APPENDIX E

Bowstring Bridge Hydraulic Investigation Report

Hypothetical Meander Belt at Langstaff

June 3, 2019

Attn: Mr. Markus Hillar, BLArch
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Re: Hydraulic Analysis of Bowstring Bridge over Humber River for Vaughan Trail

Dear Markus,

Aquafor reviewed the series of TRCA Hydraulic (HEC-RAS) models provided for informing the Vaughn – Humber Multi-Use Trail Design. The upstream most floodplain map is shown below, which encompasses the subject bowstring bridge upstream of Langstaff Road. Please note, the adjacent sheet 34 has not been provided as part of the background review.

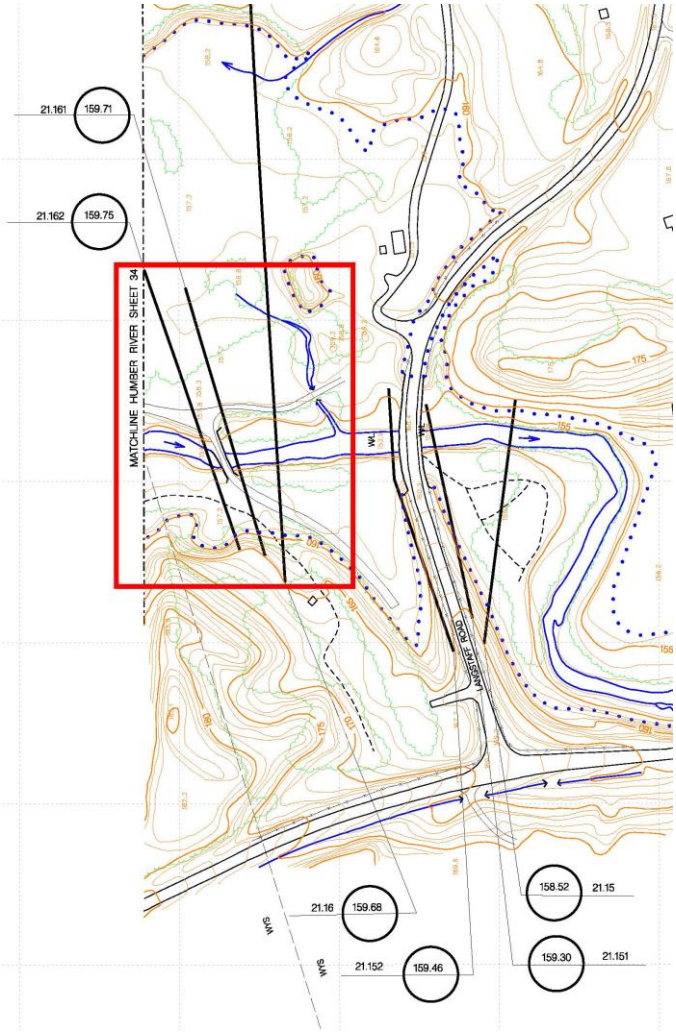

Figure 1. Humber Floodplain Map (Sheet 32), Highlighting Langstaff Road and Bowstring (Don Eddy) Bridge.

Application of the model, referred to as **TRCA (Catchment 21, east_humber_21)**, provided insight into water surface elevations of the 2 & 5 year floods as shown in **Figure 2**. The cross section planform is illustrated in Figure 3, confirming the model is not georeferenced as per current TRCA standards, and mapping of flood level estimates requires engineering analysis of topographic information.

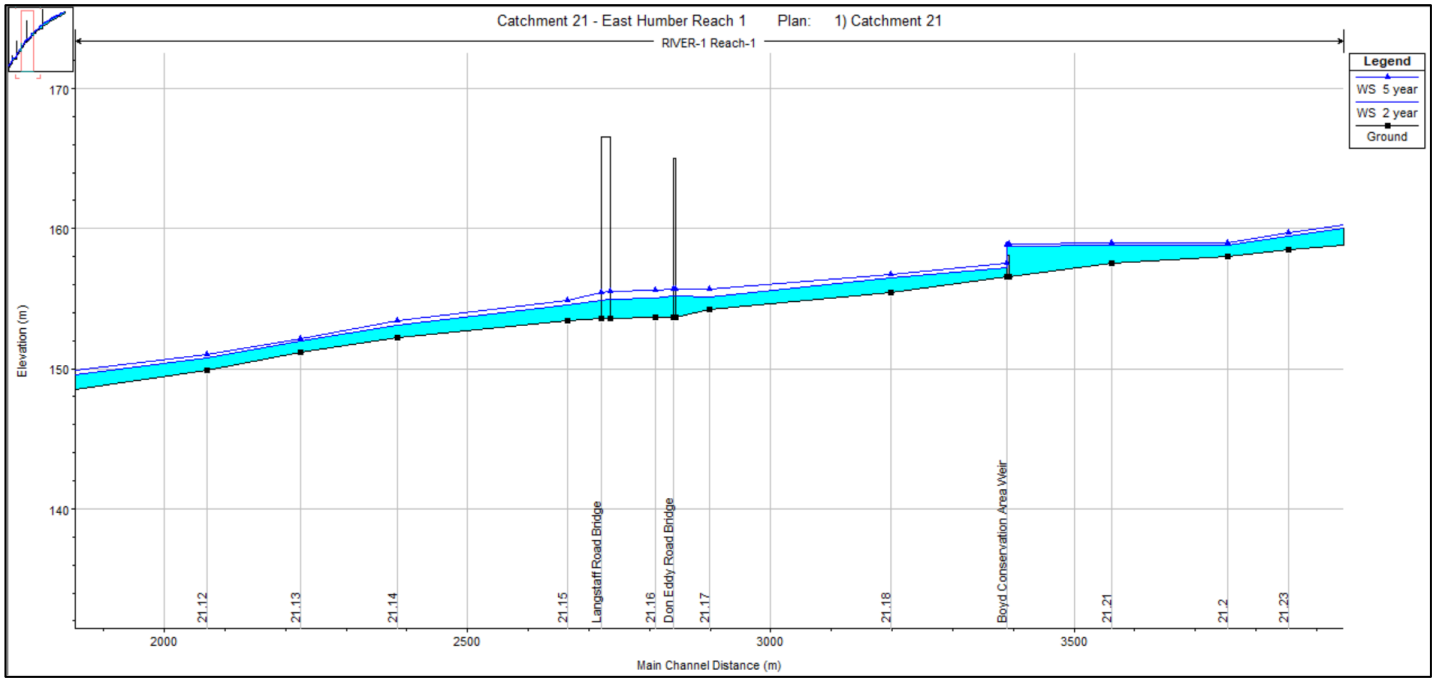

Figure 2. Water Surface Elevation Profile, 2 and 5 year return period.

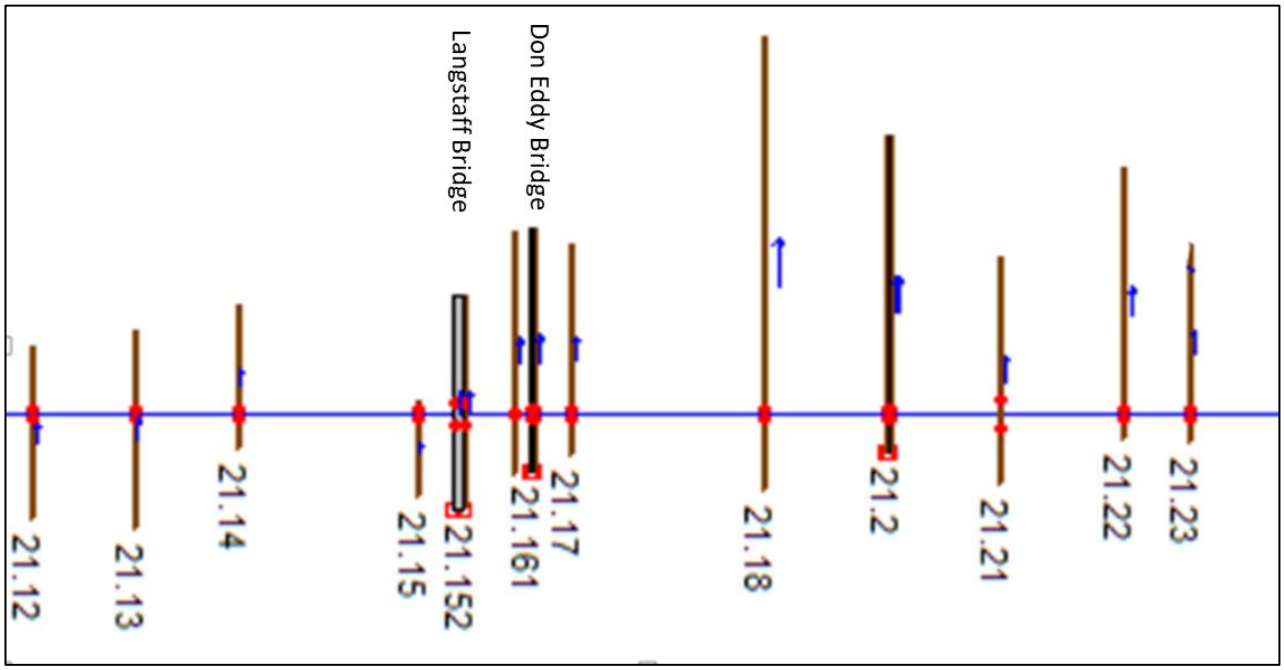

Figure 3. Cross sections 21.23 to 21.12 in HEC-RAS model

The 2 and 5 year elevations can also be reviewed as per the table below. In order to further plot these onto the Humber Trail Design, the locations of each cross section will need to be applied onto the Schollen CAD design, then floodlines will be plotted based on topographic survey, LiDAR, and contour information.

Table 1: Tabular Water Surface Elevations for 2 and 5 year return period within subject area.

Reach	River Sta	Profile	Q Total (m^3/s)	W.S. Elev (m)
Reach-1	21.23	2 year	26.6	159.42
Reach-1	21.23	5 year	43	159.73
Reach-1	21.22	2 year	26.6	158.78
Reach-1	21.22	5 year	43	158.95
Reach-1	21.21	2 year	26.6	158.8
Reach-1	21.21	5 year	43	159.01
Reach-1	21.2	2 year	26.6	158.75
Reach-1	21.2	5 year	43	158.92
Reach-1	21.195		Inl Struct	
Reach-1	21.19	2 year	26.6	157.2
Reach-1	21.19	5 year	43	157.5
Reach-1	21.18	2 year	26.6	156.47
Reach-1	21.18	5 year	43	156.73
Reach-1	21.17	2 year	26.6	155.12
Reach-1	21.17	5 year	43	155.64
Reach-1	21.162	2 year	26.6	155.19
Reach-1	21.162	5 year	43	155.68

Reach	River Sta	Profile	Q Total (m^3/s)	W.S. Elev (m)
Reach-1	21.1615		Bridge	
Reach-1	21.161	2 year	26.6	155.19
Reach-1	21.161	5 year	43	155.68
Reach-1	21.16	2 year	26.6	155.03
Reach-1	21.16	5 year	43	155.57
Reach-1	21.152	2 year	26.6	154.95
Reach-1	21.152	5 year	43	155.5
Reach-1	21.1515		Bridge	
Reach-1	21.151	2 year	26.6	154.91
Reach-1	21.151	5 year	43	155.45
Reach-1	21.15	2 year	26.6	154.55
Reach-1	21.15	5 year	43	154.86
Reach-1	21.14	2 year	26.6	153.11
Reach-1	21.14	5 year	43	153.43
Reach-1	21.13	2 year	26.6	151.95
Reach-1	21.13	5 year	43	152.12
Reach-1	21.12	2 year	26.6	150.74
Reach-1	21.12	5 year	43	150.98

December 15th , 2018

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Re: Meander Belt Analysis of Humber River at Langstaff Road for Vaughan Humber Trail

Aquafor Beech was retained by Schollen & Company Inc. to complete a meander belt analysis for a segment of East Humber River, near Vaughan Humber Trail, in the city of Vaughan, Ontario. The site is bounded by Islington Ave. and Langstaff Rd.(Figure 1). The meander belt represents the area that a channel can reasonably be expected to occupy, both now and in the future, with respect to channel movement or migration. Meander belt delineation is one component considered in hazard mapping to define limits of development and is intended to not only protect natural channel processes within the study area, but also to protect private property and public health and safety.

The purpose of the current study is strictly to apply a "hypothetical meander belt" (HMb) to satisfy provincial policies related to delineating potential impacts to Redside Dace habitat, regulated by both MNRF and DFO. The meander belts presented in this report do not represent an erosion hazard assessment. The East Humber River within the study area is classified as confined system and therefore meander belts do not apply to erosion hazards according provincial guidelines (MNR, 2002).

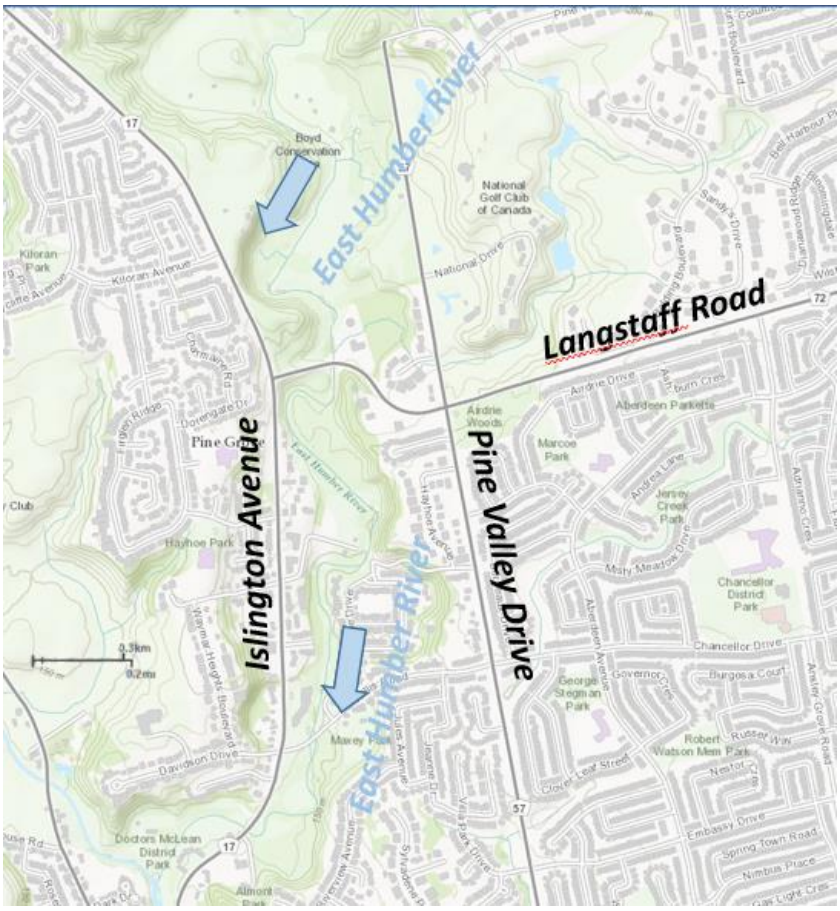

Figure 1 General Study Area Extents of Meandering Belt

Historic Assessment

This study is high level meander belt assessment, which did not considered detailed assessment of historical images, but used them as reference a in identifying the meander pattern and axis for future. **Error! Reference source not found.**, Figure 3, Figure 4, and Figure 5 illustrates the historical change in the river planform as well as surrounding development. As can be seen in the figures below, the river course was straightened between the years 1959 and 1964. We can also see, a reduction in agricultural land, and the development of infrastructure during this time, which is indicated by parking lot construction. The site also has a bow string bridge, which is of historical importance, but is no longer in operation. From 1969 to 1975, there is no major change in river planform, or surrounding area.

Figure 2 Historical Aerial Images of site in 1959

Figure 3 Historical Aerial Images of site in 1964

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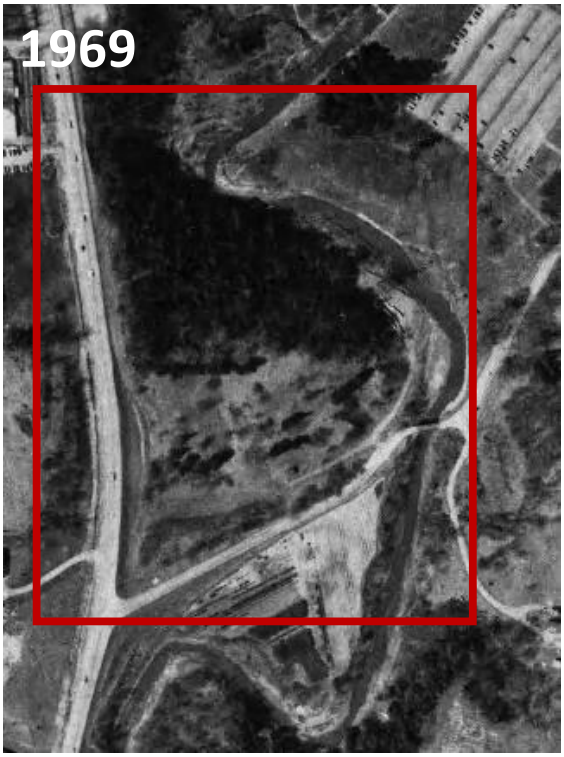

Figure 4 Historical Aerial Images of site in 1969

Figure 5 Historical Aerial Images of site in 1975

Reach and Meander Belt Delineation

The Toronto and Region Conservation Authority (TRCA) (2004) meander belt delineation procedures are generally accepted guidelines for completing river erosion hazard mapping within the TRCA jurisdiction and most other conservation authority watersheds in southern Ontario. Other relevant guidelines in Ontario for assessment of meander belts and slope erosion hazards include MNR (2002) and Conservation Ontario (2005). Meander Belt delineation—which for erosion hazards is strictly for unconfined systems (MNR, 2002)—is basically a mapping exercise, which has following steps.

Step 1: Delineation of Watercourse into Reaches: A channel reach represents a length of channel that exhibits essentially the same physical characteristics such as channel form, geology, vegetation, sinuosity, physical dimensions, channel function, water flow, and sediment transport; as well as anthropogenic (human induced) influences such as land use. The delineation of a reach is guided by desktop and field analysis and considering the influence of localized channel patterns and processes. The reaches delineated for this study are shown in Figure 6. It is also assumed that meander belt amplitude remains constant within a reach.

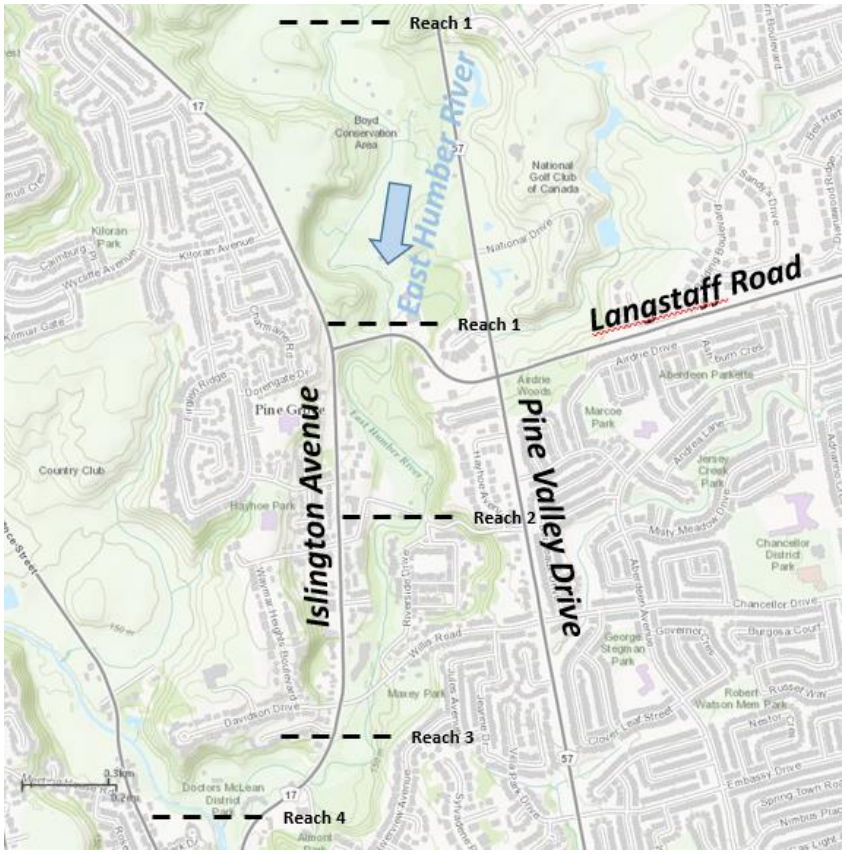

Figure 6: Study Reach

Step 2: Defining Meander Belt Axis: A meander belt represents the area that a channel can reasonably be expected to occupy both now and in the future, with respect to channel movement and migration. Meander belt delineation is used in conjunction with hazard mapping for unconfined reaches (MNR, 2002), and is generally required by permitting agencies for works within and adjacent to watercourses, since anything situated within a meander belt could, at some time in the future, be subject to erosion by the channel. The meander axis describes general down valley orientation of meander pattern. The meander belt is centered around the meander axis.

As the East Humber River within the study area is classified as a confined system, the delineation of a meander belt axis must consider both the meandering planform (past and present) and the centerline of the valley bottom—a centre line approximate halfway between the toe of the valley slope on either side of the floodplain. The valley bottom and center line can be further complicated by river terraces within the valley, which also contribute to the channel confinement and problems for meander belt delineation in confined settings.

Step 3: Meander Belt Delineation: The purpose of this study is to carry out, high level a meander belt analysis, of the study reach1, to verify, whether it overlaps the areas of Vaughan Humber Trail due to the potential impacts to Redside Dace *ESA* habitat. The study reach of east Humber River is a partially confined valley setting where the TRCA mapping protocol as defined in TRCA (2004) for meander belt delineation in unconfined settings. Because the East Humber River within the study area is classified as confined based on provincial guidelines (MNR, 2002), the meander belt delineation procedures applied in this case can only be considered a "hypothetical meander belt" (HMb) width—the term hypothetical is used in this case to reflect the fact that an unconfined condition has been assumed but is incorrect. This assumption is required in that meander belt criteria for regulated Redside Dace habitat essentially force technical procedures to be applied in reaches that do not match the technical and conceptual definitions laid out in other provincial guidelines (MNR, 2002). For confined settings like the East Humber River, the erosion hazard is essentially defined by the entire valley bottom, plus geotechnical stable slope setbacks from both sides of the valley walls (MNR, 2002).

To apply the HMb for this study, the TRCA (2004) mapping procedures have generally been followed, but adapted to accommodate some aspects of the confined setting. This high-level meander belt assessment generally follows Procedure 2 from TRCA (2004), with an example for Reach 1 shown below and the results for all reaches presented in **Table 1** and **Figure 7**. Detailed historic assessment and erosion rate calculations were not carried out for this high level meander belt assessment.

Delineated Preliminary Meandering Belt width = 294m
Factor of safety = 1.1; Final Meandering Belt Width = 294 X 1.1 = 323m

Table 1: Hypothetical Meander Belt Widths for the East Humber River

Reach	Preliminary Meander Belt Width (m)	Final Meander Belt Width (m) including x1.1 Factor of Safety
1	294	323
2	180	198
3	140	154
4	180	198

Summary and Recommendations

A high level meander belt assessment has been completed for the study reaches of the East Humber River. While the analysis completed generally follows the TRCA (2004) meander belt delineation guidelines (specifically procedure 2), the confined valley setting does not satisfy provincial erosion hazard guidelines for meander belts (MNR, 2002); and thus this study has delineated what has been termed the "hypothetical meander belt" (HMb). The recommended HMb widths for reaches 1 to 4 of the East Humber River identified within the study area are **323 m, 198 m, 154 m, and 198 m**, respectively. These meander belt widths (HMb) **do not** define erosion hazards and have not included detailed historical assessments of channel locations and migration rates. Based on this high level meander belt assessment, the Vaughan Humber Trail is indeed covered within the meander belt. The recommended HMb values area are strictly for the purpose of verifying the relative location of the proposed Vaughan Humber Trail within the meander belt (HMb) with respect to ESA regulations for Redside Dace habitat , and should not be used for any other purposes.

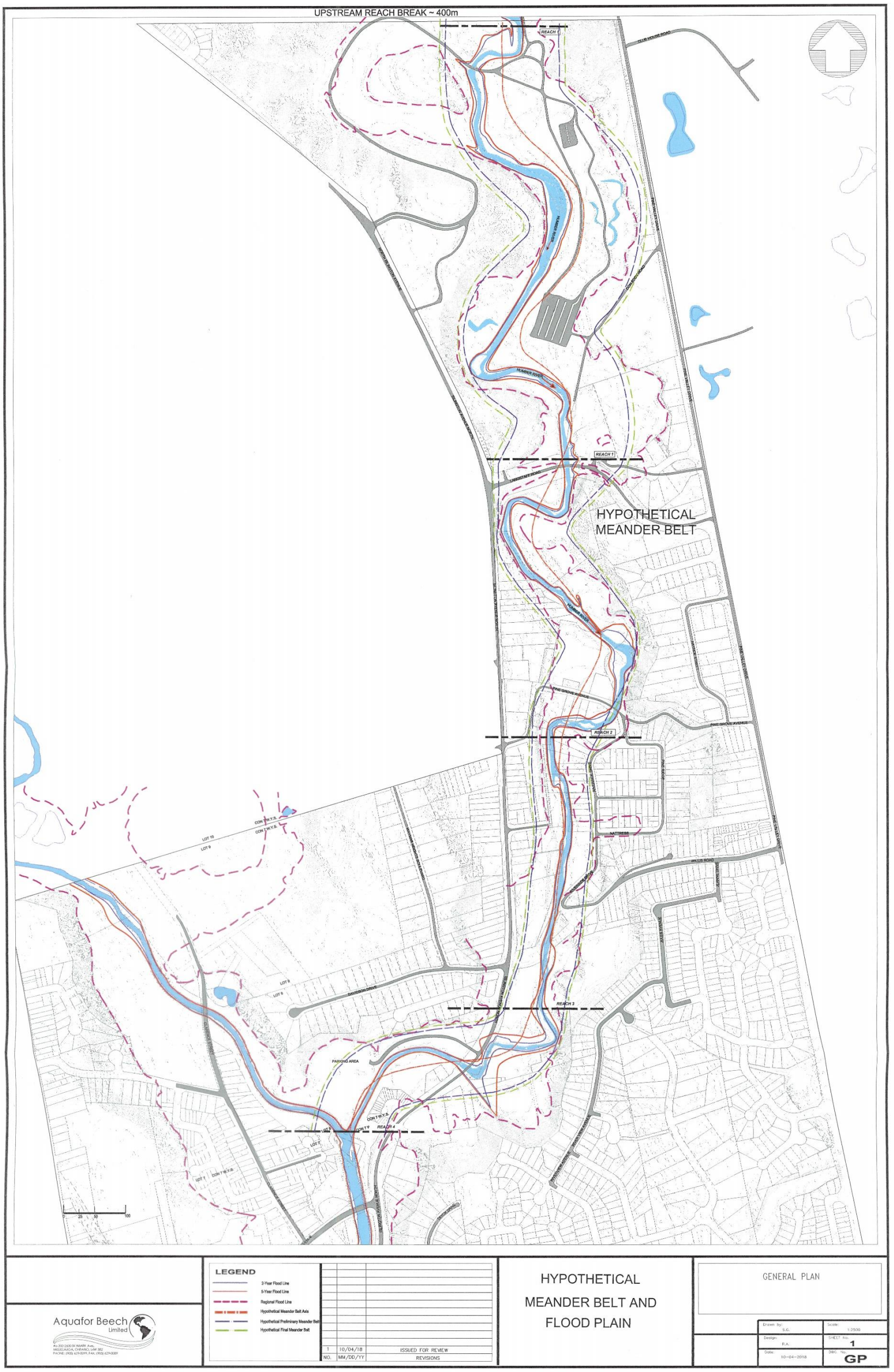

Figure 7 Meander Belt Axis and Width