







water's edge
ENVIRONMENTAL SOLUTIONS TEAM LTD.

Alinea Land Corporation: Bronte Meadows

Burlington, ON

Fluvial Geomorphological Assessment

February 12, 2026

Bronte Meadows Phase 1

By

Alinea Land Corporation

Burlington, ON

Fluvial Geomorphological Assessment

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1.0 INTRODUCTION

Water's Edge was authorized by Alinea Land Corporation to provide fluvial geomorphological assessment for the Bronte Meadows development property in Burlington, ON. The Bronte Meadows development is located partly within both the Bronte Creek and Sheldon Creek watersheds. The development property is bounded by the West Branch of Sheldon Creek on the west side, Upper Middle Road on the north, Burloak Drive on the east side, and Mainway on the south side. The Corpus Christi Catholic School is situated at the northwest corner of the block, on separate property. Additionally, the East Brach of Sheldon Creek flows through the middle of the site, while a tributary of Bronte Creek flows parallel to it on the eastern portion of the site. The site also features two woodlots, while the remaining area can be considered agricultural. In addition to the sections of the watercourses on the subject property, this assessment will assess the downstream reaches of the watercourses. The assessment of these downstream sections will include characterization of the reaches, erosion threshold analysis, and high-level meander belt width assessment.

We have completed our assessment of the creek in accordance with the approved project Terms of Reference. Data sources for the analysis include,

- 1979, 1987, 1994, 2002, 2011, 2017, and 2021 orthophotos,
- Physiography of Southern Ontario by Chapman & Putnam (digital data from Ministry of Northern Development and Mines (MNDM)),
- Ontario Watershed Information Tool (from MNRF) and,
- Site Inspections and surveys by Water's Edge staff.

Site inspections and geomorphic surveys of the site were completed by Water's Edge staff in April 2023 and April 2025. This site inspection was undertaken after a review of the available literature and maps were completed to confirm site and general system characteristics.

2.0 EXISTING CONDITIONS

2.1 Geology & Physiography

Reviewing the site area's surficial materials is important to evaluate active channel processes. Stream channel form and sediment supply are controlled by the region's physiography and surficial geology. As shown in **Figure 1** both the Sheldon Tributary and Bronte Tributary watersheds are entirely located in Till Plains physiographic region. Sheldon Creek watershed upstream is in Escarpment and Till Moraines and the downstream is in Till Plains. The property in general is located also in Till Plains. Sediments in this region are of clay to silt-textured till and Paleozoic bedrock (Chapman & Putnam, 1984). The surficial geography suggests that the substrate is made of clay to silt-textured till upstream and inside the property. Both Sheldon Creek and Sheldon Tributary also consists of Paleozoic bedrock. Outcrops of the shale outcrops are visible throughout the Sheldon Creek West Branch. The geotechnical report by MTE notes that borehole results showed native deposits of sand, silt and clay were encountered on the site typically beneath the topsoil. In addition, glacial till deposits were found typically beneath the topsoil and sand, silt and clay deposits. Cobbles and boulders should be anticipated in the glacial till soils (MTE, 2026).

2.2 General Watershed Characteristics

The following data was acquired using the Ontario Watershed Information Tool. For this project the two watersheds were delineated separately. The Sheldon Creek and Sheldon Tributary watersheds are delineated upstream of the study area. The Bronte Tributary watershed is delineated downstream of the project area since there is no creek identified on OWIT website upstream or at the study area. The watersheds are shown in **Figure 1**.

Sheldon Creek (west branch) is at least a 3rd order stream that has a total drainage area roughly 7.4 km^2 upstream of the study area. The general slope of the watershed is 2.9%. The dominant land uses are infrastructure (53.7%), agricultural (35%), followed by forest (9.9%), and swamp (0.9%) (OWIT, 2025).

Sheldon Tributary (east branch) is a 2nd order stream that has a total drainage area roughly 1.02 km^2 upstream of the study area. The general slope of the watershed is 2.1%. The dominant land uses are infrastructure (96.2%), agricultural (3%), followed by forest (0.8%), and swamp (0.02%) (OWIT, 2025).

Bronte Creek is a 1st or 2nd order stream that has a total drainage area roughly 0.7 km^2 upstream of the study area. The general slope of the watershed is 1.5%. The dominant land uses are community agricultural (52%), infrastructure (40.7%), followed by forest (4.7%), and swamp (2.5%), (OWIT, 2021).

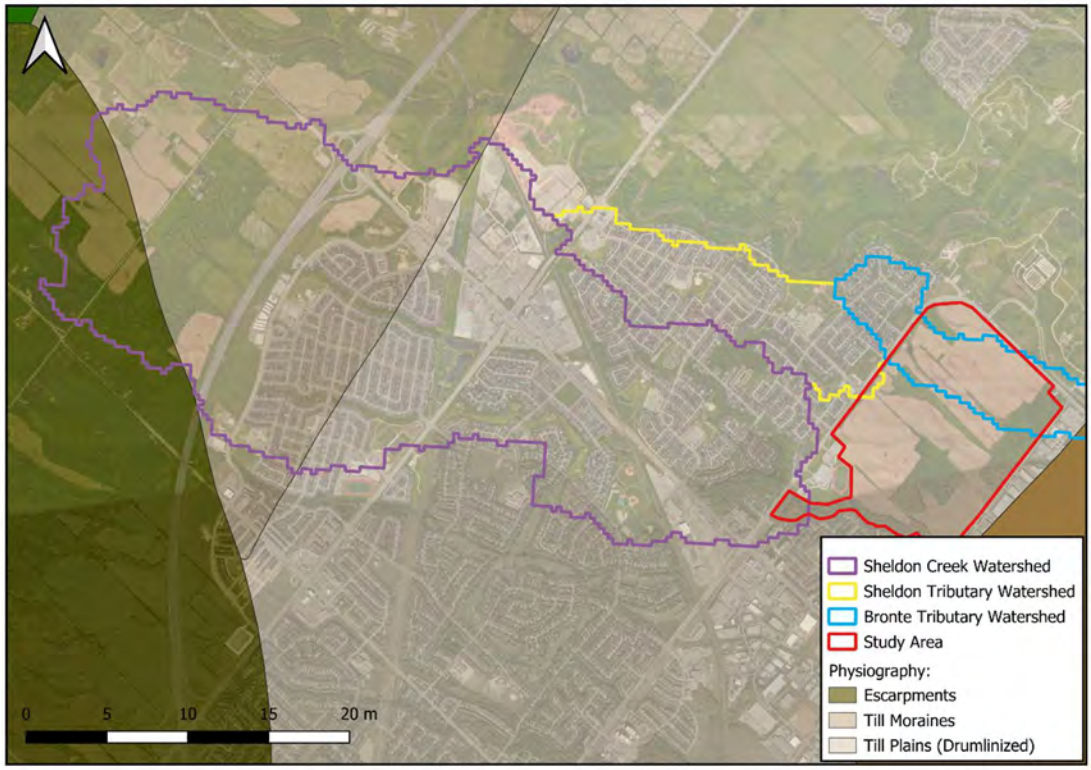


Figure 1: Site Location, Sub-watersheds, and Local Physiography (Chapman & Putman, 1984)

2.3 Reach Delineation

Channel morphology and substrate characteristics can change along a watercourse. To account for these changes lengths of a watercourse that exhibit similar planform, sediment substrate, land use, local geology, valley confinement, hydrology and slope are delineated. There are typically fluvial geomorphic differences from reach to reach, including slope, sinuosity, substrate, and also riparian vegetation. Six sections of watercourses are included in this assessment. These sections are both on the Bronte Meadows property and downstream of the property, generally lying between Mainway to the north and Hwy 403 to the south. The sections for each of the subject watercourses display similar characteristics relative to themselves. Therefore, breaking the study reaches down into subreaches is not necessary for this assessment. Each watercourse will be referred to as Sheldon Creek West Branch, Sheldon Creek East Branch, and Bronte Creek Tributary. Further description can be used to differentiate between the subject property of Bronte Meadows and the subwatershed study reaches, where the reaches on the property are 'upstream' and the sections

that are the focus of this subwatershed assessment are referred to as 'downstream'. **Figure 2** shows the sections of the creek and the reach breakdown for each watercourse.

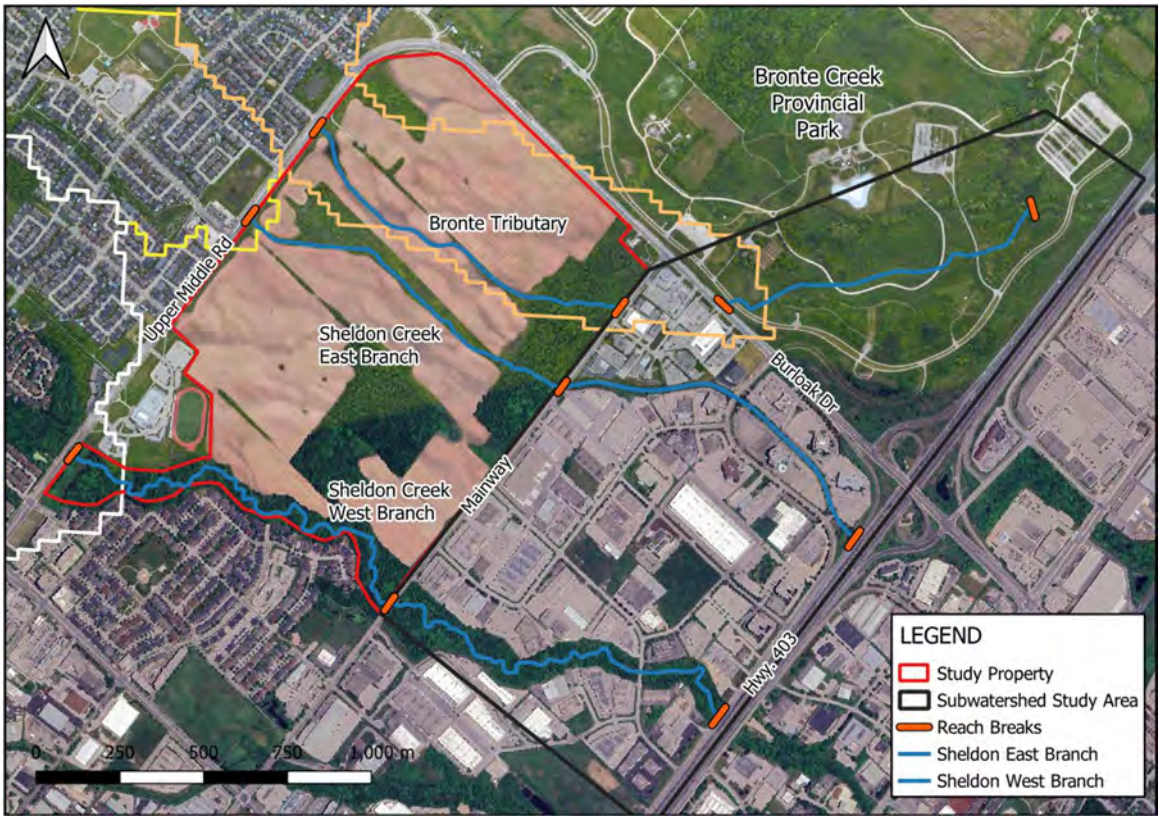


Figure 2: Study Area with Reach Breaks (Google Maps)

2.4 Channel Characterization

A site visit to assess the fluvial geomorphological characteristics of the creeks was performed in April 2023 and again in April 2025. All the creeks were examined over the entire subwatershed study area to find any locations of active erosion. Reaches were delineated using the field visit. Cross section data and channel slope data were collected in addition to general creek observations to identify typical bankfull characteristics and to analyze and describe the existing conditions in the creeks. The characteristics of the creeks are detailed below. The Rapid Geomorphic Assessment and the Rapid Stream Assessment Techniques were used to provide stream characterization in an industry standardized format.

Sheldon Creek West Branch Upstream

The Study Reach for Sheldon Creek at this site is approximately 1300 m, from downstream of the confluence near the north side of the property. The study reach is surrounded by agricultural land on one side and developed areas on the other side. The riparian buffer is narrow but well vegetated with good canopy coverage on both sides. Bank erosion is occurring through the entire reach on both sides of the creek with some eroding banks over 1 metre in height. On the west side of the creek there are exposed shale banks exceeding 3 metres in height. Tree roots are exposed, and leaning trees can be seen for much of the reach. In the upper section of the reach the creek spreads out through the floodplain due to past debris jams diverting flow. At the downstream section of the reach the left bank, which is the bank adjacent to the study area, toe erosion and fallen trees were observed. The reach also has fresh deposits of silt and gravels, particularly on point bars, this substrate is derived from the exposed shale found adjacent to the creek. The process that is occurring is likely a form of widening or planform adjustment. Site photos are found in **Appendix B**.

Bankfull channel indicators were collected including bankfull depth and width for the Study Reach. The geomorphic bankfull conditions were measured and calculated from the surveyed cross sections. Bankfull maximum depth and width were calculated to be 0.6 m and 5.3 m, respectively. The width-depth ratio is 14.13, and the entrenchment ratio is 2.42. The general slope of the reach is 1%. The calculated geomorphic parameters are summarized in **Table 1**.

Table 1: West Sheldon Creek Upstream Geomorphic Parameters

Parameter	West Sheldon Creek Upstream
Bankfull Width (m)	5.3
Bankfull Mean Depth (m)	0.4
Bankfull Max Depth (m)	0.6
Bankfull Area (m^2)	2.33
Wetted Perimeter (m)	5.57
Hydraulic Radius (m)	0.38
Width-Depth Ratio	14.13
Entrenchment Ratio	2.42
Slope (%)	1.0
Substrate	Med to Lrg Gravel

Sheldon Creek West Branch Downstream

The Study Reach for Sheldon Creek at this site is approximately 1300 m, from Mainway to the QEW. The study reach flows through a well forested valley, in which it is confined. The valley occasionally has large vertical shale walls that have been eroded into by the creek. Some of these walls exceed 4 metres in height. The study reach is surrounded by commercial properties above the valley walls. The riparian area along the creek is very well vegetated with mature trees and shrubs. Bank erosion is occurring through the majority of the reach on both sides of the creek, with some eroding banks over 1 metre in height. Tree roots are exposed, and leaning trees can be seen for much of the reach. The reach also has fresh deposits of silt and gravels, particularly on point bars, this substrate is derived from the exposed shale found adjacent to the creek. The process that is occurring is likely a form of widening or planform adjustment rather than degradation of the bed.

Upstream and downstream of the Sutton Drive crossing as well as the approach to the QEW the creek has been channelized with rip rap to ensure protection of the infrastructure. The rip rap channel has done a good job in this regard and the crossings are not at risk of erosion at this time. A few concrete weirs are present in this reach. The purpose at one time was likely to concentrate flow away from eroding shale slopes or slow channel knickpointing. At one of these weirs the plunge pool on the downstream side has exacerbated the issue and caused significant erosion. In general, the reach is unstable and actively eroding. Some existing protection measures are working well, while others have failed. Site photos are found in **Appendix B**.

Pebble counts were completed as per a modified Wolman procedure. The resultant particle analysis is discussed in the erosion threshold section. A general description of the substrate is medium to large gravels sourced from the shale bed and banks of the creek. Large platey material was present in riffles, while in slow sections and deeper pools there is siltation occurring. Deposits of smaller gravels and sand sized particles were present on point bars and medial bars.

Bankfull channel indicators were collected including bankfull depth and width for the Study Reach. The geomorphic bankfull conditions were measured and calculated from the surveyed cross sections. Bankfull maximum depth and width were calculated to be 6.8 m and 0.40 m, respectively. The width-depth ratio is 17.6, and the entrenchment ratio is 5.67. The general slope of the reach is

approximately 0.8%, while the riffle slopes are 4%. The calculated geomorphic parameters are summarized in **Table 2**.

Table 2: West Sheldon Creek Downstream Geomorphic Parameters

Parameter	West Sheldon Creek Downstream
Bankfull Width (m)	6.81
Bankfull Mean Depth (m)	0.40
Bankfull Max Depth (m)	0.63
Bankfull Area (m^2)	2.72
Wetted Perimeter (m)	7.11
Hydraulic Radius (m)	0.39
Width-Depth Ratio	17.56
Entrenchment Ratio	5.67
Slope (%)	0.8
Substrate	Med to Lrg Gravel

Sheldon Creek East Branch Upstream

Sheldon Tributary study reach flows from north to south through the study area. The Study Reach for this creek at this site is approximately 1100 m, from downstream of the culvert north of the study area to south, located in the agricultural land. The Study Reach is a small channel likely straightened in the past for agricultural drainage purposes. At some locations in the study area the water spreads over the adjacent fields rather than being channelized. This is likely due to an accumulation of sediments which have filled the main channel and diverted flow. There is no riparian buffer for most of the creek length in the study area, but at a few sections several trees can be found next to the creek. Canopy coverage is low for most of the creek length. At the most downstream section (downstream of the study site) there is a wide riparian buffer from a mature woodlot that is well vegetated and good canopy coverage on both sides.

The channel substrate is fine sized grains consisting of sand and clay. At the downstream section of the creek the substrate is mostly gravel and sand. Basal scour can be seen through most of the reach on both sides. The common signs of bank erosion at this location are basal scour, exposed tree roots, and fallen/leaning trees. The process that is occurring in this small creek is likely a form of planform adjustment. Site photos are found in **Appendix B**.

Bankfull channel indicators were collected including bankfull depth and width for the Study Reach. The geomorphic bankfull conditions were measured and calculated from the surveyed cross sections. Bankfull maximum depth and width were calculated to be 0.33 m and 2.43 m, respectively. The width-depth ratio is 10.79, and the entrenchment ratio is 4.3. The general slope of the reach is 1%. The calculated geomorphic parameters are summarized in **Table 3**.

Table 3: East Sheldon Creek Upstream Geomorphic Parameters

Parameter	East Sheldon Creek Upstream
Bankfull Width (m)	2.43
Bankfull Mean Depth (m)	0.22
Bankfull Max Depth (m)	0.33
Bankfull Area (m^2)	0.61
Wetted Perimeter (m)	2.65
Hydraulic Radius (m)	0.2
Width-Depth Ratio	10.79
Entrenchment Ratio	4.3
Slope (%)	1.0
Substrate	Sand/clay

Sheldon Creek East Branch Downstream

The downstream reach of Sheldon East Branch is approximately 1000 m from Mainway to the QEW. The Study Reach is a small channel that flows through a commercial area and has been heavily channelized. For the entire length of the Study Reach, the channel is lined by articulated concrete blocks covered with a fine layer of silt. The concrete is exposed throughout much of the reach. At multiple points along the reach there are large armourstone-lined control structure covering the streambed and surrounding floodplain. The riparian zone is limited mainly to grasses, some of which are mown, meaning there is no canopy coverage for the entire length of the reach.

The channel substrate is mainly silt, but small gravels can be found in some sections of the reach as well. Bank material consists of silt and soil. Basal scour can be seen through most of the reach on both sides. The creek has adjusted to a low-flow/no-flow state. Site photos are found in **Appendix B**.

Bankfull channel indicators were collected including bankfull depth and width for the Study Reach. The geomorphic bankfull conditions were measured and calculated from the surveyed cross sections. Bankfull maximum depth and width were calculated to be 0.30 m and 1.23 m, respectively. The width-depth ratio is 5.68, and the entrenchment ratio is 6.3. The general slope of the reach is 0.3%. The calculated geomorphic parameters are summarized in **Table 4**.

Table 4: East Sheldon Creek Downstream Geomorphic Parameters

Parameter	East Sheldon Creek Downstream
Bankfull Width (m)	1.23
Bankfull Mean Depth (m)	0.23
Bankfull Max Depth (m)	0.30
Bankfull Area (m^2)	0.29
Wetted Perimeter (m)	1.51
Hydraulic Radius (m)	0.18
Width-Depth Ratio	5.68
Entrenchment Ratio	6.30
Slope (%)	0.3
Substrate	Small Gravels

Bronte Tributary Upstream

Bronte Tributary Upstream study reach flows from north to south through the study area. The Study Reach for this creek at this site is approximately 1100 m, from downstream of the pond north of the

study area to south, located in the agricultural land. The flow from in this tributary originates from a SWM pond on the north side of Upper Middle Rd. The Study Reach is a very small channel, with a poorly defined low flow channel. At most locations in the study area the creek flows overland rather than in a defined channel. The channel substrate consists of highly erodible fine materials such as sand and clay. At some locations throughout the reach small gravels can also be seen. There is no riparian buffer for most of the creek in the study area, however at a few sections several trees can be found next to the creek. Canopy coverage is low for most of the creek length. Since this is a very small watercourse, areas with active erosion were difficult to detect although it is occurring with depositional features noted in some sections. Site photos are found in **Appendix B**.

Although it is difficult to define a channel for this creek, channel cross section data was collected including depth and width for the reach. Channel maximum depth and width were calculated to be 0.09 m and 0.84 m, respectively. The width-depth ratio is 20.49, and the entrenchment ratio is 6.46. The calculated geomorphic parameters are summarized in **Table 5**.

Table 5: Bronte Tributary Upstream Geomorphic Parameters

Parameter	Bronte Tributary
Bankfull Width (m)	0.84
Bankfull Mean Depth (m)	0.06
Bankfull Max Depth (m)	0.09
Bankfull Area (m^2)	0.04
Wetted Perimeter (m)	0.88
Hydraulic Radius (m)	0.05
Width-Depth Ratio	20.49
Entrenchment Ratio	6.46
Slope (%)	0.9
Substrate	Sand/clay

Bronte Tributary Downstream

Bronte Tributary Downstream study reach flows from west to east through the study area. The Study Reach for the creek at this site is approximately 1000 m in length, and runs from Burloak Drive through Bronte Creek Provincial Park towards Parking Lot F. The channel is small but well defined through much of the study area, although some stretches of the channel had very limited or no flow at the time of the field survey. The first section of the creek has previously been altered by way of natural channel design. The channel here is stable but has sedimented in over time. The next section has a knickpoint issue and has cut down into the surrounding floodplain. The knickpoint stops at a large tree rootmat just downstream from the first section. The next section is a large open grassed area where the flow is not concentrated in a channel at all times but rather percolates through the low-lying

area. The flow eventually concentrates again prior to flowing through a minor road crossing. The final section prior to the end of the reach is more similar to a wetland area where the channel is generally undefined. Overall, there are some minor erosion issues in the form of bed degradation, but the majority of the reach is stable.

The channel substrate generally consists of small gravels embedded by silt and sand throughout the study area. The riparian buffer consists mainly of tall grasses throughout the reach, but there are some stretches (the upstream and downstream limits of the reach) that have mature trees on the banks which provide canopy coverage in these areas. Site photos are found in **Appendix B**.

Channel cross section data was collected including depth and width for the reach. Channel maximum depth and width were calculated to be 0.30 m and 1.34 m, respectively. The width-depth

ratio is 7.45, and the entrenchment ratio is 9.54. The calculated geomorphic parameters are summarized in **Table 6**.

Table 6: Bronte Tributary Downstream Geomorphic Parameters

Parameter	Bronte Trib D/S
Bankfull Width (m)	1.34
Bankfull Mean Depth (m)	0.21
Bankfull Max Depth (m)	0.30
Bankfull Area (m^2)	0.27
Wetted Perimeter (m)	1.62
Hydraulic Radius (m)	0.17
Width-Depth Ratio	7.45
Entrenchment Ratio	9.54
Slope (%)	0.5
Substrate	Small Gravels

3.0 STREAM ASSESSMENT SCORES

In addition to classification of a stream system, various techniques for geomorphic assessments are used to better understand general stream conditions (stability, habitat, erosion/degradation, riparian, etc.). In our assessment of the three creeks in the study area, we used Rapid Geomorphic Assessment and Rapid Stream Assessment Technique.

3.1 Rapid Geomorphic Assessment (RGA)

Creek stability was assessed using a Rapid Geomorphic Assessment (MOE, 2003). The RGA assessment focuses entirely on the geomorphic component of a watercourse. The RGA method consists of four factors that summarize various components of channel adjustment, specifically: aggradation, degradation, channel widening, and plan form adjustment. Each factor is assessed separately, and the total score indicates the overall stability of the system (**Table 9**). This methodology has been applied to numerous streams and rivers and **Table 7** details the ranking criteria.

Table 9 presents the results of the RGA and RSAT assessments. Generally, for the RGA the lower the score the more stable the channel is, or at least closer to a state of quasi-equilibrium. West Sheldon Creek Upstream received a score of 0.51 which classifies it as 'In Adjustment', meaning the channel is currently mostly unstable. Evidence of instability was apparent in three of the four categories of the RGA and these were in the Aggradation, Widening, and Planimetric Adjustment. Indices visible for Widening include fallen/leaning trees, exposed tree roots, and basal scour through much of the channel. We could also see most indices of Aggradation such as Lobate bar, coarse material in riffle embedded, siltation in pools, medial bars, accretion on point bars, poor longitudinal sorting of bed materials, and deposition in the overbank zone. In addition, near the upstream end downstream of the confluence, evidence of Planimetric Form Adjustment such as single thread channel to multiple channel can be found.

West Sheldon Creek Downstream received a score of 0.48 which classifies it as 'In Adjustment', meaning the channel is currently mostly stable. Evidence of instability was apparent in three of the four categories of the RGA and these were in the Aggradation, Widening, and Planimetric Adjustment. Indices visible for Widening include fallen/leaning trees, exposed tree roots, basal scour through much of the channel and fracture lines along the top of bank. There were also visible indices of Aggradation which include medial bars and accretion on point bars. Additionally, evidence of Planimetric Form Adjustment was noted by the presence of cutoff channels and the formation of islands.

East Sheldon Creek Upstream received a score of 0.29 which classifies it as 'Transitional/Stressed', meaning the channel has evidence of instability. Evidence of instability was mainly apparent in one of the four categories of the RGA and this was in Widening. Indices visible for Widening include fallen/leaning trees, and exposed roots through much of the channel. Also noted was poor longitudinal sorting of bed materials in the study area.

East Sheldon Creek Downstream received a score of 0.20 which classifies it as 'In Regime', meaning the channel is generally stable. This is likely due to the small size of the heavily modified channel. However, evidence of instability was apparent in two of the four categories of the RGA and this was Aggradation and Widening. Indices visible for Aggradation include coarse materials in riffles embedded, siltation in pools, and deposition in the overbank zone. Indices visible for Widening included basal scour through more than half of the reach.

Table 7: Interpretation of RGA Score

Stability Index (SI) Value	Classification	Interpretation
SI ≤ 0.20	In Regime	The channel morphology is within a range of variance for rivers of similar hydrographic characteristics and evidence of instability is isolated or associated with normal river meander processes.
0.21 ≤ SI ≤0.40	Transitional/Stressed	Channel morphology is within a range of variance for rivers of similar hydrographic characteristics, but the evidence of instability is frequent.
SI ≥ 0.40	In Adjustment	Channel morphology is not within the range of variance and evidence of instability is widespread.

3.2 Rapid Stream Assessment Technique (RSAT)

The Rapid Stream Assessment Technique (RSAT) was developed by John Galli and other staff of the Metropolitan Washington (DC) Council of Governments (Galli et al, 1996). The RSAT systematically focuses on conditions reflecting aquatic-system response to watershed urbanization. The form groups responses into six categories, presumed to adequately evaluate the conditions of the river system at the time of measurement on a reach-by-reach basis. The six categories are,

1. Channel stability,
2. Channel scouring and sediment deposition,
3. Physical in-stream habitat,
4. Water quality,
5. Riparian habitat conditions, and
6. Biological conditions.

River channel stability and cross-sectional characterization is a critical component of RSAT. The entire channel was inspected for signs of instability (such as bank sloughing, recently exposed non-woody tree roots, general absence of vegetation within the bottom third of the bank, recent tree falls, etc.) and channel degradation or downcutting (such as high banks in small headwater streams and erosion around man-made structures).

A rapid assessment of soil conditions along the riverbanks is also conducted to identify soil texture and potential erodibility of the watercourse bank. Qualitative water quality measurements were also made (temperature, turbidity, colour and odour) along with an indication of substrate fouling (i.e., the unwanted accumulation of sediment).

RSAT also typically involves a quantitative sampling and evaluation of benthic organisms. As no benthic sampling was undertaken, the score was based on site conditions and general observations of water quality.

Each category was assigned a value which was then summed to provide an overall score and ranking. **Table 8** details the range of scores and rankings with a higher score suggesting a healthier system.

Within these broad categories, we evaluated each reach and determined the RSAT scores (**Table 9**). The scores for all the four reaches rank them as Fair. West Sheldon Creek had low scores in channel stability, channel scouring and sediment deposition, and riparian habitat conditions. East Sheldon Creek had low scores in physical instream habitat, riparian habitat conditions, and biological conditions.

Table 8: Interpretation of RSAT Score

RSAT Score	Ranking
41-50	Excellent
31-40	Good
21-30	Fair
11-20	Poor
0-10	Degraded

Table 9: RGA and RSAT Scores

CREEK	RGA	RSAT
West Sheldon Creek Upstream	0.51	23.6
East Sheldon Creek Upstream	0.29	23.0
West Sheldon Creek Downstream	0.48	28.5
East Sheldon Creek Downstream	0.20	20.5
Bronte Tributary Upstream	0.38	20.7
Bronte Tributary Downstream	0.28	24.9

4.0 MEANDER BELT WIDTH ASSESSMENT

4.1 Aerial Photography Analysis

Air photos from 1979, 1987, 1994, 2002, 2011, 2017, and 2021 were analyzed for changes in stream planform using GIS mapping where the photos are used to trace the bankfull limits of the two channels which the meander axis and belt widths are based on. Reviewing the series of air photos there are a couple of items to note. West Sheldon Creek is partially confined due to the west bank, however it is also partially confined on the left bank at downstream, but not at the upstream end. Also, this creek through the study area has changed little over the 42 years of the air photo range. The upstream land cover has changed from agricultural to urban over the last 42 years. Minor channel variations are normal and even a few minor realignments, however much of the channel is in a similar location as 42 years ago. This means the meander axis has changed very little if at all inside the study area. The intensity of impervious land covers has not changed significantly since 2002, which means the alignment of the creek has not been affected much.

By looking at the historical air photos and contour lines, East Sheldon Creek is not confined. The upstream land cover has changed from agricultural to urban over the last 42 years. This creek is small in size and therefore, it moved slightly over the last years. Similarly, looking at the historical air photos and contour lines, Bronte Tributary is not confined. The upstream land cover has

changed from agricultural to urban over the last 42 years. This creek is small in size and therefore, it moved only slightly over the air photo duration.

4.2 Meander Belt Width Delineation

Assessment of the meander belt width is undertaken in accordance with commonly accepted standard meander belt width delineation procedures which are established for watercourses with well defined, meandering bankfull channels as laid out by the Toronto Region Conservation Authority's *Belt Width Delineation Procedures* manual. Using the manual, Sheldon Creek was evaluated to identify the final meander belt width near the subject property. Procedure 2 from the manual which assumes no change in hydrology has been completed and outlined below, however the procedure is also contrasted with Procedure 5 due to the historical impacts that the agricultural practices have had on the watercourses.

All procedures from the manual require that the confinement of the channel be determined. The OMNR guideline considers unconfined channels to be in areas of 'relatively flat to gently rolling plains and not confined by valley walls.' Confinement can be difficult to determine for some creeks, but in general the main concern is whether the channel is definitively bound to its valley corridor or if it contacts large valley walls. Valley walls are also described as slopes adjacent to the creek that are roughly 2 metres or higher. Reviewing the contours and through site observations it is clear that Sheldon Creek in the study area is clearly confined to a valley and not able to meander outside of it. The presence of the valley wall requires that the site be classified as a confined channel. The Sheldon Creek East Trib and the Bronte Trib are unconfined.

For Procedure 2, the meander axis needs to be identified for the channel. The meander axis is the general valley direction or trend of a stream's planform (**Map 1**). Channels can have either simple or compound meander patterns. Compound meandering channels have primary and secondary patterns that can have differing meander axis. The channels have a large-scale axis that is considered the secondary axis, which places the belt width lines outside of larger meander trends in the system, often crossing controlling contours. The primary axis uses a smaller scale axis that focuses on localized meander axis and more accurately accounts for contours in the surrounding topography. Sheldon Creek has a compound meander pattern as two meander patterns can be delineated, and the more localized primary axis will be used for the belt width assessment.

Once the channel has had the meander axis delineated (**Map 1**), parallel lines are drawn on either side of the meander axis at the outermost edge of the historical meanders. These parallel lines follow the meander axis of the reach and are described as the preliminary belt width. However, as per the guidelines, when the river is partially confined within a valley the preliminary meander belt width is adjusted and placed halfway up the valley slope instead of on the outside of the historical meanders. **Map 1** shows the delineated belt width and meander belt axis.

Calculating erosion rates is dependent on high-quality, high-resolution aerial photography, precise orthorectification, and minimal canopy coverage. While it is difficult to delineate the bankfull line where Sheldon Creek flows through trees, it is possible where the vegetation is limited and the bankfull line can be easily delineated. This is also ideal, since these are the areas along the bank most likely to erode. In calculating the erosion rates the 2002, 2011, 2017, and 2021 photos were used to provide a reasonable representation for how the creek has adjusted in the past 19 years. **Map 1** shows the locations that the erosion rates were measured, and **Table 10** shows the calculated erosion rates for West Sheldon Creek. The average final meander belt width is 83.5 m for this creek. The average 100-year erosion between the 5 locations rate was used to identify the final belt width which is also shown in **Table 10**. The final belt width or final erosion hazard offset for West Sheldon Creek is the combination of the preliminary belt and the 100-yr erosion rate and is noted on **Map 1**.

Table 10: Erosion Rate Calculations for West Sheldon Creek

	2002 to 2011 (m)	2011 to 2017 (m)	2017 to 2021 (m)	Total Difference (m)	100-yr Rate
#1	1.93	1.29	1.12	4.34	22.8
#2	0.40	1.00	0.73	2.13	11.2
#3	0.39	0.21	0.51	1.11	5.80
#4	0.48	0.56	0.20	1.24	6.50
#5	0.51	1.60	0.66	2.77	14.6
#6	0.17	4.74	0.13	5.04	26.5
#7	0.55	0.23	0.45	1.23	6.50
				Average 100-yr Erosion Rate:	**13.4**

For the East Sheldon Creek and Bronte Tributary a similar methodology was followed. Within the manual there are a few different procedures that can be followed for the varying factors associated with different studies, and as stated for this study Procedure 2 has been completed but due to the historical modifications and past changes in hydrology upstream of the site Procedure 5 will also be reviewed. Procedure 2 requires 'accurate delineation and quantification of the meander belt since it will affect planning of the site and corridor', which will be conducted below.

Procedure 2 requires that the confinement of the channel be determined. East Sheldon Creek and the Bronte Trib have flat to gently sloping floodplain which are not constricting or restricting the movement of the channel and are therefore considered unconfined.

Next, the meander axis needs to be determined for the channels. The meander axis is the general valley direction or trend of a stream's planform. Once the river has a line drawn as its meander axis (seen in **Map 2**), parallel lines are drawn on either side of the primary meander axis at the outermost edge of the meanders. These parallel lines follow the meander axis of the respective reach. Continuing with Procedure 2, a 100-year erosion rate is applied if erosion rates have been calculated. An exception arises for the application of erosion rates when a reach has a preliminary belt width of greater than 50 metres. When the preliminary belt width is greater than 50 metres then a 10% factor of safety are used. The preliminary belt widths within the Study Area for both Sheldon and Bronte Tributaries are less than 50 meters. The average final beltwidth is 33.2 m for Sheldon East Branch and it is 32.4 m for Bronte Tributary. **Table 11** and **Table 12** show the erosion rate calculations for both Sheldon and Bronte Tributaries.

Table 11: Erosion Rate Calculations for East Sheldon Creek

Location	2002 to 2007 (m)	2007 to 2017 (m)	2017 to 2021 (m)	Total Difference (m)	100-yr Rate
#1	0.42	1.24	0.24	1.9	10
#2	0.5	0.37	0.38	1.25	6.6
#3	0.13	0.11	0.52	0.76	4
#4	0.35	0.22	0.38	0.95	5
#5	0.8	0.48	0.22	1.5	7.9
#6	0.93	0.24	0.38	1.55	8.2
				Average 100-yr Erosion Rate:	**7**

Table 12: Erosion Rate Calculations for Bronte Tributary

Location	2002 to 2011 (m)	2011 to 2017 (m)	2017 to 2021 (m)	Total Difference (m)	100-yr Rate
#1	1.25	0.4	0.57	2.22	11.7
#2	0.23	0.89	0.51	1.63	8.6
#3	0.3	0.2	1.45	1.95	10.3
#4	0.43	0.75	0.68	1.86	9.8
				Average 100-yr Erosion Rate:	**10.1**

The upstream reaches require the meander belt widths for planning purposes. No development or change is proposed downstream of the subject property and therefore meander belt widths were not completed for the downstream reaches.

A review of Procedure 5 from the TRCA manual was also completed for the Sheldon Creek East Branch and the Bronte Tributary. Procedure 5 assumes that the channel has been altered, typically from past agricultural uses, and that the channel is attempting to re-establish the planform or meander belt width that suits it in this current physical setting. This is likely the case for both the subject tributaries as there is evidence of them being straightened and also impacted in subsequent agricultural practices.

Procedure 5 is an empirical approach to determining the theoretical belt width of a creek. The procedure uses three key components to determine the resultant meander belt width. They are the drainage area, gradient of the creek, and the 2-year flow. This data has been gathered and input to the formula provided from the TRCA manual.

Firstly, the stream power is calculated. The formula to determine stream power is SP = yQs, where:

SP = Stream Power (Wm^{-2})
y = specific gravity of water (9806 kg/m^2s^2)
Q = 2-year flow
s = channel gradient (m/m)

Subsequently, the formula to determine belt width is Wb=-14.827+8.319ln(SP*DA), with an R^2=0.739 and S=8.63, where:

DA = drainage area (km^2)
R^2 = Correlation coefficient of regression
S = standard error

The TRCA manual requires that for watercourses that anticipate a change in hydrology, as the subject property does, then the standard error should be doubled and added to the belt width result. The results for each tributary are provided in Table 13, along with the results of the belt width delineation as per Procedure 2. The table provides the average, maximum plus the standard error (8.63), and maximum plus standard error multiplied by 2. The table also provides the average belt width for all meander axis through the study area, along with the maximum belt width within the study area. The results show that the existing meander belt width calculated over the past 19 years of air photos is very similar to the empirical equation plus the standard error. However, the empirical equation plus two times the standard error is larger than the average belt width for both the Sheldon East Branch and Bronte Creek Tributary.

Table 13: Belt Width Procedure Comparison

Tributary	Procedure 5 Empirical BW (Avg) (m)	Procedure 5 Empirical BW (Max) (m)	Procedure 5 Empirical BW (Max x2) (m)	Procedure 2 BW (Avg) (m)	Procedure 2 BW (Max) (m)
Sheldon Creek East Branch	24.2	32.9	41.5	33.2	37.5
Bronte Creek Tributary	17.3	26.0	34.6	32.4	45.9

4.3 Meander Belt Width Application

For the existing conditions meander belt width application, the Procedure 2 in place belt width should be applied. This would be used in the scenario where the existing Sheldon Creek East Branch and the Bronte Creek Tributary would remain in place. The Procedure 2 belt width as shown on Map 1 would be used for the existing meander belt width and erosion hazard limit. The belt widths listed in Table 13 only provide maximum and average widths of the belt widths represented on Map 1.

For a scenario where the creeks are realigned and placed into a new corridor the calculated meander belt width from Procedure 5, with 1x the standard error being suitable. That provides an average meander belt width for the Sheldon Creek East Branch at 33.2 m and 32.4 m for the Bronte tributary. The larger result which uses two times the standard error is excessive, particularly given that the channel will be realigned and designed to accommodate any increased hydrology that may occur as part of the development. The newly realigned channel would incorporate a riffle-pool sequence with a calculated riffle stone size to protect the bed. In addition, the corridor will be vegetated with native grasses, shrubs, and trees which would significantly improve the riparian buffer along the low flow channel, minimizing the likelihood of excessive meandering in the future.

5.0 EROSION THRESHOLD ASSESSMENT

5.1 Overview

In natural channels it is normal to have processes of erosion and deposition occurring on a regular basis. Upstream hydrology and sediment supply can also change in a watercourse through natural processes. Typically, these changes occur over a long time period, and watercourses slowly react and adapt to the changes in the hydrology and sediment supply. Sudden changes to these factors can lead to negative effects such as severe erosion of the bed and banks of a watercourse. Therefore, it is important to ensure that changes in the hydrology do not create these adverse effects. Development of the Bronte Meadows property inherently has the potential to change the hydrology of the three watercourses within the downstream study area. An erosion threshold assessment looks at the existing potential for erosion in the watercourse on the study property as well as in the downstream reaches and provides a critical threshold where the channel is at risk of eroding the bed or banks if the threshold is exceeded. These critical thresholds can be used for planning of the stormwater management measures that are required for the development.

For this study the downstream reaches of the watercourses were used as the representative reaches. Specific cross sections that exhibited a high degree of potential for erosion were used. Conservation Halton requested that the erosion threshold assessment consider the downstream channel up to a point where the proposed development property encompasses less than 10% of the contributing drainage area. The study reaches are shown in Figure 2.

The downstream assessed reach for Sheldon Creek West Branch encompasses significantly more than the 10% of total drainage area. The on property drainage area being 0.242 km^2 while the upstream drainage area already is 7.08 km^2. The study reach between Mainway and Hwy 403 is

also a very sensitive reach and provides a conservative representation for the rest of the downstream channel.

The downstream assessed reach between Mainway and Hwy 403 for Sheldon Creek East Branch does not encompass 10% of the total drainage area that is on the development property because the upstream drainage area is very small. The on property drainage area is 0.491 km^2, which means that in order for the study area to encompass 10% or less of the drainage area the total area required would be 4.91 km^2. Calculations show that the study reach would have to extend to just above Lake Ontario at the confluence with the larger Sheldon West Branch before the total drainage area is sufficient. At this time the original study area has been retained and the justification is further discussed in the results below.

The downstream assessed reach for the Bronte Tributary went downstream to the confluence of a slightly larger tributary. The on property drainage area is 0.339 km^2, however the tributary is such a small tributary with only a 0.954 km^2 drainage area up to this confluence that it is not possible to have the development property encompass less than 10% of the overall area. The downstream study reach also captures highly sensitive eroding sections of the channel and therefore provides a conservative representation of the tributary drainage area.

5.2 Methodology

For the purposes of an erosion threshold assessment, bankfull cross-sections were surveyed at riffle or run locations because it can be expected that channel velocities and shear stresses on the bed are greatest through these sections therefore providing the most representative values. The longitudinal profile was also surveyed to determine the local energy gradient (slope). Substrate measurements either by way of Wolman pebble count or sieve sampling were completed in order to determine the particle distributions for each cross section. Cross sections and the general reach characteristics were also analyzed to determine whether it is the bed or the banks of the creek that are most at risk of erosion. The material found in the bed of the creek can be significantly larger than the material in the banks and this can lead to lateral movement of the creek rather than vertical degradation of the bed.

This detailed field data (cross-section, gradient, and particle distribution) is used to estimate the bankfull discharge, shear stress, and critical discharge values. Specifically, the critical discharge indicates the point at which sustained flows will tend to entrain and transport sediment. In this study, D_{16} of the particle distribution was used for both branches of Sheldon Creek as well as Bronte Trib since this size better represents the banks of the creek which are typically eroding in the reaches.

To determine the critical shear stress for particle entrainment, the methods presented by Komar (1987), Julien (1995) and Fischenich (2001) were used. These methods adapt and update the work of Shields (1936). The Komar method is most appropriate to gravel sized material, while Fischenich also incorporates finer material (sands). Based on the critical shear stress determined by each method, a critical depth is back-calculated and a critical discharge is determined. Then, if required, this critical discharge is applied as an erosion threshold target when controlling the flow rate and timing for stormwater releases for a range of design storm events. Otherwise, the critical discharge provides an understanding on the sensitivity of the channel to erosion.

Each cross section used in the analysis was selected to provide representative erosion thresholds for their respective reaches. Attempts were made to locate naturally formed riffles or runs for cross-sectional surveys as these provide locations where flows are concentrated, and their composition is indicative of the type of material that becomes mobilized under frequent flow conditions below and up to the bankfull discharge - before spilling onto the floodplain. Representative cross sections were selected from the downstream reaches of each of the watercourses.

5.3 Results

Using the data collected during the field investigations and desktop analysis, bankfull characteristics for cross-sections were summarized. The bankfull energy gradient and bed materials are also summarized (**Table 13**). Related hydraulic parameters were determined including stream power, unit stream power, bed shear stress at each riffle cross-section. Results are presented for both reaches (**Table 14**).

Table 13: Summary Hydraulics

Parameter	Locations		
	West Sheldon Creek	East Sheldon Creek	Bronte Tributary
Relative Roughness (m)	15.3	21.0	17.8
Shear Velocity (m/s)	0.27	0.05	0.17
Velocity based on ff/RR (m/s)	2.58	0.56	1.73
Bankfull Discharge (m^3/s)	8.17	0.15	0.52
Froude #	1.20	0.41	1.20
Stream Power (W/m)	1450.4	2.9	97.3
Unit Stream Power (W/m^2)	215.2	2.1	68.0
Mean Bed Shear (N/m^2)	73.2	2.9	30.4

Table 14: Threshold Results

Formula	Parameter	West Sheldon Creek	East Sheldon Creek	Bronte Tributary
Komar (1987)	Critical Shear (N/m2)	7.86	1.75	6.63
	Ratio of Critical Shear/Bed Shear	9.32	1.67	4.59
	Critical Depth (m)	0.04	0.09	0.04
	Critical Flow (m^3/s)	**0.03**	**0.07**	**0.01**
	Ratio of Critical Flow/Bankfull Flow	0.004	0.467	0.03
Julien (1995)	Critical Shear (N/m2)	19.26	4.49	6.48
	Ratio of Critical Shear/Bed Shear	3.80	0.65	4.69
	Critical Depth (m)	0.11	0.23	0.03
	Critical Flow (m^3/s)	**0.31**	**0.64**	**0.01**
	Ratio of Critical Flow/Bankfull Flow	0.038	4.40	0.03
Fischenich (2001)	Critical Shear (N/m2)	8.19	1.63	6.42
	Ratio of Critical Shear/Bed Shear	8.95	1.79	4.47
	Critical Depth (m)	0.05	0.08	0.03
	Critical Flow (m3/s)	**0.04**	**0.06**	**0.01**
	Ratio of Critical Flow/Bankfull Flow	0.005	0.39	0.03

Estimated bankfull hydraulics reveals that under bankfull conditions, available shear stresses are great enough to entrain particles larger than the median grainsize in the analyzed reaches. This suggests that bankfull conditions are highly favourable for bank or bed erosion. The mean bed

shear in the existing channel is also higher than the critical shear for each reach which suggests that under the existing conditions the watercourses are capable of entraining the analyzed particle size.

The different methods (Komar, Julien, and Fischenich) used produced similar results. Although the Julien and Fischenich methods are typically used for material finer than gravel, while the Komar method is used for gravels or cobbles. The West Sheldon Creek study reach had an average critical flow of 0.04 m3/s. This critical flow is very low, and the existing conditions of the channel are favourable for bank erosion and lateral migration. The bed of the creek is more armoured with course slaty material sourced from shale being found along the channel bed and is therefore much less likely to erode.

The East Sheldon Creek study reach was analyzed for the critical threshold which resulted in a critical flow of 0.32 m3/s. This reach however is highly channelized as the bed of the creek is lined with articulated concrete. On the surface of the concrete deposition of fine silty material is occurring, build up over time of this material has formed the banks of the tributary through deposition. No bed degradation is anticipated in this reach. Generally, this section of the Sheldon Creek is not at risk of severe erosion since the underlying concrete channel can accommodate much higher shear stresses than are currently occurring. The material that was used in the analysis for the threshold was the fine bank material that was deposited in the reach. The study reach was not extended further downstream than Hwy 403 since the results of the threshold analysis already provides a highly sensitive result due to the fine material. The sensitivity is not likely to greatly increase based on additional sections of the creek downstream.

The Bronte Creek tributary had an average critical flow of 0.04 m3/s. The channel showed signs of knickpointing in a few different locations in the study reach and therefore the bed material was used for the critical threshold analysis. This study reach of the Bronte Creek tributary is highly favourable for bed and bank erosion.

Continuous modelling using the results of the erosion threshold assessment should be completed to determine the erosion exceedance through the study reach based on the proposed conditions of the development property. Stormwater management measures may be required for each of the three study reaches based on the results of the modelling.

5.3 Continuous Modelling Results

While several criteria can be used to compare pre- and post-development exceedances, ones which quantify effects following exceedance are generally valued over those that simply identify the number of exceedances or time in exceedance. Continuous modelling was completed by MTE and based upon the TRCA Stormwater Management Criteria (2012), Water's Edge has completed additional flow exceedance analyses for the following:

- Cumulative effective shear stress:

$$CESS = \sum(\tau - \tau_c)$$

- Cumulative effective velocity:

$$CEV = \sum(V - V_c)$$

- Cumulative erosion index:

$$E_i = \sum(V - V_c) \cdot \Delta t$$

- Cumulative effective work (cumulative effective unit stream power):

$$W_i = \sum (\tau - \tau_c) \cdot V \cdot \Delta t$$

Where τ is instantaneous shear stress, V is mean channel velocity, Q is channel discharge, and Δt is time step (1 hour in these analyses). Subscript 'c' designates 'critical'

The critical velocity and shear stress values utilized in the analyses are those presented above. In this case, the continuous modelling was performed with an hourly timestep, and cumulative effective velocity is therefore equal to cumulative erosion index in terms of comparative value between pre- and post-development scenarios.

The results of the continuous modelling were used in conjunction with a stage-discharge relationship for the representative cross-section in each reach. The representative cross-section was selected as the one with physical ratios (width/depth) most closely matching the reach average but conservative physical dimensions (bankfull area, etc.).

Table X.3: Exceedance Analysis over 31-year period (1985-2015 incl.)

Parameter	Sheldon Creek (SCWB)			Sheldon Tributary (SCEB)			Bronte Tributary (BCT)		
	Pre-Dev	Post-Dev	% Diff.	Pre-Dev	Post-Dev	% Diff.	Pre-Dev	Post-Dev	% Diff.
CESS	-1206439	-1186897	+1.62	29740	29414	+1.10	-1621668	*	*
E_i	35636	36368	+2.05	32535	32548	+0.04	12263	*	*
W_i	297246	312654	+5.18	96174	93340	-2.95	-4182	*	*

*Pending final modelling results

Table 3 shows increases are generally within 3% between pre-and post-development scenarios. The one exceedance of 5% in the cumulative work is attributed to the increase in velocity observed in a conservatively selected cross-section (with reduced flow area). This effect is evident when compared to the smaller change in cumulative effective shear stress through the reach. Over such a long period, the slight subjectivity in conservative cross-section selection and modelling parameters may also contribute to greater changes than would be expected.

The negative Work Index for the Bronte Tributary under existing conditions is attributed to the minor/intermittent flow in the channel, whereby minimal depth results in minimal shear stress which is smaller in magnitude than the critical shear stress. The same can be said for the cumulative effective shear stress values.

Ultimately, the Erosion Indices expected within the Sheldon Creek reaches indicate limited change between pre- and post-development conditions. This is especially true in reaches which are already prone to erosion during bankfull (or smaller) events. Hydrologic changes in the upstream catchments may currently be enacting geomorphic change that would further limit the influence of the proposed developments.

6.0 CHANNEL REALIGNMENT

Realignment of the Sheldon Creek East Branch and the Bronte Tributary are proposed. The realignments are proposed for the overall benefit of the watercourses. Both of the channels are currently heavily impacted by historical agricultural practices. The results of the interference with the watercourses includes heavy erosion through the main section and resultant deposition near the lower end. The realignment of the channels will rectify the erosion and depositional issues as well as increase habitat and fish passage.

The channels are to be placed in corridors that accommodate the meander belt width of each creek at the bottom of the corridor. Design of each of the channel realignments should be completed using natural channel design principles. The design should consider the existing topography and substrate found at the site. The proposed designs should also look to improve the erosion and depositional processes that are occurring in the existing channels. Improving fish habitat and passage is also a consideration during detailed design.

A section of the East Sheldon Branch that lies within the woodlot north of Mainway is also proposed to be realigned as part of the modification to the creek block through the development property. The section is required to be realigned in order to accommodate the slope of the corridor. The section of the creek through the woodlot is significantly different than the upper portion of the tributary which flows through an agricultural field and has been heavily impacted by the farming practices. The section in the woodlot has a well defined channel that has not been altered within the last few decades as is noted by the mature woodlot surrounding the channel. However, the banks of the creek are erodible and are undergoing constant erosion. This is exhibited in the undercut banks, exposed roots, and fallen trees. The bed of the channel however has generally stabilized and is not degrading vertically. This is likely due to the grade control structure immediately north of Mainway.

This section of the channel is naturalized however it is unstable with fallen and undercut trees being common. Leaving this section of the watercourse in its current state would continue the lateral erosion trends and cause further tree falls which can create log jams at the Mainway culvert. Therefore, it is recommended that the entire length of the Sheldon Creek East Branch through the woodlot up to the grade control structure north of Mainway be realigned using natural channel design principles. The natural channel design would also be designed to accommodate any erosion exceedances from increased stormwater flows.

7.0 RECOMMENDED MONITORING PLAN

A monitoring plan is proposed for the constructed natural channel corridor. The purpose of the post-construction monitoring is to ensure the long-term stability of the constructed channel and wetland areas as well as to ensure that the either the channel and wetlands are functioning as designed or that the channel is not functioning as designed but it has reached a quasi-equilibrium and is stable. The following components form the basis of the fluvial geomorphological component of the monitoring program:

1. Post Construction Inspection and As-Built survey to establish the baseline for future monitoring,
2. Inspections to occur at years 1, 3, and 5 after construction,
3. Photographic records taken at the same location and viewpoint,
4. Geomorphic survey along the entire constructed channel profile during inspections,
5. Geomorphic survey through the representative cross sections that will be monumented for consistency,
6. Assessment of substrate characteristics during inspections,
7. Visual assessments of erosion and sedimentation patterns within the channel.

Reporting will be completed for each of the post-construction inspections (post-construction and years 1, 3, and 5). Reports will be forwarded to the CH for review. Along with the results of the inspection, the reports will outline any deficiencies or failures of the channel such as instability, erosion, or sedimentation. The report will summarize the results of the monitoring program and provide any necessary conclusions and recommendations.

In the event of any erosion, failure, or noticeable deviation from the functional design of the channel the site will be assessed to determine the cause of the issue and to understand whether the failure is critical enough that it requires remediation or if it is an acceptable change in the nature of the

channel that does not affect its long-term stability. It is understood that natural channels are dynamic and are regularly altered based on changes to the surrounding systems and this also applies to designed channels. If the issue is a noticeable yet stable change to the system, the changes will be addressed in the yearly monitoring report, but no action will be taken. In the event that the issue is a significant failure of the channel function a report will be prepared that outlines the concern and nature of the issue. The report will be forwarded to the CH, and a follow up meeting will be organized to discuss the next steps prior to any remediation implementation. Any subsequent work required to correct the issue will be coordinated by a Fluvial Geomorphologist and confirmed with CH staff.

8.0 SUMMARY AND RECOMMENDATIONS

The following is a summary of the fluvial geomorphic and erosion assessment for Bronte Meadows property:

- Alinea Land Corporation has requested a fluvial geomorphological assessment to support development of the Bronte Meadows property.
- The Study Reach of Sheldon Creek crosses the property with 2 tributaries and a Bronte Creek Tributary runs northwest to southeast through the west side of the property.
- The physiography under the watershed is escarpments and till plains and the channel substrate is mostly silty clay and small gravels in the study area.
- Through a geomorphic analysis of the existing conditions West Sheldon Creek Upstream is noted to have a maximum bankfull depth of 0.6 m and a bankfull width of 5.3 m, West Sheldon Creek Downstream is noted to have a maximum bankfull depth of 0.63 m and a bankfull width of 6.81 m, East Sheldon Creek Upstream is noted to have a maximum bankfull depth of 0.33 m and a bankfull width of 2.43 m, and East Sheldon Creek Downstream is noted to have a maximum bankfull depth of 0.30 m and a bankfull width of 1.23 m, Bronte Creek Tributary Upstream is noted to have a maximum bankfull depth of 0.09 m and a bankfull width of 0.84 m, while downstream has a 1.34 m width and 0.30 depth.
- Rapid assessments of the creek using RGA and RSAT forms suggest that both reaches of West Sheldon Creek are in adjustment condition and have fair form and function, East Sheldon Creek Upstream is in transitional condition and has fair form and function, and East Sheldon Creek Downstream is in regime condition and has fair form and function, Bronte Tributary is in transitional and has fair form and function.
- Through historical air photo analysis and looking at the site photos, it is noted that the West Sheldon Creek is highly eroding at the study site with signs of basal scour, tree root exposure and fallen/leaning trees. East Sheldon Creek has basal scour at some points and the substrate has small particles, which are easily eroded. The Bronte Tributary is small but shows minor signs of erosion and modification.
- Geomorphic analysis completed on the watercourses was used to determine the erosion threshold for each reach. Continuous modelling has shown minimal exceedances of relevant erosion indices.
- Channel realignment has been proposed for the East Sheldon tributary as well as the Bronte Tributary, it is recommended that these channels be realigned using natural channel design principles.
- A monitoring plan has been recommended to ensure that the implemented watercourse realignments are successful in the long-term.

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References

Chapman, L. J. and D. F. Putnam. 1984. The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2, Ontario Ministry of Natural Resources, Toronto.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York

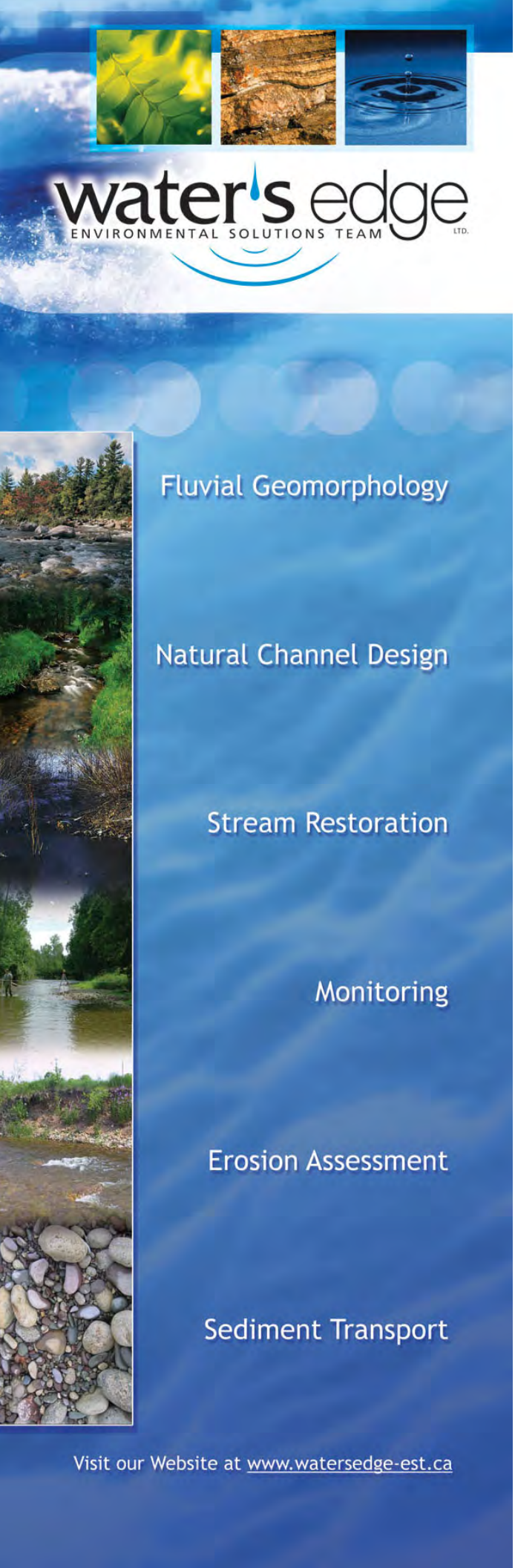
Galli, J. et al. 1996, *Rapid Stream Assessment Technique (RSAT) field methods*. 36 pp. Metropolitan Washington Council of Governments, Department of Environmental Programs, Washington, DC.

Pemberton E.L & Lara, J.M., 1984. "Computing Degradation and Local Scour." Technical Guideline for Bureau of Reclamation, U.S. Department of Interior, Bureau of Reclamation, Denver, CO.

Simons Li & Associates. 1985. "Design Manual for Engineering Analysis of Fluvial Systems." Prepared for Arizona Department of Water Resources.

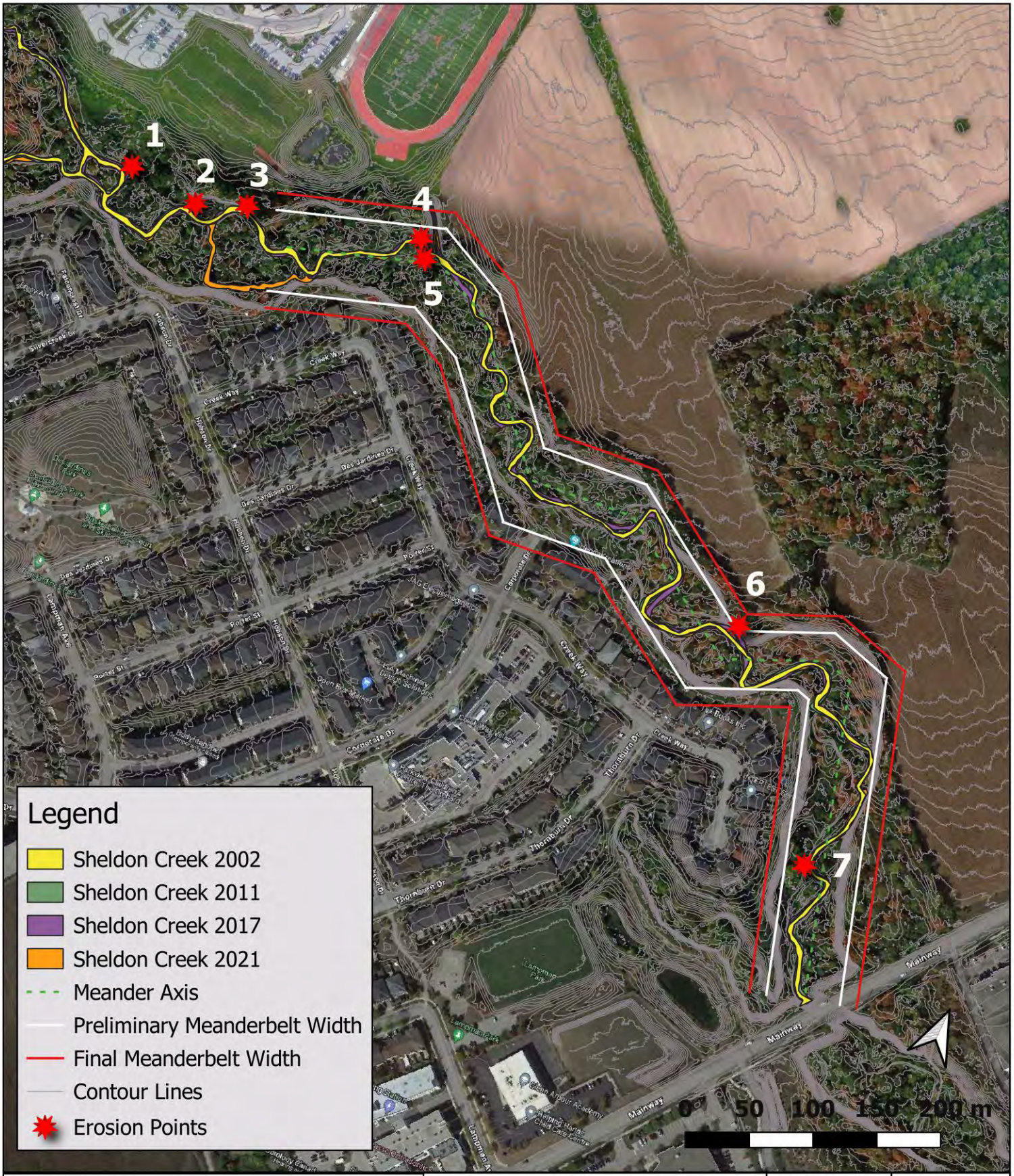
Ministry of Natural Resources and Forestry (MNRF) 2016. Guidance for Development Activities in Reside Dace Protected Habitat. Version 1.2 Ontario Ministry of Natural Resources and Forestry.

MTE, 2026. Bronte Creek Meadows Development – Preliminary Geotechnical Investigation.

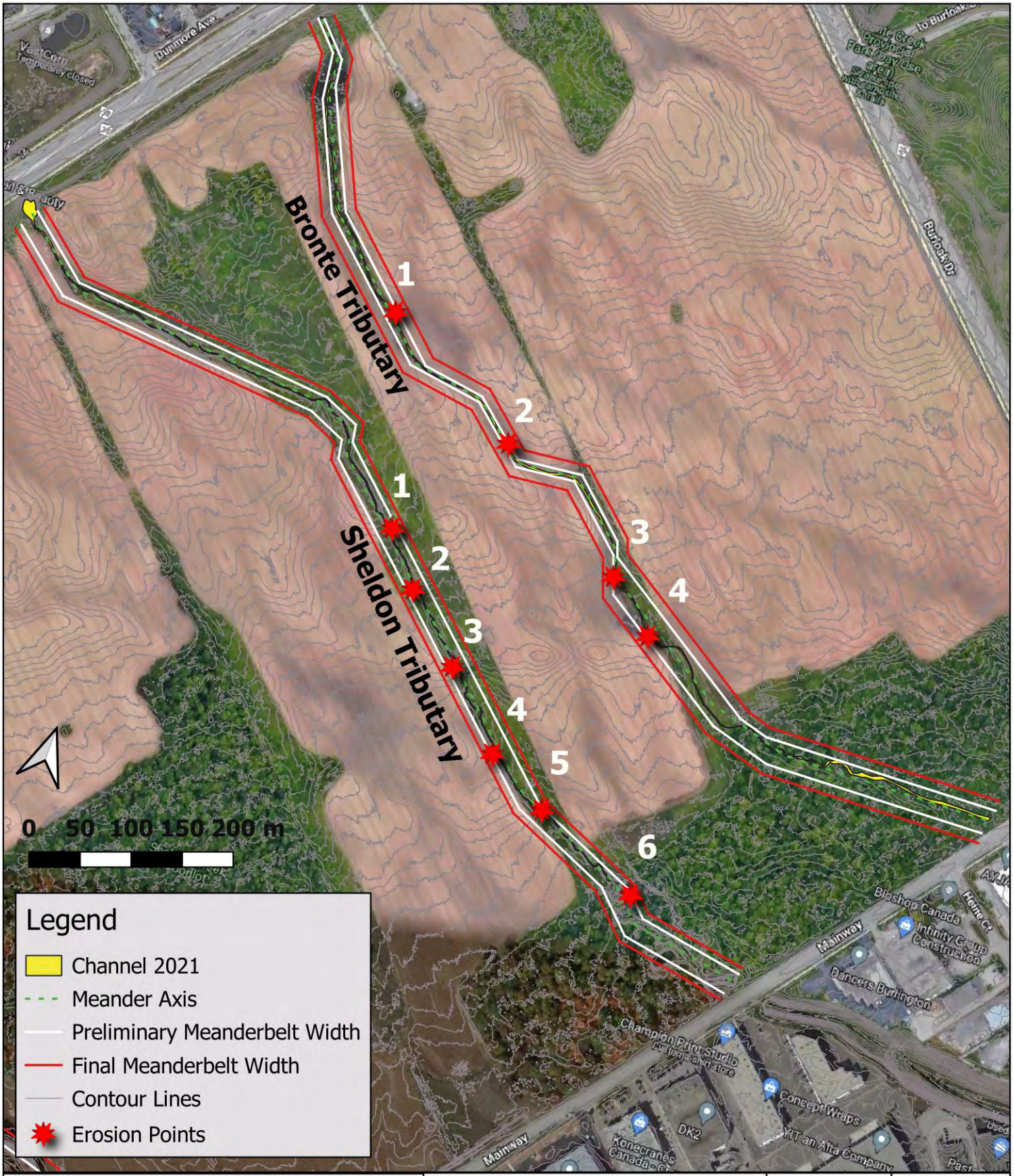


APPENDIX A:

Maps



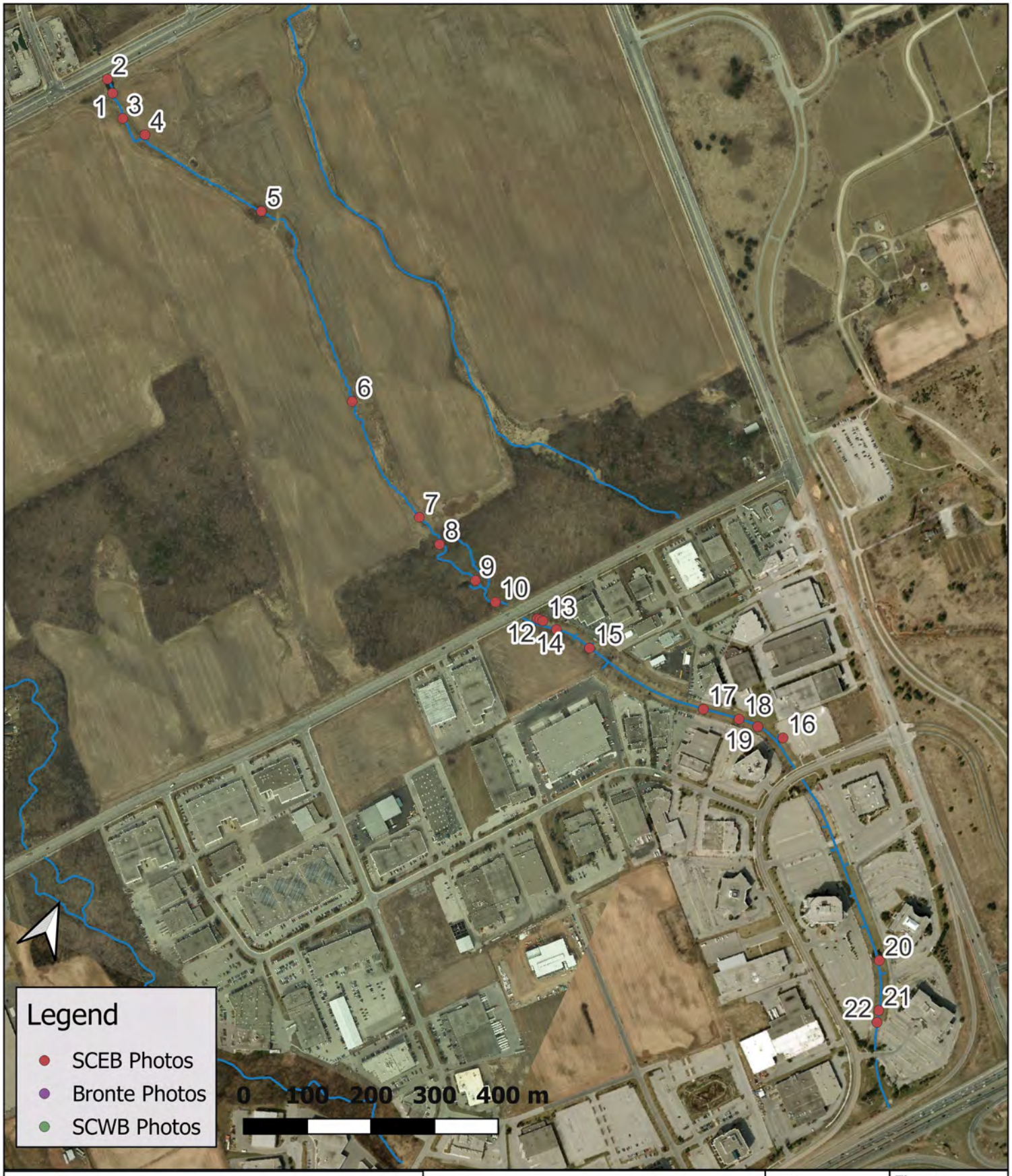
waters edge ENVIRONMENTAL SOLUTIONS TEAM LTD.	Bronte Meadows City of Burlington	Date: Nov. 30, 2023	Figure: Map 1
	Meander Beltwidth Assessment of Sheldon Creek	Checked By: NG	Drawn By: AM



waters edge ENVIRONMENTAL SOLUTIONS TEAM LTD.	Bronte Meadows City of Burlington	Date: Nov. 30, 2023	Figure: Map 2
	Meander Beltwidth Assessment of Sheldon and Bronte Tributtaries	Checked By: NG	Drawn By: AM



water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD.	Bronte Meadows City of Burlington	Date: Feb 10, 2026	Figure: Map 3
	Sheldon Creek West Branch Photo Locations	Checked By: NG	Drawn By: MB



waters edge ENVIRONMENTAL SOLUTIONS TEAM LTD.	Bronte Meadows City of Burlington	Date: Feb 10, 2026	Figure: Map 4
	Sheldon Creek East Branch Photo Locations	Checked By: NG	Drawn By: MB



waters edge ENVIRONMENTAL SOLUTIONS TEAM LTD.	Bronte Meadows City of Burlington	Date: Feb 10, 2026	Figure: Map 5
	Bronte Tributary Photo Locations	Checked By: NG	Drawn By: MB



APPENDIX B:

Photo Appendix

BRONTE TRIBUTARY UPSTREAM (APRIL 2023):



FROM: Bronte Tributary Upstream Culvert
LOOKING: Downstream
COMMENT: The creek is highly vegetated when the water comes out of the culvert.



FROM: Upstream Culvert
LOOKING: Upstream
COMMENT: The culvert outlet is covered with vegetation



FROM: Upstream of the creek
LOOKING: Downstream
COMMENT: The channel is not well defined at this section. The channel is made with loose materials.



FROM: Downstream of the channel
LOOKING: Upstream
COMMENT: As it gets closer to downstream the channel gets narrower and deeper. However, it is still highly erodible.



FROM: Downstream of the creek
LOOKING: Downstream
COMMENT: The channel becomes wider at this location.

BRONTE TRIBUTARY DOWNSTREAM



FROM: Culvert on east side of Burloak Drive, in Bronte Creek Provincial Park
LOOKING: At culvert and outlet of Bronte Trib
COMMENT: Channel is lined with rip rap



FROM: In Bronte Creek Provincial Park
LOOKING: Downstream
COMMENT: This section of the creek was realigned and protected in areas. Mostly sedimented in since.



FROM: Downstream of the realigned section.
LOOKING: Downstream
COMMENT: Channel is entrenched and has degraded due to knickpointing



FROM: Open field area near Dog Park
LOOKING: Downstream
COMMENT: The channel is at times undefined through this section. At the time of the visit this section was completely dry. Assumed that water was percolating through the area.



FROM: Downstream end of open area.
LOOKING: Downstream at road crossing.
COMMENT: The channel becomes steeper and entrenched again. Heavy bed and bank erosion.



FROM: Downstream of the road.
LOOKING: Downstream towards flat wet area.
COMMENT: Channel is defined for a short section before entering a low lying wetland type of area.



FROM: The end of the Bronte Tributary Stud Reach.
LOOKING: Downstream towards confluence with another slightly larger trib before flowing into Bronte Creek.
COMMENT: Channel is mostly undefined and is more of a wetland feature than a channel.

EAST SHELDON CREEK UPSTREAM (APRIL 2023):



FROM: Upstream of the creek at the study site (upstream culvert)
LOOKING: Upstream
COMMENT: There is a pool downstream of the culvert. The channel starts with boulders downstream of the pool.



FROM: Upstream of the Creek
LOOKING: Downstream
COMMENT: There is a pool downstream of the culvert.



FROM: Upstream of the study area
LOOKING: Upstream
COMMENT: The channel gets wide and shallow downstream of the pool.



FROM: At the study area
LOOKING: Upstream
COMMENT: The channel is covered with hay. The channel is deep and narrow at this location.



FROM: At the study area
LOOKING: Upstream
COMMENT: The channel is narrow and deep and the channel banks are made of loose materials.



FROM: At the study site
LOOKING: Right bank
COMMENT: Basal scour and exposed tree roots are observed at this location.



FROM: At the study area
LOOKING: Upstream
COMMENT: Signs of erosion such as tilted and fallen trees can be seen at this location of the creek.



FROM: Downstream of the study area
LOOKING: Downstream
COMMENT: Right bank is failing. Exposed tree roots can be seen.



FROM: Downstream of the study area
LOOKING: Upstream
COMMENT: Basal scour and bank erosion can be seen at this location.



FROM: The downstream of the study area
LOOKING: Downstream
COMMENT: The channel is protected right upstream of the downstream culvert.

EAST SHELDON CREEK DOWNSTREAM



FROM: Upstream end of study area
LOOKING: Upstream
COMMENT: The upstream culvert (under Mainway) and weir structure can be seen in this picture



FROM: Left bank, near upstream end of study area
LOOKING: Across channel to right bank
COMMENT: Very narrow channel with limited riparian buffer



FROM: Left bank
LOOKING: Downstream/right bank
COMMENT: Gently sloping banks on both sides of the channel



FROM: Centre of channel
LOOKING: Upstream
COMMENT: Articulated concrete blocks lining the channel



FROM: Centre of channel
LOOKING: Downstream
COMMENT: Articulated concrete blocks lining the channel



FROM: Top of left bank
LOOKING: Upstream/right bank
COMMENT: Limited riparian zone and canopy coverage



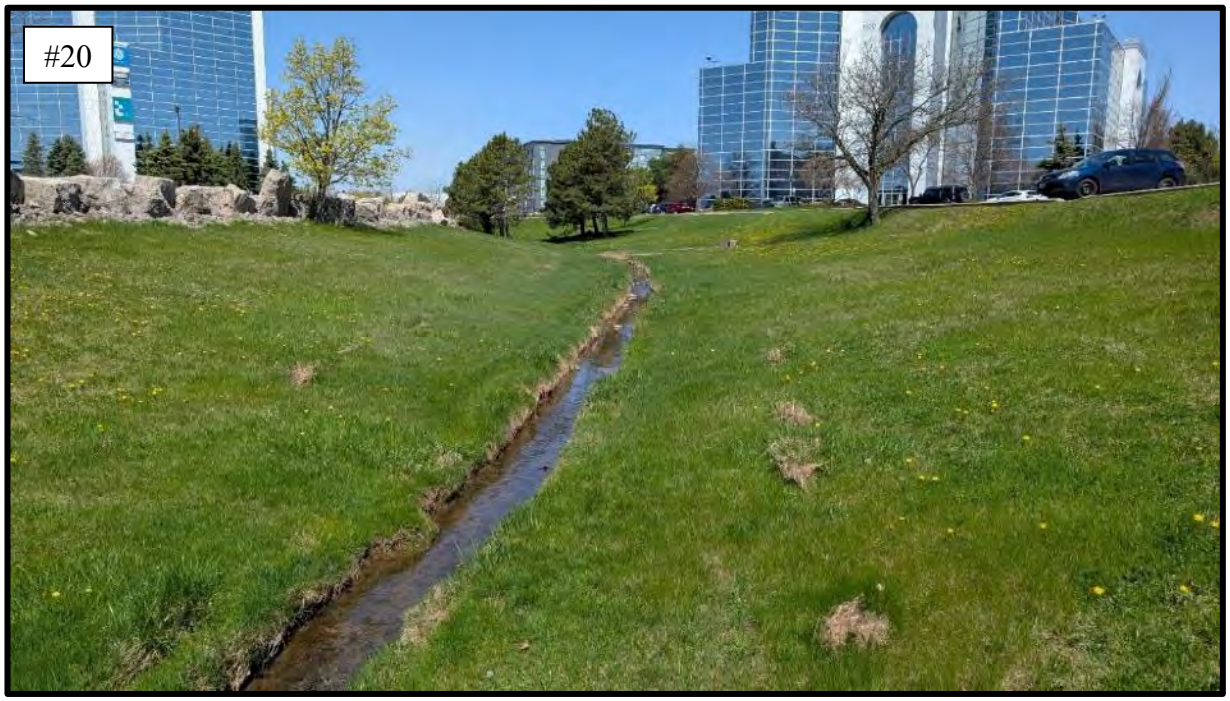
FROM: Centre of channel
LOOKING: Upstream
COMMENT: Stagnant water, some basal scour visible



FROM: Left bank
LOOKING: Downstream
COMMENT: Stagnant water and siltation



FROM: Left bank
LOOKING: Down at channel/upstream
COMMENT: Layer of siltation on articulated concrete blocks



FROM: Right bank
LOOKING: Downstream/left bank
COMMENT: Typical conditions throughout majority of reach.



FROM: Left bank
LOOKING: Downstream towards driveway culvert
COMMENT:



FROM: Centre of channel, downstream extent of reach
LOOKING: Armourstone-lined control structure/driveway culvert
COMMENT:

WEST SHELDON CREEK UPSTREAM (APRIL 2023):



FROM: Downstream of the upstream culvert
LOOKING: Upstream
COMMENT: Upstream Culvert can be seen in this picture.



FROM: Upstream end of the creek
LOOKING: Downstream
COMMENT: Exposed tree roots and fallen trees can be seen as signs of erosion at this location.



FROM: At the study area
LOOKING: Upstream
COMMENT: The channel divides into two branches and they connect again at some point downstream.



FROM: At the study area
LOOKING: Upstream
COMMENT: Formation of island at some point along the channel.



FROM: At the study area
LOOKING: Downstream
COMMENT: Log jam



FROM: At the study area
LOOKING: Left bank
COMMENT: Banks are failing and exposed tree roots can be seen in this picture.



FROM: At the study area
LOOKING: Downstream
COMMENT: Exposed tree roots and tilted/fallen trees can be seen as signs of erosion.



FROM: At the study area
LOOKING: Upstream
COMMENT: Left bank is failing. Basal scour and fallen trees can be seen at this bend.



FROM: Centre of creek
LOOKING: Downstream
COMMENT: Left bank is unstable with signs of erosion. Right bank is fairly stable.



FROM: Downstream end of the study area
LOOKING: Downstream
COMMENT: Fallen trees and exposed tree roots can be seen.



FROM: Centre of creek
LOOKING: Downstream
COMMENT: Left bank is unstable with signs of erosion. Right bank is fairly stable.



FROM: Downstream end of the reach, centre of the creek.
LOOKING: Downstream
COMMENT: The downstream culvert can be seen in this picture.

WEST SHELDON CREEK DOWNSTREAM (APRIL 2025):



FROM: Left bank
LOOKING: Upstream at Mainway culvert
COMMENT: Banks protected with rip rap on either side (covered by deposition mostly).



FROM: Centre of channel, downstream of Mainway culvert
LOOKING: Downstream
COMMENT: Large woody debris in channel, point bar accretion



FROM: Left bank
LOOKING: Downstream/right bank
COMMENT: Basal scour and bank overhang visible



FROM: Centre of channel
LOOKING: Downstream
COMMENT: Large woody debris on banks



FROM: Left bank
LOOKING: Upstream
COMMENT: Exposed shale, fallen and leaning trees



FROM: Centre of channel
LOOKING: Upstream/right bank
COMMENT: Exposed shale in bank, fallen and leaning trees



FROM: Centre of channel
LOOKING: Upstream
COMMENT: Exposed shale in bank



FROM: Right bank
LOOKING: Upstream/left bank
COMMENT: Exposed roots, basal scour, fallen/leaning trees



FROM: Centre of channel
LOOKING: Left bank
COMMENT: Erosion monitoring location, basal scour, bank overhang, exposed roots



FROM: Left bank
LOOKING: Across channel at right bank
COMMENT: Large debris jam



FROM: Centre of channel
LOOKING: Downstream
COMMENT: Exposed shale bank



FROM: Left bank
LOOKING: Upstream
COMMENT: Weir structure



FROM: Left bank
LOOKING: Downstream
COMMENT: Large point bar formation



FROM: Right bank
LOOKING: Downstream/left bank
COMMENT: Large debris jam



FROM: Centre of channel
LOOKING: Upstream
COMMENT: Rip rap and manmade knick points



FROM: Centre of channel
LOOKING: Downstream at Sutton Drive culvert
COMMENT: Articulated concrete blocks line bottom of channel



FROM: Left bank
LOOKING: Right bank/downstream end of Sutton Drive culvert
COMMENT: Articulated concrete blocks lining banks



FROM: Centre of channel, downstream of Sutton Drive culvert
LOOKING: Downstream
COMMENT: Rip rap lining bottom of channel and left bank