APPENDIX

H

MEANDER BELTWIDTH ASSESSMENT REPORT

water's edge
ENVIRONMENTAL SOLUTIONS TEAM LTD.

Mount Pleasant GO Station

Brampton, On

Fluvial Geomorphological and Meander Beltwidth Assessment

October 2, 2017
(Revised November 28, 2019)

October 2, 2017
Revised Nov. 28, 2019
WE 14019

Mr. Mehemed Delibasic, M.Sc. (Env.), P. Eng.
Manager / Transportation Planning
WSP
600 Cochrane Drive, 5th Floor
Markham, Ontario
L3R5K3

Dear Mr. Delibasic:

RE: East – West Connector Class EA (Mount Pleasant GO Station to West of Mississauga Road)
Fluvial Geomorphological Assessment
City of Brampton, Ontario

Water's Edge as part of the WSP study team completed a fluvial assessment in conjunction with the environmental assessment for the East – West Connector Class EA by Mississauga Road. The study area is located within the Huttonville Creek subwatershed of the Credit River. This report outlines the following details about the channels located within the study area:

- Geomorphic Field Assessments and Surveys (Water's Edge); and
- Aerial photography; 1974, 1985, 1991 (City of Brampton)
- Aerial photography; 2013 (WSP)
- Desktop analysis of survey details
- OFAT III (MNRF)

Site inspections and a geomorphic survey of the study area were completed by Water's Edge staff in October 2014. The site inspection was undertaken after an initial review of the mapping and available literature was completed in order to confirm site and general system characteristics.

1.0 EXISTING CONDITIONS

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 underlying surficial geology.

The study area is in the South Slope physiographic region and within a drumlinized till plain landform. The South Slope is characterized as a drumlinized area with thin sand deposits underlain by glacial till deposits.

General Watershed Characteristics

The study area is in the Huttonville Creek subwatershed of the Credit River. Historically the majority of the subwatershed is farmland although this is rapidly changing. The East Branch is currently under development while the East Branch remains completely agricultural. The East Branch has a drainage area of approximately 4.5 square kilometres upstream of the confluence. The East Branch also has a drainage area of 4.5 square kilometres upstream of the confluence. Roughly 280 metres downstream of Bovaird Dr. the total drainage area is 9.7 square kilometres. Drainage area can be seen in Figure 1. The two branches that join to begin Huttonville Creek both start at Mayfield Road and flow through mainly agricultural lands until they meet just north of

Bovaird Drive in the study area. Huttonville Creek then continues on through residential areas picking up approximately 5 other tributaries until the confluence with the Credit River just south of Queen Street.

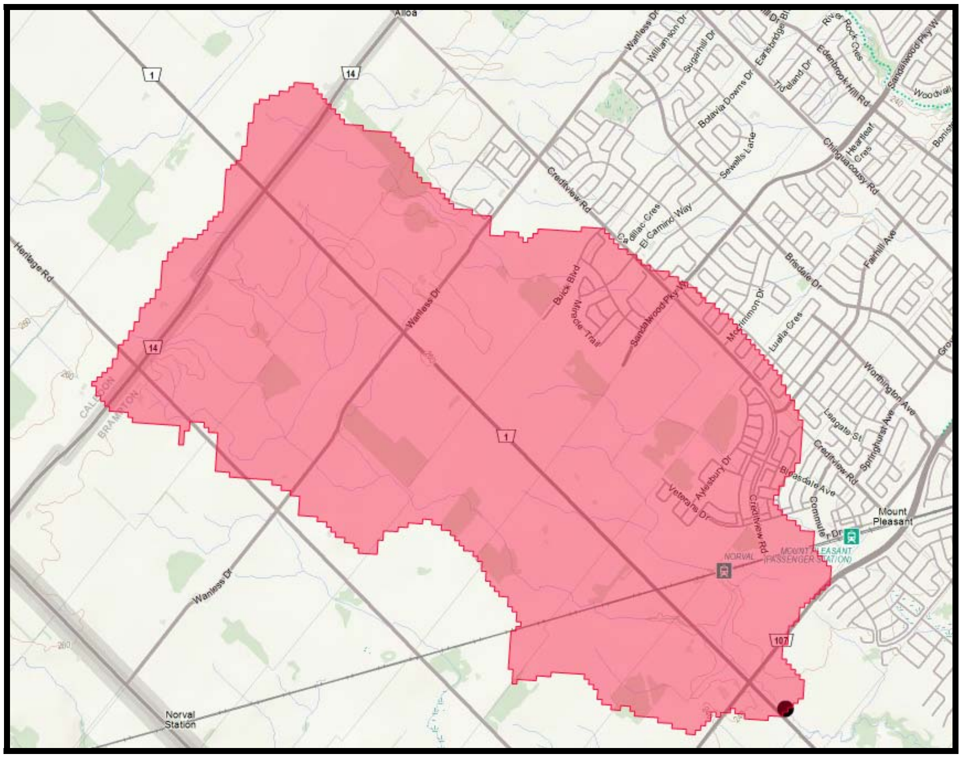

Figure 1: Drainage Area to end of Study Reach (OFAT III)

Channel Characterization

Figure 2 presents an aerial photograph of the site using a 2013 air photo. In addition to confirming our desktop assessment, field reconnaissance and a topographical survey included the determination of various geomorphic parameters. Details regarding these parameters can be seen in Table 1 which is separated into reaches. Multiple cross sections were surveyed at the site along with a longitudinal profile of the extending creek to gain reference data. The data was analyzed and the specific channel characteristics were determined. The site was also split into 4 separate reaches based on channel characteristics, vegetation and/or road separation. Reach delineation can be seen in Figure 2. Table 1 outlines the general characteristics of each of the four reaches.

Figure 2: Location of Site with Reach Breaks (2013 Air Photo)

Table 1: General Reach Characteristics

Reach	Characteristics
1	Natural channel with mainly grassed banks, few trees and shrubs Good pool/riffle pattern and profile Substrate is gravel and cobble with some sands Riparian is grassed with few trees and shrubs
2	Realigned channel with grassed banks and riparian zone Good pool/riffle pattern and profile Good in-stream cover Substrate is gravel with some cobbles and sands
3	Natural channel with grassed banks and well vegetated with trees and shrubs Average amounts of woody debris Good in-stream habitat with deep pools and ample cover Substrate is gravel and cobble with some sands
4	Natural channel vegetated with trees and grasses Wide and flat channel with poor riffle/pool profile Large amounts of woody debris Substrate is gravel and cobble with some sands

2.0 Detailed Field Data Collection

Beyond desktop and synoptic level assessments, detailed field surveys were conducted to determine the actual form of the channel, characterize its bed material and then assign a common stream type based on the Rosgen classification. These detailed surveys focused on the bankfull channel cross-section to collect data. The term 'bankfull' refers to the point at which flows are contained entirely within the active channel cross-section before spilling onto the floodplain. This geometry is reflective of the dominant forces acting upon the channel as it attempts to develop a dynamic equilibrium and stability. The following text and Table 2 summarize detailed data for each reach. Typical photos are available in Appendix B.

Reach 1 runs parallel to Mississauga Road. The reach begins at the confluence of the east and west branches approximately 200 metres upstream of Bovaird Drive and continues for 200 metres downstream of Bovaird. The reach there has a single thread, sinuous channel. Five riffle cross section were surveyed in this reach and one pool. The channel here is only slightly entrenched and the Width/Depth ratio is low. The bankfull slope is relatively low at 0.0051 m/m. The general bankfull width is approximately 2.75 m. The channel sinuosity is 1.12. The channel was predominantly covered by gravels and cobbles with some sand. For the purposes of communicating the characteristics of the stream, the reach can be considered a Rosgen C3/4.

Reach 2 is the East Branch in the study reach and begins at the railway. This reach is 550 metres in length. The channel has been realigned in the past although the date is unknown. Six cross-sections were surveyed in this reach. The typical channel in this reach is slightly entrenched and has a Width/Depth ratio of 11.07 which is low. The bankfull slope is low at 0.0062 m/m and the general bankfull depth is 0.48m while the bankfull width is 2.64m. The channel sinuosity is low due to its previous straightening. The channel substrate is gravels with few cobbles and sands. For the purposes of communicating the characteristics of the stream, the reach can be considered a Rosgen C4.

Reach 3 is on the East Branch and begins at Mississauga Road where it continues for 230 metres until the confluence with the East Branch. One cross section was surveyed in this reach and the following details observed. The channel here is not entrenched and the Width/Depth ratio is moderate to high (14.78). The bankfull slope is relatively low at approximately 0.0064 m/m. The general bankfull width is 3.99m and bankfull depth is 0.51m. The channel sinuosity is 1.16. The channel was predominantly cobbles and gravels with some sands and siltation in pools. For the purposes of communicating the characteristics of the stream, the reach can be considered a Rosgen C3/4.

Reach 4 is part of the East Branch in the study reach. The reach begins at the railway and continues until it passes under Mississauga Road. The reach is a single thread channel with low sinuosity. Three cross section were surveyed in this reach. The channel here is not entrenched and the Width/Depth ratio is low at 10.96. The bankfull slope is relatively low at 0.0054 m/m. The general bankfull width is approximately 2.97m. The channel had a predominantly gravel and cobble bed with some sands and siltation in the pools. For the purposes of communicating the characteristics of the stream, the reach can be considered a Rosgen C3/4.

In summary, and for the purposes of communicating the characteristics of the channel, the typical classification for the studied natural reaches would be a Rosgen C3/4 channel.

Reach	1	2	3	4
Bankfull Width (m)	2.75	2.64	3.99	2.97
Bankfull Depth (m)	0.43	0.48	0.51	0.55
Width-Depth Ratio	11.03	11.07	14.78	10.96
Entrenchment Ratio	3.01	3.13	4.23	5.03
Bankfull Slope (m/m)	0.0051	0.0062	0.0064	0.0054
Sinuosity	1.12	1.06	1.16	1.07
Substrate D_{50} (mm)	Cobble/ Gravel	Gravel	Cobble/ Gravel	Cobble/ Gravel

Table 2: Summary of Channel Morphology and Substrates for Reaches

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 Huttonville Creek and tributaries in the study area, we used Rapid Geomorphic Assessment and Rapid Stream Assessment Technique. The raw worksheets for these assessments can be found in Appendix C.

Rapid Geomorphic Assessment (RGA)

Creek stability was assessed using a Rapid Geomorphic Assessment (MOE, 2004). The RGA assessment focuses entirely on the geomorphic component of a river system. 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. This methodology has been applied to numerous streams and rivers and the following table details the ranking criteria (see Table 3A and 3B).

The scores for the reaches of the study area were determined to range from 0.18 to 0.33. Any score below 0.18 can be considered to be indicative of an “In Regime” channel, or a channel that is relatively stable. Between the scores of 0.21 and 0.40, which reaches 2 and 3 fall within, a channel is described as transitional/stressed, meaning there are signs of instability.

Reach	RGA Score	Classification
1	0.18	In Regime
2	0.33	Transitional/Stressed
3	0.33	Transitional/Stressed
4	0.16	In Regime

Table 3A: Results of RGA Assessments

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 wide spread.

Table 3B: Interpretation of RGA Score

Rapid Stream Assessment Technique (RSAT)

Rapid Stream Assessment Technique 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. It 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 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). Observations were noted and cross-section measurements were made.

A rapid assessment of soil conditions along the river banks is also conducted to determine 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 4 details the range of scores and rankings with a higher score suggesting a healthier system.

Within these broad categories, we evaluated the study area and determined an average RSAT score of 23.5. In general, the creeks within the study area, are a "fair" system. A reach by reach breakdown score indicates that the downstream most reach is in a "good" condition, while reach 2 and 3 are "poor". Reach 4 which is on the East Branch in the study area, was ranked as "fair" A possible reason for the downstream most reach scoring higher than the other reaches is that this reach is the most "natural" reach in the system. Other reaches have been altered and have undergone some form of channelization to accommodate developments.

Reach	RSAT Score	Ranking
1	31	Good
2	19	Poor
3	18	Poor
4	26	Fair

Table 4A: Results of RSAT Assessment

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

Table 4B: Interpretation of RSAT Score

4.0 MEANDER BELTWIDTH ASSESSMENTS AND 100 YEAR EROSION ASSESSMENT

Assessment of the meander beltwidth is undertaken in accordance with the CVC's Fluvial Geomorphic Guideline Fact Sheet 3.0 in addition to the Toronto Region Conservation Authority's Beltwidth Delineation Procedures manual. It has been assumed that there will be no change in the upstream hydrology as any future development upstream will require sufficient controls that post-development hydrology will match that of existing conditions. The confinement of a channel also has implications when determining beltwidths, where typically a confined channel has additional setbacks due to slope processes that can require slope stability analysis as well as toe erosion allowance. An unconfined channel on the other hand only takes into account the erosion of a channel and its migration. It has been determined that the reaches of Huttonville Creek in the study area are unconfined channels, meaning they are not restricted in their lateral migration by valley walls.

Historic Analysis

We have acquired and examined 1954, 1974, 1985, 1991, 2002 and 2013 aerial photography. Planform changes of the river alignment since 1954 have been examined. Air photos from 1954 and 1974 were reviewed and analyzed but not used in the beltwidth determination. The 1991 air photo was also not used due to poor photo quality. Meander assessments typically require a minimum 30-year historical analyses. From a historical aerial perspective, it can be seen that both branches are relatively stable systems. Even when comparing 1954 to present there is very little planform change in the channel and the meander axes.

The majority of the East Branch (Reach 2) is typically a straightened channel flowing through agricultural land. As it approaches the confluence the East Branch begins to exhibit a more unrestricted natural meander.

The East Branch shows natural meanders throughout Reaches 3 and 4 and show little movement from a historical perspective. After the confluence (Reach 1) the channel travels south along Mississauga Rd. and shows good natural meandering. The channels closest point to the edge of the Mississauga Rd. roadway is approximately 15 metres since 1974.

Meander Axes and Amplitude
For the determination of the meander axes and amplitude widths the air photos from 1985, 2002 and 2013 were used. The meander axis is the general direction in which a series of meanders are aligned. A stream generally has multiple meander axes. The meander axes for the entire study reach have remained well aligned from each of the air photo years including 1954.

The amplitude width is the initial beltwidth of the study reaches; it is determined using the centreline of the channel from the outside of each meander axis, this is also shown in Figure 4. The East Branch has been broken down into 12 different meander axes with amplitude widths ranging from 5.8m to 33.2m. The East Branch has 5 meander axes with a range of amplitude widths from 6.5m to 11.2m while the main confluence has 3 meander axes with a range of 12.6m to 28.3m.

Meander Beltwidths from Regime Equations
Inferences on meander beltwidths can also be made based on regime equations as per Williams (1986). These equations are based on bankfull dimensions such as cross-sectional area, width and mean depth. The beltwidth measurements made resemble the regime equations based on cross sectional area, width and mean depth as seen in Table 5. The East Branch (Reach 2) is an exception to this as it has an average preliminary beltwidth of 8.8 metres and therefore generally falls below the regime equation calculations. This is due to the obvious historical anthropogenic influences on it.

Criteria	Low	Mid	High
Cross Section Area	12	18	28
Width	7	13	22
Mean Depth	23	49	104

Table 5: Beltwidths based on Regime Equations

100 Year Erosion Assessment
In addition to the determination of the meander axis of the creek, 100-year erosion rates were also determined. The 100-year erosion rate functions as a factor of safety when added to the beltwidth of the creek as it accounts for the fact that the creek has not yet achieved the state of quasi-equilibrium. To assess the erosion, centerline locations were measured in comparison to previous years. Four outside bend locations were identified throughout the study area. Two erosion measurement locations are located on the East Branch, one in reach 4 and one in reach 3. Two erosion locations were identified on the main channel after the confluence. The 100-year erosion rate for the East Branch is calculated to be 15 metres or 0.15 metres per year. The East Branch, although stable through its meander axes, was difficult to assess erosion rates for because of the unpredictability of its channel, therefore no erosion rates were taken from the East Branch. The East Branch will be applied a 10% factor of safety to each amplitude width instead of an assessed 100-year erosion rate. The average amplitude width for Reach 2 is 8.8 metres therefore 0.88m will be added to the amplitude widths. The 100-year erosion rate for the main channel is 20 metres or 0.20 metres per year. Each branch will have its corresponding erosion rate added to the amplitude width. The locations of the measurements can be seen on the attached Figure 4 and the erosion measurement results can be seen in Table 6.

Erosion Location	West Branch 1	West Branch 2	Main Branch 1	Main Branch 2
Years				
1985 - 2002	0.17m/yr	0.14m/yr	0.26m/yr	0.19m/yr
2002 - 2013	0.12m/yr	0.13m/yr	0.31m/yr	0.0m/yr

Table 6: Summary of Erosion Measurements

Beltwidth Determination

The methodology involves determining a preliminary beltwidth using aerial photography. First, each channel has a line drawn as its meander axis (seen in Figure 4). Next, parallel lines are drawn on either side of the meander axis at the outermost edge of the meanders. These parallel lines follow the meander axis of the reach. The assessed beltwidths follow the valley trend and, where possible, fall within the valley confinement as is shown in Figure 4. The preliminary width was determined using the centerline of the channel for the years 1985, 2002, and 2013. Bankfull width is then applied to the amplitude width based on the average width for each branch to come to the preliminary beltwidth. The 100-year erosion rate is then added to the preliminary width of each beltwidth axis to get the final beltwidth. The range of final beltwidths for each reach are shown in Table 7. The final beltwidths are shown on Figure 4.

Reach	Min. Beltwidth	Max. Beltwidth
1	24.8m	38.3m
2	16.2m	20.8m
3	21.8m	31.4m
4	20.8m	48.2m

Table 7: Summary of Final Beltwidths by Reach

Huttonville Creek is currently considered to be habitat for Redside Dace (RSD). As per the Recovery Strategy for Redside Dace in Ontario a 30 metre riparian buffer is to be applied to the preliminary meander beltwidth (MNR, 2010). This 30 metre buffer is shown on Figure 4.

5.0 ROAD ALIGNMENT DISCUSSION

Five possible road alignments have been produced by WSP with varying pros and cons, however alignment Alternative 5 has been ruled out as an option as it does not meet the project objectives. The alignments are discussed below, and each is weighed against the applicable guidelines. The criteria for selecting appropriate crossing locations, sizing, and placement is to follow the CVC Fluvial Geomorphic Guideline Fact Sheet 3.3 for crossing design as well as consider the MNRF's Guidance for Development Activities in Redside Dace Protected Habitat. The 2015 CVC guideline recommends that in regard to crossing location and where feasible a crossing location should be:

- stable and in a relatively straight reach of channel,
- within an envelope outside the potential future meander migration, and
- cross the stream perpendicular to the channel.

The guideline also recommends that the crossing opening should:

- address potential channel erosion,
- not impact sediment transport processes,
- span the current and potential future location of the watercourse,
- not impact channel velocity, and
- be at a minimum three times the bankfull width for channels less than 4m wide.

Finally, the guideline also recommends the type of crossing, and states that open arches or bridges are required except when there is sufficient reasoning for closed bottom box culverts to be used. Where closed bottom culverts are used, they are to be embedded and use natural substrate within the crossing. In all cases the water depths and velocities should mimic the upstream and downstream reaches of the creek.

These recommendations will be weighed against each alignment alternative as provided by WSP.

The MNRF's document lays out a few guidelines for new structures. Keeping in mind that Huttonville Creek in the study area is an unconfined system, the guideline recommends that crossings should:

- be open bottom culverts (or better),
- be designed to span the meander belt of the stream,
- minimize the length of culverts, and
- minimize disruption to riparian habitat and channel bed.

Additional guidelines are also noted in the document in regard to construction, and it is recommended that these be adhered to during such activities.

Alignment Alternatives
Four alternative design concepts have been evaluated and the alignment alternatives either have one or two new creek crossings proposed. All crossings are proposed to be precast girder bridges and all crossings attempt to span the meander belt associated with the creek through their respective reaches. In light of the fact that all crossings are precast girder bridges and will typically not affect the creeks in any way, satisfies the CVC requirements on crossing openings as well as crossing type. In terms of location of the crossings there are minor variations in the alternatives, and these will be discussed on an individual basis. Generally, however the precast girder crossing structures will have their abutments outside of the 30 metre RSD setback, this therefore includes spanning the meander beltwidths of their respective crossings as required by the guidelines. Bridges will however require the use of piers placed within the 30 m setback but outside of the meander belt, which is acceptable, and is common for confined systems.

Alignment 1 has two new crossings of the creeks within the study area, the first is in Reach 2 and the other in Reach 3, as represented in Figure 3. The crossing on Reach 2 does not cross the channel perpendicularly while the crossing on Reach 3 does. The beltwidth at the Reach 2 crossing is 18.5m however it does not cross perpendicularly and would likely need a span of roughly 35-40m. The proposed span at this crossing is 35m which may be adequate. The beltwidth at the Reach 3 crossing is 31.5m which is greater than the span of 29m for the proposed crossing. In terms of channel stability, the RGA assessment suggests both reaches are in transition while the RSAT ranks the channels as Poor, which indicates the stability of the reach is low but not extreme. Alignment 1 received the highest score based on the WSP ratings and second highest from a fluvial geomorphic perspective.

Alignment 2 only has one new crossing and it would be located in Reach 1 immediately downstream of the confluence. The crossing would be a precast girder bridge with a span of 35 metres which is less than the meander belt of 38.5m at the proposed location. Reach 3 is the most stable of the Study Area reaches according to the RSAT and RGA scores and in addition the crossing intersects perpendicularly with the channel. This alternative ranks the highest from a fluvial geomorphic perspective.

Alignment 3 has two new crossings the first of which would be located in Reach 2 and the second at the end of Reach 3/start of Reach 4. The crossings would be precast girder bridges with the first crossing having a span of 26m and the second a total span of 69m. The beltwidth at the first location is 18.5m which is less than the bridge span while the second location is 31.5m which is also less. The biggest issue with the Alignment 3 alternative is that the second crossing occurs at the existing Mississauga Road crossing which currently has two almost 90-degree bends in the channel so that it can cross the road perpendicularly. This means a newer structure in the proposed alignment will not cross the creek perpendicularly unless channel realignment occurs. The length of the structure would also need to be much larger in order to span the existing meanders at this location if the channel was to remain. The RGA for Reach 2 and Reach 3 are transitional while the RSAT results for these reaches are Poor, which indicates the stability of the reach is low, but again not extreme. Alternative 3 is the least favourable from a fluvial geomorphic perspective.

Alignment 4 has two new crossings, the first of which would be located in Reach 2 at the same location as Alignments 1 and 3. The second crossing would be at the end of Reach 4, adjacent to the CN Railway. Both crossings would be a precast girder bridge with the first having a span of 25m which is less than the meander belt of 18.5m at the proposed location. The second crossing would have a span of 38m which is more than the beltwidth of 29m, however it does not cross the creek perpendicularly which increases the length of bridge required to span the creek to roughly 50m. The RGA and RSAT results for Reach 2 are noted in Alignment 1 and 3 while the results for Reach 4 show a stable channel for the RGA and a Fair ranking for the RSAT. Alternative 4 ranks the second highest along with Alternative 1 from a fluvial geomorphic perspective.

Alignment Alternatives Conclusions
Each alignment alternative has been compared to the CVC and MNRF guidelines for stream crossings. From a general perspective all of the alternatives incorporate the use of precast girder bridges that would generally span the meander belts of the respective creeks, which is noted as a positive option. Minor differences in the location of each alternative can be used to separate a favoured and least favoured alternative. Alignment 2 is the most favoured alternative due to the fact that it only requires one new crossing which crosses the creek perpendicularly and also crosses at a stable portion of the creek. Alignments 1 and 4 are similarly rated in the middle due to the fact that they both require two new crossings where one will cross the creek perpendicularly and the other one crosses at an angle to the creek. These two crossings are similar in terms of stability as well. The least favoured alternative is Alignment 3 due to the fact that it requires two new crossings, neither of which cross perfectly perpendicularly, the second crossing would likely require channel realignment, and the stability of the channel at the second crossing is the lowest of the reaches in the Study Area.

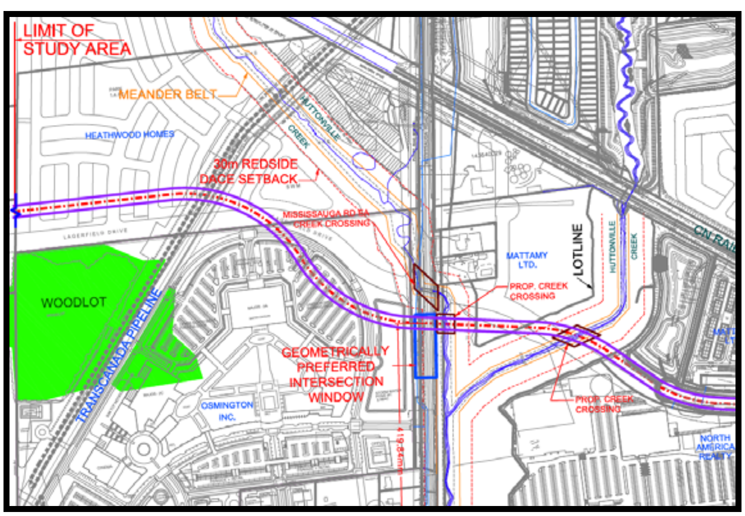

Figure 3: Alignment Alternative 1

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6.0 STUDY CONCLUSIONS

Huttonville Creek is a 3rd order stream that flows through the South Slope physiographic region. The study area is located in the City of Brampton north of the intersection of Mississauga Road and Bovaird Drive. The study area is separated into four reaches to better characterize the channels. Channel conditions have been noted and the main channel has characteristics typically related to a Rosgen C3/4. A historical assessment was completed which makes note of the fact that the channel has reasonably stable meander axes. One-hundred-year erosion rates were calculated for each reach and these rates are applied to the overall beltwidth of each meander axes. The final beltwidth also has an added 30 metre RSD buffer added to it. Figure 4 shows the preliminary beltwidth, final beltwidth and RSD buffer. Four alignment alternatives were compared to the CVC and MNRF guidelines and from a fluvial geomorphic perspective Alignment 2 is the best alternative. However, if the span of the bridges is adequate to cross the meander belts of the creeks then there is limited impact to the stream corridors and any of the alternatives are viable options.

Respectfully submitted,

Ed Gazendam, Ph.D., P.Eng.,
President, Sr. Geomorphologist
Water's Edge Environmental Solutions Team Ltd.

Nik Gazendam, C. Tech., CAN-CISEC
Fluvial Geomorphic Technician

Attachments
Figure 4 - Meander Beltwidth Map
Appendix A – Photographs

References

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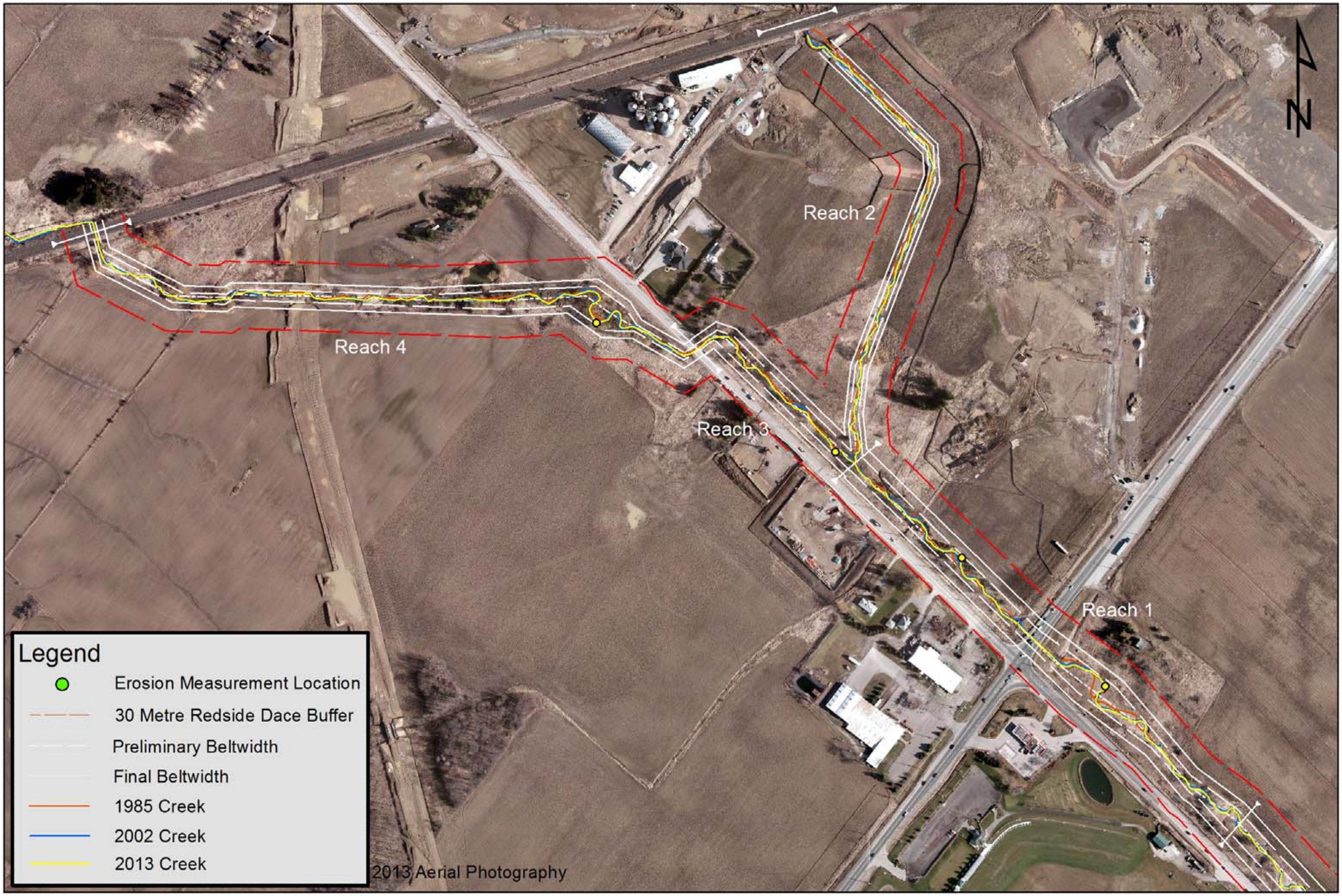
APPENDIX A:

Meander Beltwidth

Figure 4



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Meters

Mt. Pleasant GO Station	Figure No.: 4	Date: Oct. 2, 2017
Huttonville Creek and Tributaries Meander Beltwidth Assessment	Checked By: EG	Drawn By: NG

APPENDIX B:

Photographs

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Left Bank
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Right Bank
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (D/S of Bovaird)
FROM: Left Bank
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Bovaird Dr. Culvert
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Eroding Bank

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 1 (U/S of Bovaird)
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 2
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: New channel alterations near rail line

CREEK NAME: Huttonville Creek - Reach 2
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 2
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 2
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 2
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 2
FROM: Left Bank
LOOKING: Upstream
COMMENT: Valley Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 3
FROM: Centre of Channel
LOOKING: Downstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Centre of Channel
LOOKING: Upstream
COMMENT: Typical Channel Conditions

CREEK NAME: Huttonville Creek - Reach 4
FROM: Left Bank
LOOKING: Upstream towards rail line
COMMENT: