS FROM THE CONSTRUCTION ACTIVITIES, THE ONSITE SUPERVISOR/INSPECTOR AND/OR THE LOCAL REGULATORY BODY RESERVE THE RIGHT TO REQUEST ADDITIONAL ESC MEASURES WHICH WOULD BE INSTALLED PRIOR TO FURTHER CONSTRUCTION ACTIVITIES.

DELETERIOUS SUBSTANCE CONTROL/SPILL MANAGEMENT

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

WORK AREA ISOLATION

1. ALL WORK IN ISOLATED WORK AREAS MUST BE COMPLETED IN THE DRY. AN ADEQUATE NUMBER OF PUMPS MUST BE USED FOR UNWATERING.
2. CROSSING AN ACTIVE WATERCOURSE OR WETLAND BY EQUIPMENT, VEHICLES, PERSONNEL, ETC. IS NOT PERMITTED UNLESS APPROVED BY THE CONSERVATION AUTHORITY. ALL ACCESS TO WORK SITES SHALL BE FROM EITHER SIDES OF THE WATERCOURSE OR WETLAND.
3. THE UNWATERING DISCHARGE LOCATION MUST BE LOCATED AT LEAST 30 m FROM ANY WATERCOURSE OR WETLAND IN AN AREA WITH DENSE VEGETATIVE GROUNDCOVER, AND WHERE THE DISCHARGE CAN RETURN TO THE WATERBODY DOWNSTREAM OF THE WORK AREA OVER THE GROUNDCOVER.
4. FISH MUST BE REMOVED FROM THE WORK AREA ONCE ISOLATED. FISH SALVAGE MUST BE COMPLETED BY A QUALIFIED TECHNICIAN WITH A LICENSE FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES.

	DATE	BY	REVISIONS

DESIGNED BY: LD
CHECKED BY: PV
DRAWN BY: SE
DATE: MAY 2025

DRAFT FOR INTERNAL DISCUSSION

NOT FOR CONSTRUCTION

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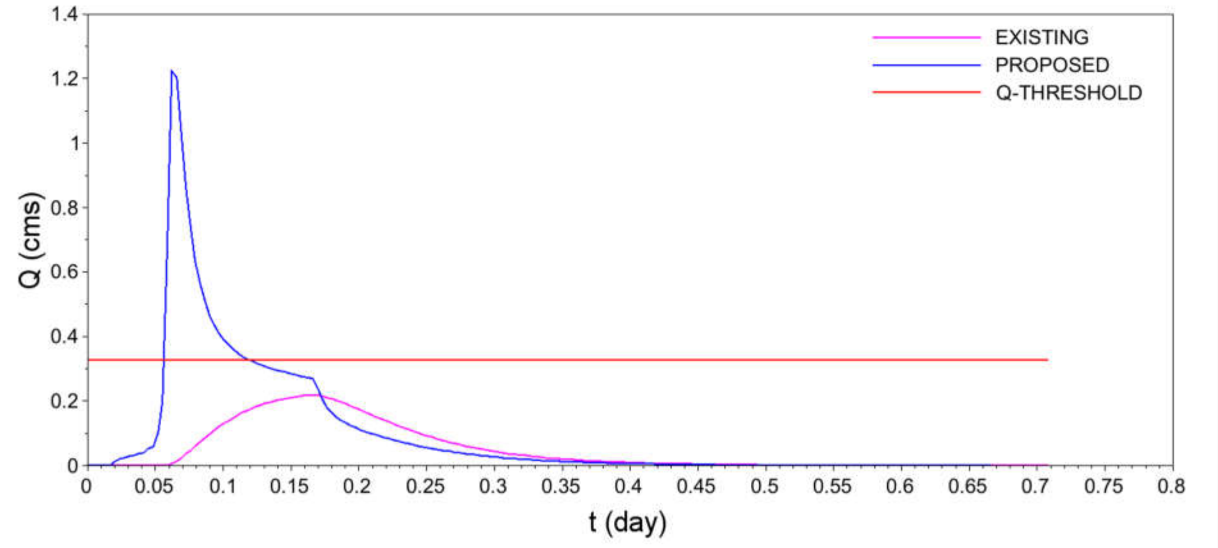
MOUNT HOPE WEST
HUMBER RIVER TRIBUTARIES
TOWN OF CALEDON

COLD CREEK
CONCEPTUAL CHANNEL DESIGN
RESTORATION DETAILS

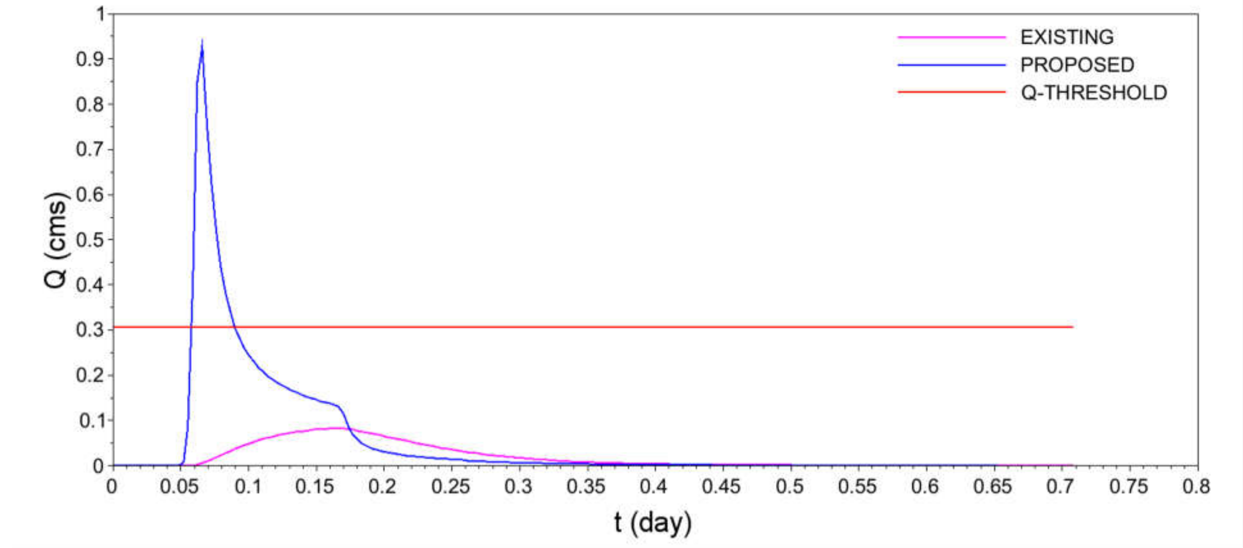
PROJECT No.: PN25026
DRAWING No.: DET-3
SCALE: AS NOTED
SHEET 4 OF 4

Appendix G:
Post- and Pre-Development Hydrographs

Erosion exceedance hydrographs – uncontrolled conditions

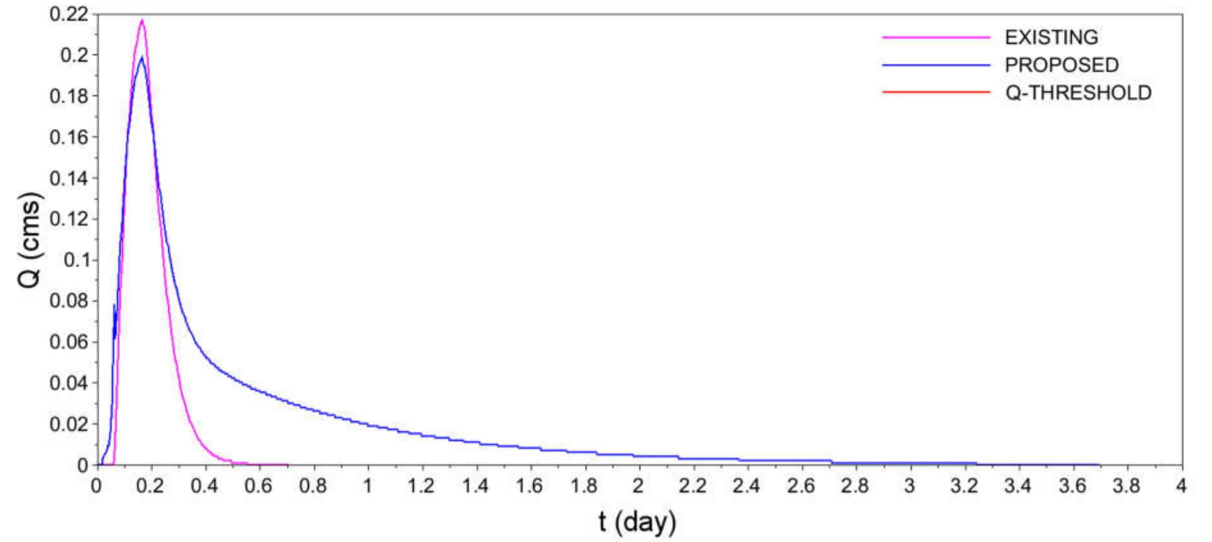


THRF-1 – Scenario 1: uncontrolled 25mm event

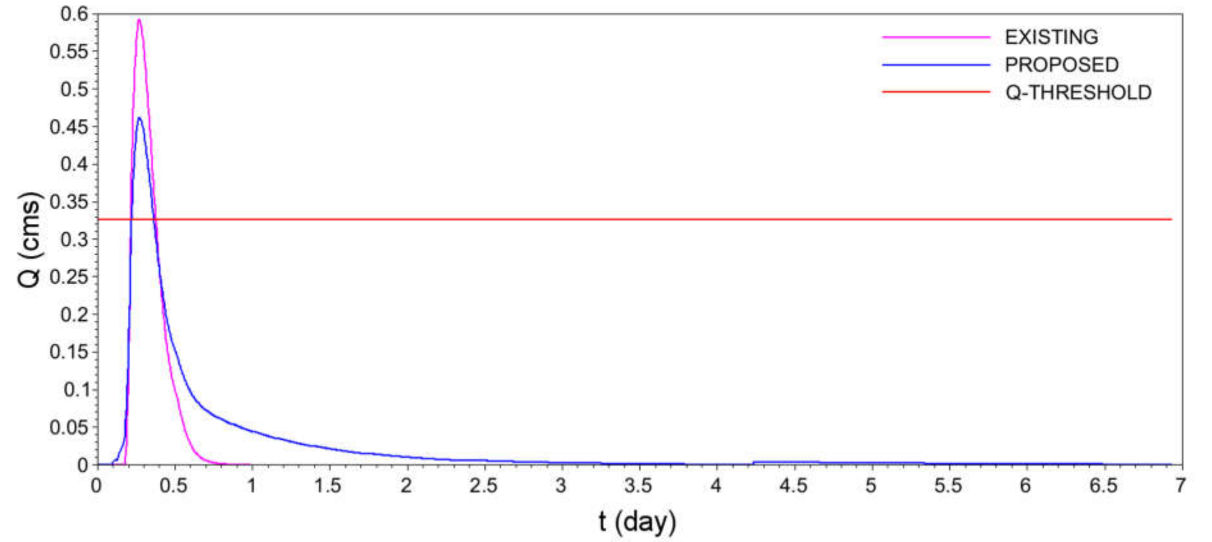


THRF-2 – Scenario 1: uncontrolled 25mm event

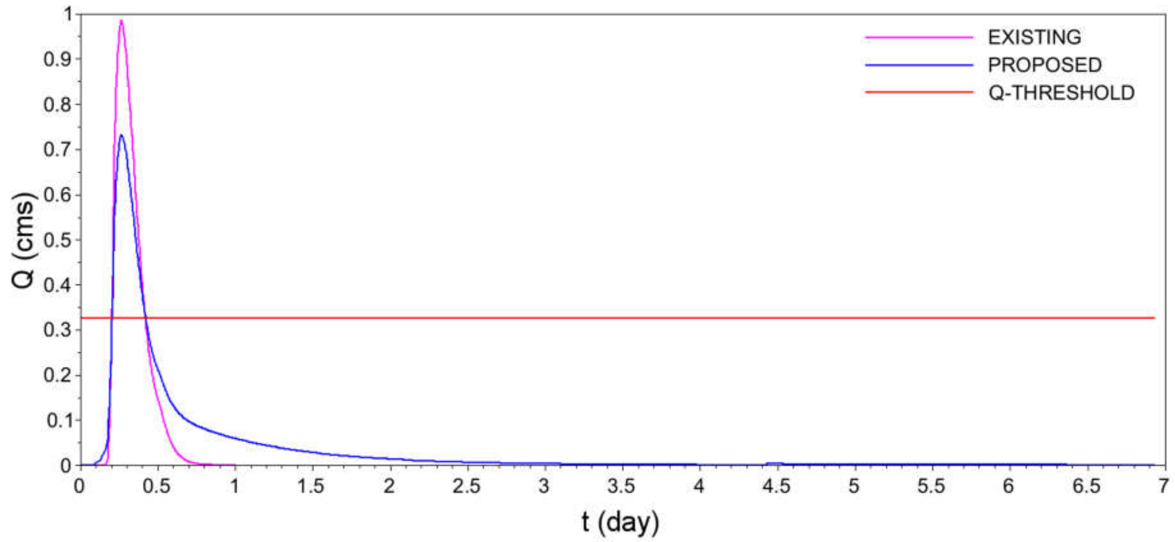
Erosion exceedance hydrographs – controlled conditions



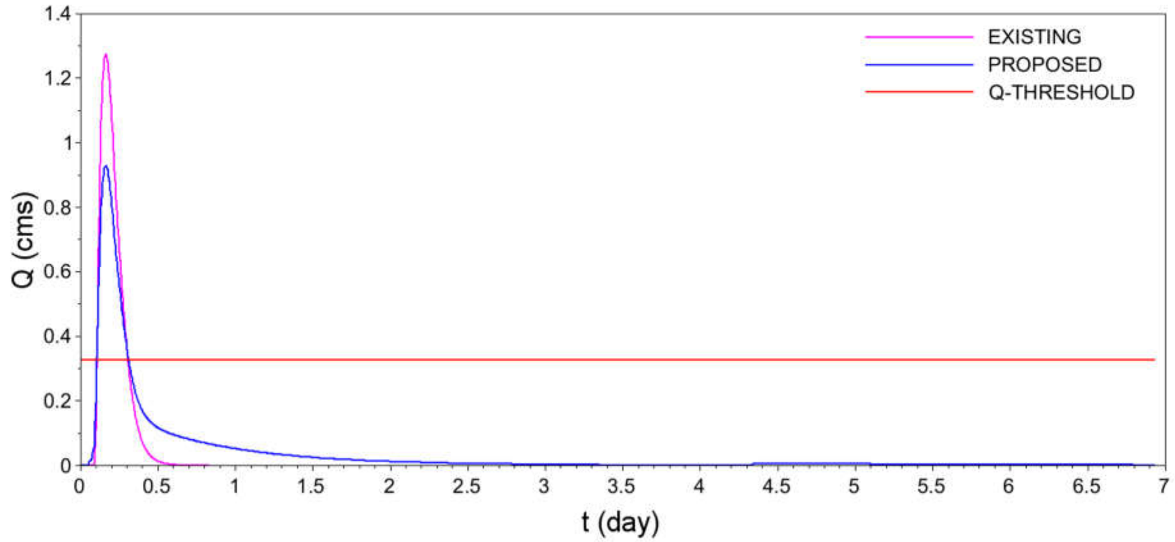
THRF-1 – Scenario 2: controlled 25mm event



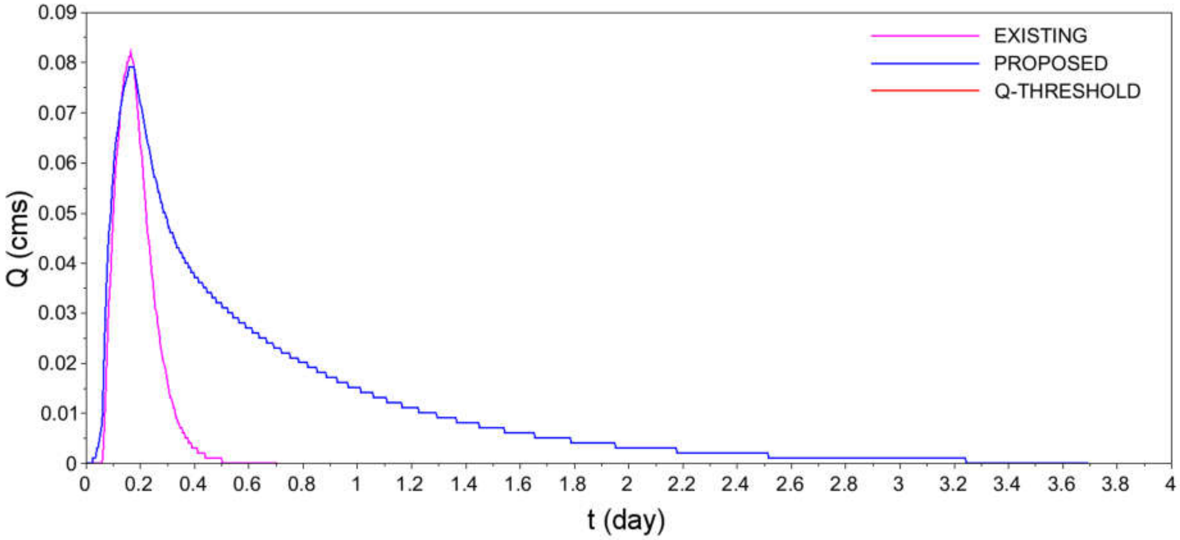
THRF-1 – Scenario 2: controlled 2-year event



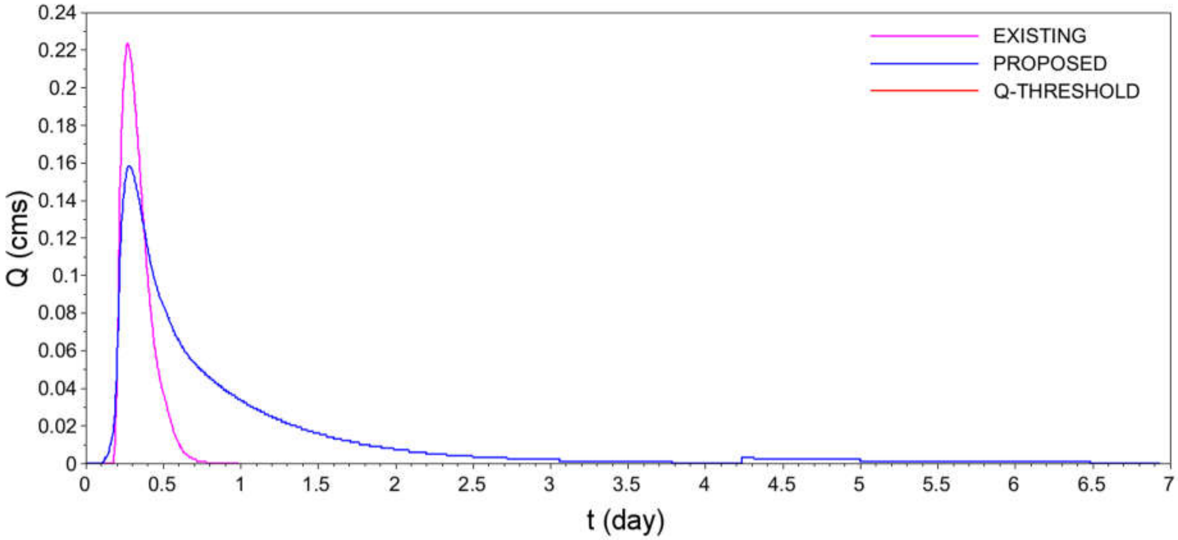
THRF-1 – Scenario 2: controlled 5-year event



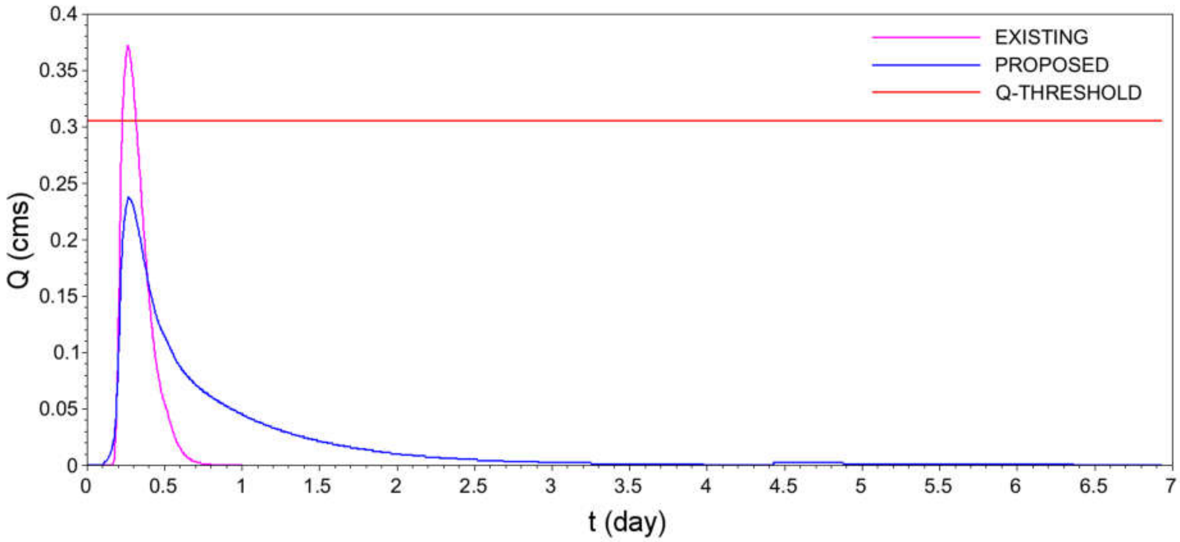
THRF-1 – Scenario 2: controlled 10-year event



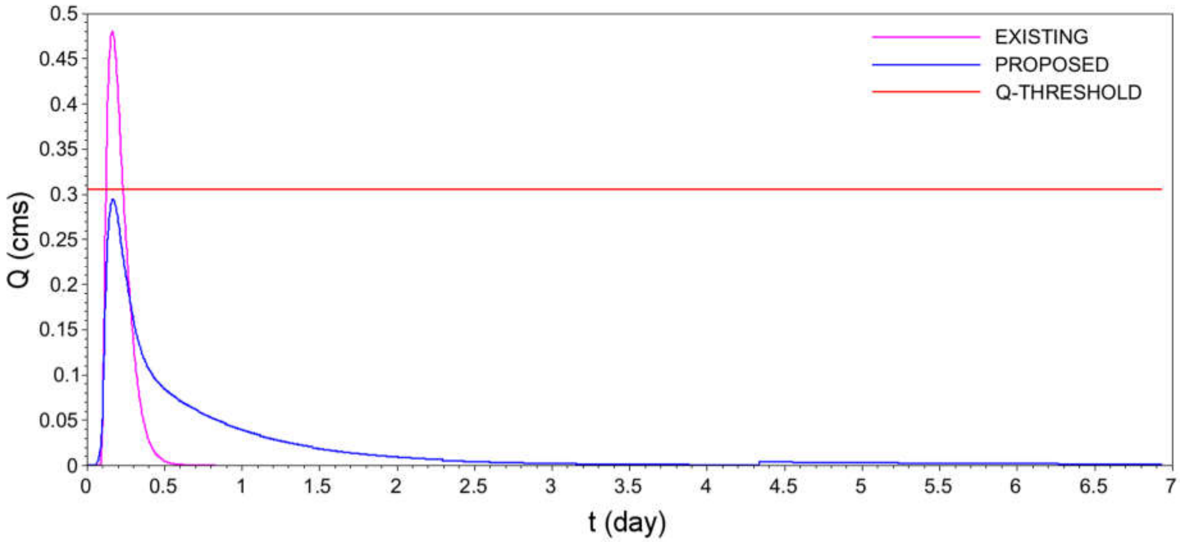
THRF-2 – Scenario 2: controlled 25mm event



THRF-2 – Scenario 2: controlled 2-year event



THRF-2 – Scenario 2: controlled 5-year event



THRF-2 – Scenario 2: controlled 10-year event