Downtown Brampton Flood Protection

Feasibility Study

Prepared for:

Toronto and Region Conservation Authority

Prepared by:

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DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY

CITY OF BRAMPTON

Submitted to:

Toronto and Region Conservation Authority

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1.0 STUDY BACKGROUND AND PURPOSE

1.1 Introduction

The City of Brampton downtown core, prior to 1952, was subject to frequent riverine flooding. Etobicoke Creek, which historically flowed through Downtown Brampton, was the source of flooding. The Etobicoke Creek subwatershed drains a substantial land area (6760 hectares) which under current land uses conditions is made up of approximately one-quarter urban area with the balance being agricultural land uses (ref. Figure 1.1). Local business owners of this area described annual flooding reaching depths of several feet and causing significant property damage (ref. Appendix 'A' Photographic Reconnaissance). In response to the frequent flooding, a concrete-lined by-pass channel was constructed between Church Street and Wellington Street in 1952, which subsequently facilitated development and protected Downtown Brampton from riverine flooding since its construction. The by-pass channel extends from Church Street to just downstream of the CN railway crossing of Etobicoke Creek (ref. Figure 1.2). The channel is of trapezoidal shape with an approximate top width of 21 metres, including a 5 m wide by 1 m deep low flow channel, and is constructed of reinforced concrete (ref. Figure 1.3). The by-pass is contained within a larger 40 - 45 m wide +/- easement owned by TRCA and along the upper western frontage the bypass channel is adjacent to Rosalea Park, with the balance fronting local road right-of-ways and residential and commercial land uses.

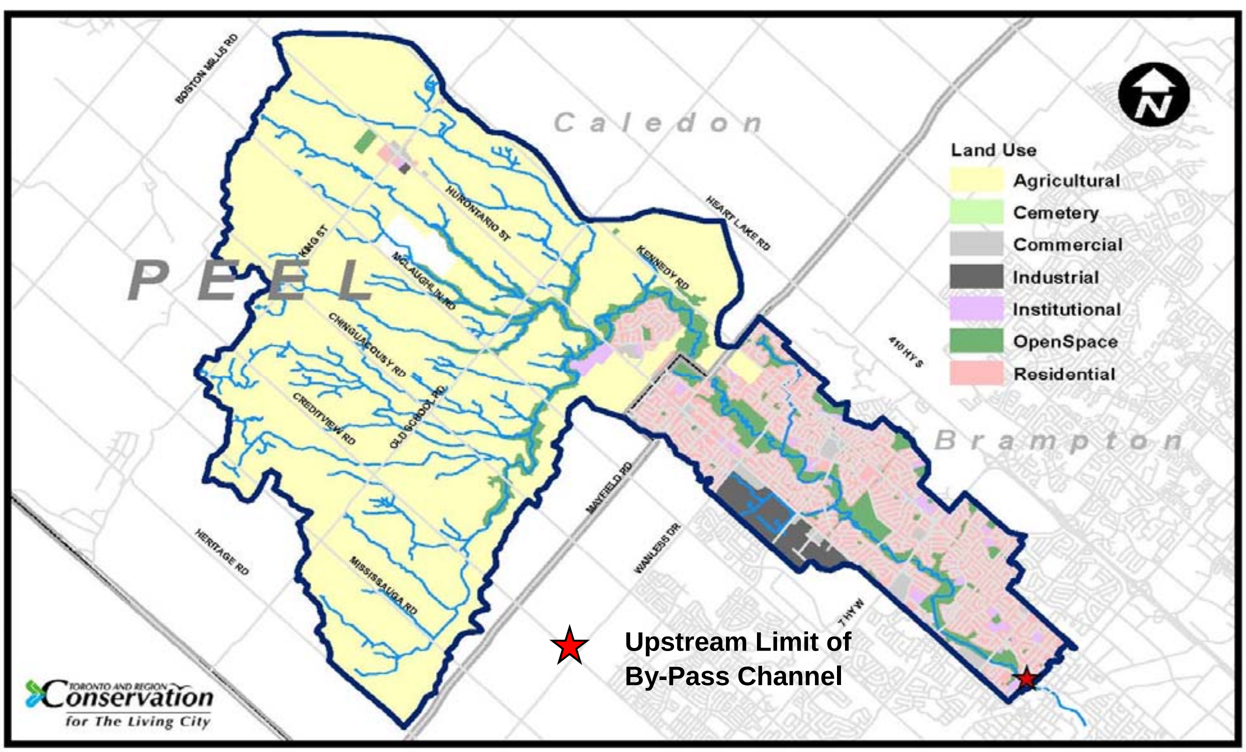


Figure 1.1: Etobicoke Creek Subwatershed (upstream of the by-pass channel)

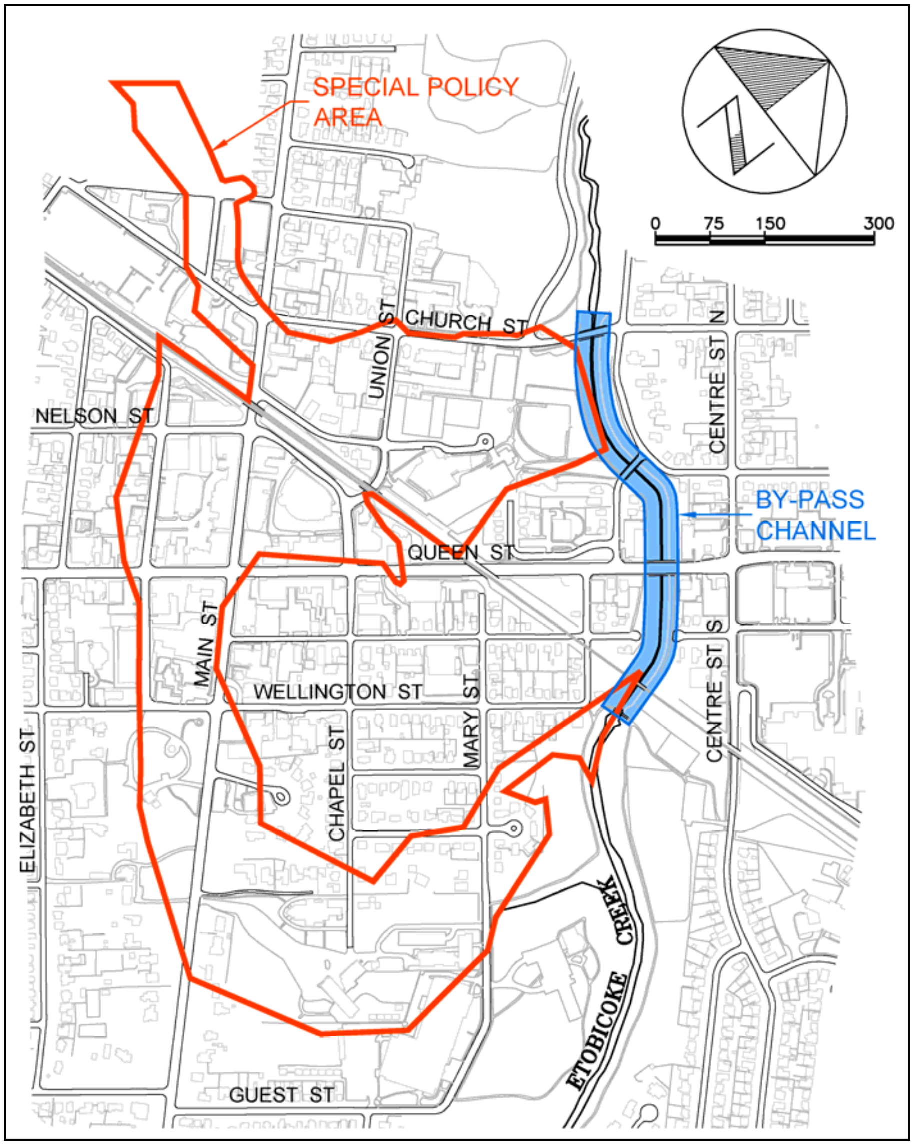


Figure 1.2: By-pass Channel and SPA

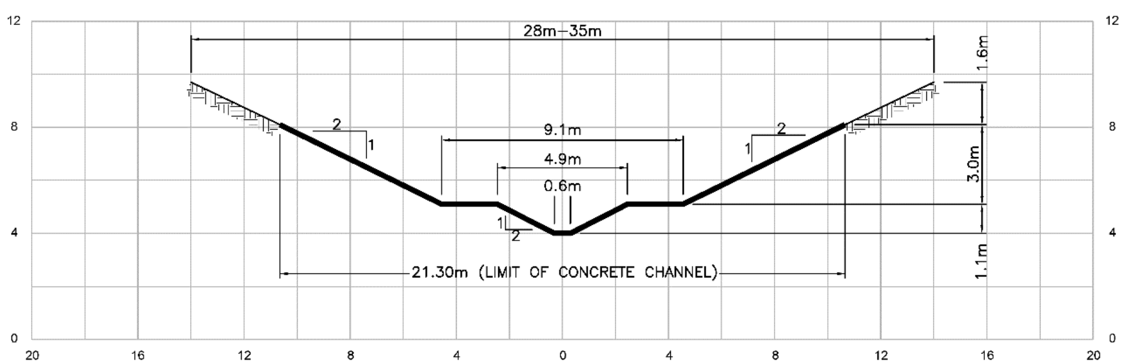


Figure 1.3: By-pass Channel Cross Section

The downtown core however remains within the Regulatory (Regional Storm) floodplain due to a simulated spill condition that leaves Etobicoke Creek at the upstream limit of the by-pass channel and flows through the 'remnant' valley associated with the original watercourse plan form (i.e. prior to construction of the by-pass channel), eventually rejoining the original unaltered Etobicoke Creek, just downstream of the by-pass channel.

Provincial flood hazard policy restrict development in the Regulatory floodplain. Strict adherence to these policies, particularly in high volume commercial districts such as downtown areas, can have significant social and economic impacts to the community. To recognize the need for flexibility with regard to development in key socio-economic areas impacted by flood hazards, Provincial flood management policies allow for the designation of a Special Policy Area (SPA). Downtown Brampton was recognized as such an area and designated a Special Policy Area (SPA 3, Secondary Planning Area 7) in 1986, as part of the Brampton Central Secondary Plan (ref. Figure 1.2). The SPA3 policies were then incorporated into the Downtown Brampton Secondary Plan (1998). Section 2 provides a detailed discussion on provincial flood hazard policy and other relevant policy.

In recent years, significant development interest has increased with a focus on intensification of holdings in Downtown Brampton and specifically within SPA3. In addition, the Provincial Policy Statement (PPS, 2005) generally encourages intensification and redevelopment in core areas and Downtown Brampton has been specifically identified as an Urban Growth Centre by the Province. In response to these development pressures and Provincial objectives, the City of Brampton submitted a formal application to amend SPA3 through the Province's SPA amendment process on August 18, 2011. The amended SPA3 is intended to facilitate development to the extent possible considering the requirements of the Province with respect to managing flood risk and protecting the public, recognizing the need to clarify requirements and expected outcomes for future development applications.

1.2 Study Objectives & Integrated Process

Mitigating the flood condition in Downtown Brampton aligns the mandate of TRCA to reduce risk to life and property (from flooding) with the goals of the City of Brampton to support development potential in SPA3. As such, both organizations have initiated the formation of a Joint Steering Committee (JSC) to manage the integrated effort of community/neighbourhood planning with flood protection in SPA3. The JSC provides an opportunity for TRCA and City to ensure each organization's respective goals and objectives are aligned in the integrated initiatives of planning for the intensification of Downtown Brampton while meeting the flood protection mandate of TRCA & the Province:

Downtown Brampton Flood Protection Feasibility Study (TRCA, AMEC)
The primary objective of the current study has been to develop a short-list of feasible flood mitigation alternatives that eliminate, or reduce to the extent possible, the existing Regional Storm (Regulatory) flood risk in Downtown Brampton (SPA3). These alternatives must also be ecologically sensitive and sustainable and consider, at a high level, natural and socioeconomic

constraints and opportunities. In addition, the flood mitigation alternatives should, where possible, incorporation the City of Brampton's *Urban Design and Land Use Study* objectives (see below).

Downtown Brampton Urban Design and Land Use Study (City of Brampton, The Planning Partnership)

The objective of the City's concurrent study has been the development of urban design and land use concepts for Downtown Brampton which are in keeping with the City of Brampton's growth objectives and also compatible with the short-listed flood mitigation alternatives generated by TRCA's *Downtown Brampton Flood Protection Study* (the current study). The study is also tasked with developing concepts which would enhance passive recreational opportunities along Etobicoke Creek by focussing on rehabilitation of the by-pass channel and incorporation of a 'riverwalk' trail system, redevelopment of Rosalea Park, and a general re-orientation of development to 'face' the creek and make it a feature of the Downtown core.

1.3 Data Collection, Review & Gap Analysis

In support of the Feasibility Study, Data have generally been collected by TRCA and provided to Amec Foster Wheeler for review. Background data have been reviewed for their relevance and application in the current study. Based on the data needs for the current and future studies, a gap analysis has also been completed.

The Data Tracking Chart (ref. Appendix 'B') summarizes the various studies, policies, mapping and modelling reviewed as part of the current study.

The following summarizes key studies that represent key 'building blocks' for the concurrent TRCA and City initiatives:

Downtown Brampton Special Policy Area: Comprehensive Flood Risk and Management Analysis (City of Brampton, ongoing)

Goals include clarifying policy framework for the SPA3, establishing location and nature and extent of permitted intensification, providing greater certainty with regard to planning outcomes, and recognizing the long-term objective of eliminating flood risks related to the Regional Storm event.

Etobicoke Creek Hydrology Study (TRCA, MMM, 2012)

This study provides the most current peak flows (2-100, 350 year and Regulatory) for the Etobicoke Creek for existing and future Official Plan land uses. The Visual Otthymo 2 hydrologic model has been used in the current study for evaluation of flood mitigation alternatives.

Etobicoke Creek Floodline Mapping Report (TRCA, Greck & Associates, 2012)

This study generated the current Regulatory floodline mapping for the reach of Etobicoke Creek that includes the by-pass channel and the Downtown SPA. The HEC-RAS hydraulic model has been updated and applied by the current study.

Downtown Drainage Study (City of Brampton, Aquafor Beech, 2006)

This study established flood characteristics within the Downtown SPA and generated a long list of flood management alternatives, including a preferred alternative. Some of the flood mitigation alternatives presented in this study have been used as a starting point for the development and evaluation of alternatives in the current study.

Ken Whillans Drive Extension and Downtown Drainage Improvements Class Environmental Assessment (City of Brampton, Aquafor Beech, 2011)

This study examines alternatives for the extension of Ken Whillans Drive through Rosalea Park as well as concurrent opportunities and alternatives for providing flood protection in the Downtown SPA. This study considered similar flood mitigation alternatives as the 2006 Aquafor Beech study, some of which have been used as a starting point for the development and evaluation of alternatives in the current study.

The following data gaps have been identified as part of the data review conducted for this study:

i. By-pass Channel Geometry in Hydraulic Model – Through review of the current HEC-RAS hydraulic model for Etobicoke Creek, it was determined that cross section geometry for the by-pass channel had been generated from Digital Elevation Mapping considered to be too course to accurately represent the by-pass channel, including the low flow channel. Test simulations were undertaken by updating the channel geometry to reflect the original design drawings and the results (increased Regulatory water surface elevations) justified the provision of detailed geodetic survey to confirm channel inverts and geometry. Survey was completed as part of the current study and the HEC-RAS hydraulic model was updated accordingly. This data gap has therefore been filled by the current study (ref. Section 3.3).

ii. Flood Damage Reports – Flood damage reports are valuable for verifying the performance of modelling data as well as increasing the accuracy of future flood damage forecasts. It is understood that no riverine flooding has been experienced in Downtown Brampton since the construction of the by-pass channel (1952) which suggests the vintage of any flood damage reports would be greater than 60 years. TRCA has exhausted its resources and these data are not available. This data gap though is not considered critical to the successful completion of the current study and as such no gap-filling measure is proposed.

iii. Calibrated Hydrology – The 2012 MMM study involved hydrologic model calibration however the calibration was not recommended for adoption citing an insufficient period of record and lack of observed less-frequent (i.e. severe) flood events from the in-stream flow gauge. The calibrated flows (based on the available record) were lower than the uncalibrated flows indicating the potential to further reduce the Regulatory floodplain should an appropriate period of record be generated for future calibration efforts. Notwithstanding this hypothesis would need to be verified since extrapolation of low flow calibration to high flow events is a non-linear process, and as such would require additional data. This data gap cannot be filled for the current study given the time required to generate a reliable period of record (20 to 30 years +/-) however it is recommended that observed flow data continue to be collected for future calibration exercises.

iv. Velocity Distribution in the SPA – The existing hydraulic models are limited in their ability to accurately predict spatially varying velocity as the Regulatory flood spills through the SPA due to the nature of the one-dimensional approach (i.e. HEC-RAS). It is expected that velocity could vary significantly as the spill flow is routed in diverging directions along roads and between buildings. Improving the analysis could better inform the spatially-varying risk to pedestrians and vehicles and buildings in the flood zones and could be specifically applicable to evaluation of overall risk, in particular, trail routing options associated with the proposed connection of the Etobicoke Creek Trail though Rosalea Park and the potential future 'river walk'. This data gap could be filled through the application of 2D hydraulic modelling in the future.

1.4 Vision Statement

The Vision Statement for this integrated study process has been developed co-operatively with TRCA considering the objectives of the concurrent studies (current study and *Downtown Brampton Urban Design and Land Use Study*), as well as applicable Municipal and Provincial policy. The intent is to provide guidance for the evaluation of flood mitigation alternatives for the current study and the future application of flood mitigation approaches in the Downtown Brampton SPA, for the purpose of redevelopment/intensification.

Considering the study objectives and relevant policy, the following Vision Statement has been developed:

"Alternatives to mitigate flooding in the Downtown Brampton SPA (SPA3), caused by riverine flooding generated by a spill upstream of the Brampton by-pass channel will be required to balance the Toronto Region Conservation Authority's mandate to reduce the risk to life and property from flooding and erosion, and to encourage the protection and regeneration of natural systems. Flood mitigation alternatives shall facilitate, to the extent possible, future growth objectives of the City of Brampton which are currently limited by the provisions of the Downtown Brampton Special Policy Area. Further, the physical form of any flood control systems must consider the City's vision for the urban form within the downtown core, giving special regard to improving the public interface with the by-pass channel, including a potential riverwalk, while also satisfying current Provincial Policy with regard to the design of flood control structures (permanent or non-permanent)."

2.0 RELEVANT POLICY

2.1 Provincial Flood Hazard Policy

In 1988, the Province of Ontario adopted the *"Policy Statement on Floodplain Planning"* to provide a framework for land use planning and the regulation of development. The overall objective of this policy statement was to minimize loss of life, property damage and social disruption that can result from flooding. The principles outlined within this initial policy statement have been carried through to the current Provincial Policy Statement (PPS, 2005) adopted under the Planning Act. In the implementation of these policies, the Planning Act requires that municipalities *'shall have regard for'* these policies when making planning decisions.

This PPS states in Section 3.1.1:

> *Development will generally be directed to areas outside of:*
>
> *b) hazardous lands adjacent to river and stream systems, which are impacted by flooding and/or erosion hazards*
>
> *Specifically Section 3.1.2 states:*
>
> *Development and site alteration will not be permitted within:*
>
> *d) a floodway regardless of whether the area of inundation contains high points of land not subject to flooding.*

The PPS defines the term Special Policy Area as the following:

> *A Special Policy Area is defined as an area within a community that has historically existed in the floodplain and where site specific policies, approved by the Ministers of Natural Resources and Municipal Affairs and Housing, are intended to address the significant social and economic hardships to the community that would result from strict adherence to provincial policies concerning development.*

In addition, the PPS in Section 3.1.3 outlines the specific requirements in order to consider development within any hazardous lands including a floodplain situation such as an area designated as a Special Policy Area (SPA). The PPS defines *hazardous lands* as 'property or lands that could be unsafe for development due to naturally occurring processes. Along *river and stream systems*, this means the land, including that covered by water, to the furthest landward limit of the *flooding* or *erosion hazard* limits.'

3.1.3 Despite policy 3.1.2, development and site alteration may be permitted in certain areas identified in policy 3.1.2:

a) in those exceptional situations where a Special Policy Area has been approved. The designation of aSpecial Policy Area, and any change or modification to the site-specific policies or boundaries applying to a Special Policy Area, must be approved by the Ministers of Municipal Affairs and Housing and Natural Resources prior to the approval authority approving such changes or modifications; or

b) where the development is limited to uses which by their nature must locate within the floodway, including flood and/or erosion control works or minor additions or passive non-structural uses which do not affect flood flows.

Policy Approaches for Floodplain Management

Flood management can involve the use of both a) structural measures such as channelization, tunneling, flood storage areas, and flood proofing and b) non-structural approaches such as land use regulation to reduce risk of flooding and any potential loss of life or property damage. Policies developed for floodplain management attempt to balance the interest in development within the floodplain, against the risks caused by that development. These policies also address new uses as well as pre-existing uses within floodplain areas.

Based on the foregoing PPS policies, there are three basic planning options for addressing floodplain management:

- *One-Zone Areas*

This approach places the entire floodplain in a one-zone category. In the one-zone policy area, no new development is permitted within the floodplain; however, it is recognized that certain buildings and structures must be located in the floodplain due to the nature of their use such as public works. In the policy document, 'Valley and Stream Corridor Management Program', TRCA sets out in detail the scale and type of uses permitted within the floodplain.

- *Two-Zone Areas*

For portions of the floodplain that could potentially be safely developed with no adverse impacts, the Municipality, with the agreement of the Conservation Authority, may designate portions of the floodplain as two-zone areas. In the designated two-zone areas, the floodplain is divided into two distinct sections- floodway and flood fringe. The floodway is typically the effective flow area designated as the area of the floodplain required to pass the flow of greatest depth and velocity. The flood fringe lies between the floodway and the edge of the floodplain. Depths and velocities of flooding in the flood fringe are typically much less than those in the floodway.

In the two-zone area, new development can occur in the flood fringe provided that the development meets certain criteria. Where new development is permitted, it will be required to be flood proofed to the level of the Regulatory Flood in order to reduce susceptibility to damage. All habitable floor space must be above the elevation of the Regulatory Flood. No development, however, is allowed with the floodway.

- *Special Policy Areas*

Special Policy Areas (SPA) may be established in areas historically settled within the floodplain where 1) the application of one-zone or two-zone policies is not feasible, 2) a prohibition of development or redevelopment causes social and economic hardship for the community and 3) all other requirements for an SPA can be met. For an SPA, a more flexible approach in floodplain management is used. However, implicitly if adopted, a higher level of flood risk must be been accepted by the Municipality, Conservation Authority and the Province of Ontario. For each SPA, there must be Official Plan policies that address the minimum level of flood protection for new development, as well as any other site-specific issues.

River & Stream Systems: Flood Hazard Limit Technical Guide (Ministry of Natural Resources, 2002)

The Technical Guide is intended to assist in understanding the PPS and provide technical approaches guidelines that are consistent with the PPS. The Technical Guide provides the high level requirements for the application of flood mitigation measures, several of which have been considered under the current study as flood protection alternatives including: dykes, diversions, channelization and flood proofing. It is important to note that per the Technical Guide that dykes are not considered permanent flood control structures and as such any area protected by a dyke would still be regulated to the governing flood standard. Furthermore, the Ministry of Natural Resources generally only recognizes and supports the application of dykes to protect existing development, not for facilitating new development as is considered for Downtown Brampton.

In terms of public safety, the Technical Guide provides guidance with respect to land use planning and flood design standards, as well as risk-based parameters addressing access for vehicles and pedestrians in flood prone areas.

2.2 Downtown Brampton Special Policy Area

Downtown Brampton was designated a Special Policy Area (SPA3) in 1986. The current (February 2010) Secondary Plan for Area 7 defines the limits of SPA3 and associated development related policies. Section 2.1 describes Provincial policy with respect to flood management and land use planning and outlines the special circumstances under which an SPA designation can be made.

In recent years, significant development interest has increased with a focus on intensification in Downtown Brampton and specifically within SPA3. In addition, the Provincial Policy Statement (PPS, 2005) generally encourages intensification and redevelopment in core areas and

Downtown Brampton has been specifically identified as an Urban Growth Centre by the Province. In response to these development pressures and Provincial objectives, the City of Brampton submitted a formal application to amend SPA3 through the Province's SPA amendment process on August 18, 2011. The amended SPA3 is intended to facilitate development to the extent possible considering the requirements of the Province with respect to managing flood risk and protecting the public, and recognizing the need to clarify requirements and expected outcomes for future development applications. This application is ongoing. The following summarizes the current policy.

Special Policy Area 3, Section 5.6.3, Downtown Brampton Secondary Plan, Secondary Plan Area 7 (City of Brampton, February 2010)

The following policies apply to new structures and additions specifically in the SPA3, which covers the subject part of Downtown Brampton:

i. *the placing or dumping of fill of any kind or the alteration of any watercourse shall not be permitted without the approval of the Metropolitan Toronto and Region Conservation Authority;*

ii. *any new buildings or structures, including new additions, shall not be susceptible to flooding under regional storm conditions, as defined by the Metropolitan Toronto and Region Conservation Authority. In this regard, the City shall cooperate with the Metropolitan Toronto and Region Conservation Authority to determine, prior to the issuance of a building permit, appropriate to flood damage specifications, including setbacks, basement elevations, the strength of the foundation walls, the placement of fill, the elimination of building openings, the installation of back-water valves and sump pumps, and the installation of waterproof seals and structural joints;*

iii. *where it is technically impractical to flood proof a building or structure in accordance with Section 5.6.3.1 (ii), new buildings or structures, including new additions, shall only be permitted, if they do not have a risk of flooding in excess of 25 percent over an assumed life of 100 years (approximately the 1:350 year flood);*

iv. *notwithstanding section 5.6.3 (ii) and (iii), no new buildings or structures including additions shall be permitted within Special Policy Area Number 3 as shown on Schedule SP7(c) (ref. attached), if they would be subject to flows which, due to their velocity and/or depth would be a hazard to life, or where the buildings would be susceptible to major structural damage as a result of a flood less than the Regulatory Flood, as defined by the Metropolitan Toronto and Region Conservation Authority;*

v. *where development or redevelopment requires a zoning by-law amendment and/or a Official Plan Amendment, the City, in consultation with the Metropolitan Toronto and Region Conservation Authority, may determine that an engineering study is required, detailing such matters as flood frequency, the velocity and depth of storm flows, proposed flood damage reduction measures and storm water management; and,* *vi.* *any new zoning by-laws shall contain flood proofing provisions where appropriate, relating to minimum building setbacks, maximum lot coverage, minimum height of any opening and such other matters as may be determined by the City in consultation with the Metropolitan Toronto and Region Conservation Authority*

3.0 EXISTING RIVERINE FLOOD CHARACTERIZATION

Although riverine flooding has not been experienced within SPA3 since the construction of the by-pass physical channel in 1952, a simulated flood condition has established a regulatory risk for flooding since the original designation of the SPA. Based on the current hydrologic modelling, SPA3 is subject to flooding during the Regional Storm Event (Regulatory). The susceptibility of SPA3 to flooding relates the condition that Downtown Brampton has been developed in the native Etobicoke Creek valley feature, which is by nature an area depressed below the surrounding table land, morphologically evolved over millennia to convey runoff. The topography subjects current and future development in SPA3 to flood risk from riverine (spill) and local flooding (from direct rainfall, not assessed as part of the current study). The riverine flooding in SPA3 is a function of two mechanisms (illustrated in Figure 3.1):

1. Spill – water surface elevations are high enough upstream of the by-pass channel such that flow that is conveyed over Church Street and the south bank of the by-pass channel through Rosalea Park and is conveyed south and east by the native Etobicoke Creek valley feature and through downtown Brampton

2. Backwater – water surface elevations are high enough downstream of the by-pass channel such that flow backs up into the native Etobicoke Creek valley feature

The following sections summarize the hydrologic and hydraulic models used to establish the floodplain and associated characteristics (depths, velocities).

The next largest design storm standard that has been characterized for the Etobicoke Creek is the 350 year return period event (AES 12 hour event; Toronto City – Bloor gauge).

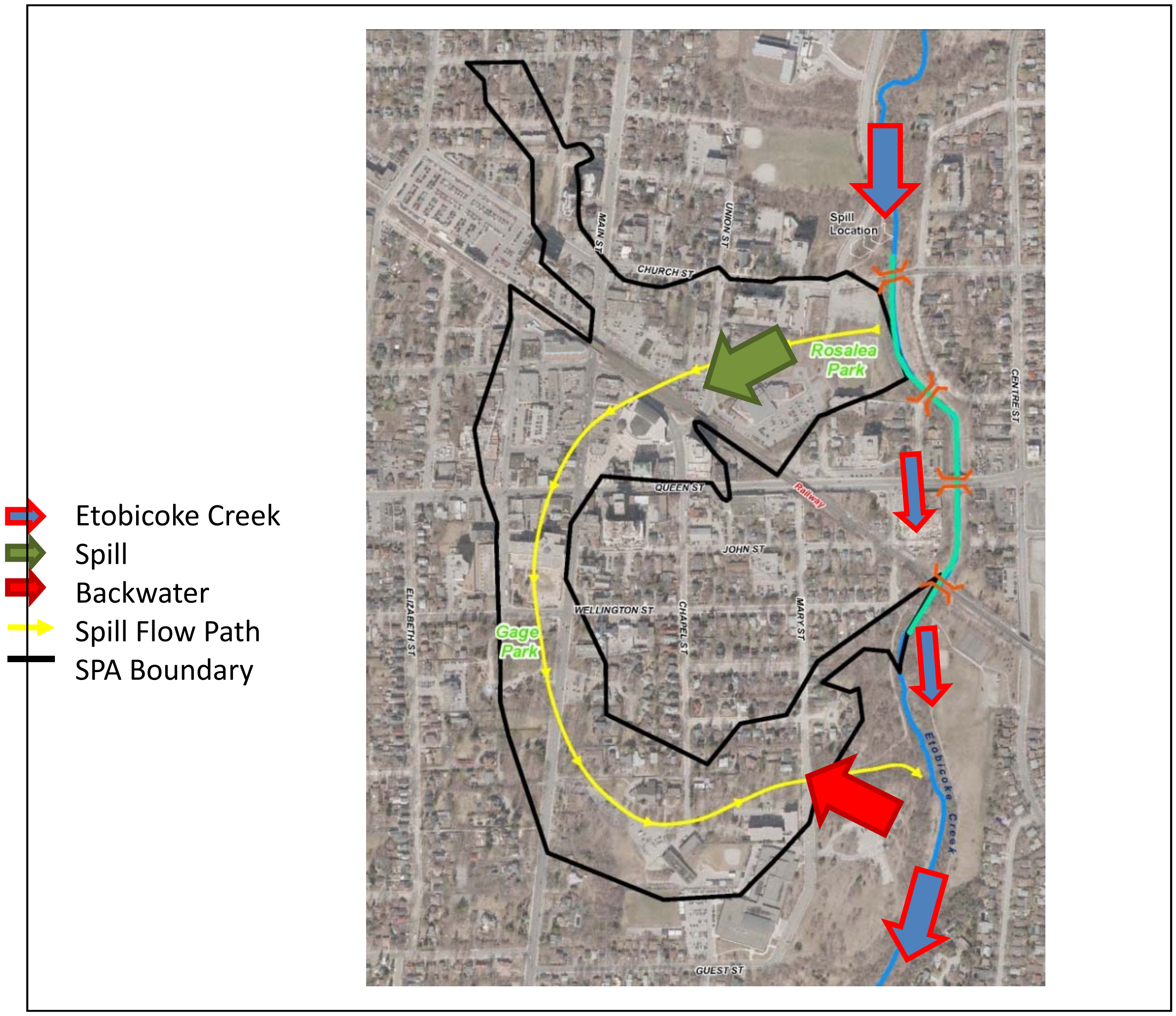


Figure 3.1: Flooding Mechanisms Effecting Downtown Brampton (SPA3)

3.1 Hydrology

TRCA has recently updated the hydrologic modelling for the Etobicoke Creek through the completion of the Etobicoke Creek Hydrology Update Study (MMM, 2012). The study applied the Toronto City – Bloor gauge intensity-duration-frequency parameters and determined that the AES 12 hour design storm governed in terms of peak flow. A 350 year design event was also calculated using frequency analysis (Toronto City – Bloor gauge) for the same design storm distribution. The Regional Storm event (based on Hurricane Hazel) peak flows were simulated per the River & Stream Systems: Flood Hazard Limit Technical Guide (MNR, 2002). Table 3.1 summarizes the calculated peak flows for Etobicoke Creek in the study area.

Table 3.1: Summary of Peak Flows (MMM, 2012) (m^3/s)								
Location	**Return Period (Years)**							
	2	**5**	**10**	**25**	**50**	**100**	**350**	**Regional**
Vodden Street	27.3	39.2	48.0	58.9	67.6	76.5	119.3	289
Church Street	29.4	42.4	52.1	64.0	73.2	83.1	128.9	306
Railway	30.6	44	53.7	65.8	75.7	85.7	132.3	300

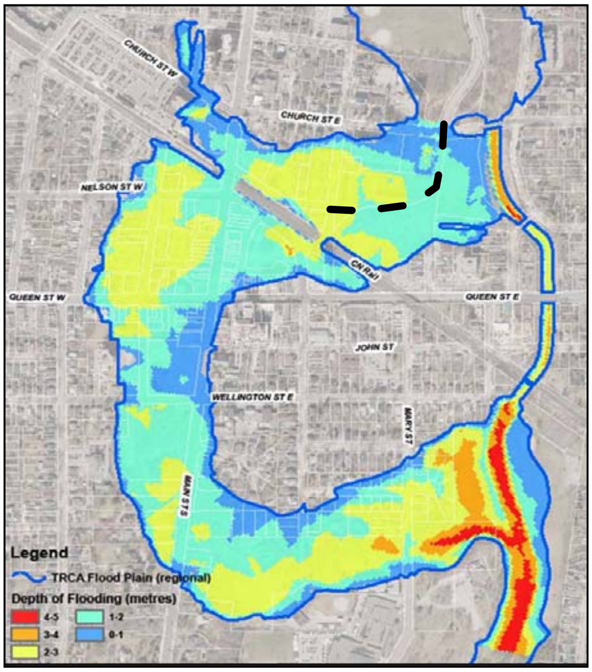
The MMM 2012 study peak flows represent a 25% decrease in the Regional Storm peak flow (404 m^3/s to 306.0 m^3/s) at Church Street relative to the previous study (ref. Etobicoke Creek Hydrology Update, TSH, 2007).

3.2 Hydraulics

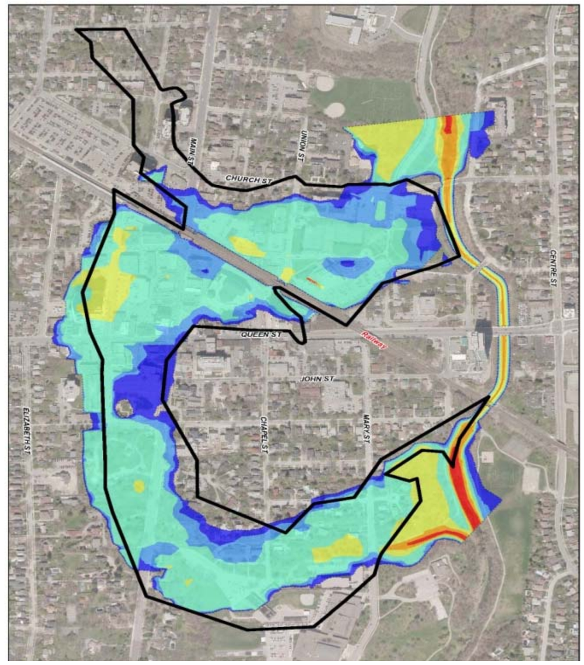
TRCA has also recently updated the hydraulic modelling for the reach of Etobicoke Creek through Downtown Brampton (ref. Downtown Brampton 2012 Floodplain Mapping, Greck & Associates, December 2012), including application of an energy balance methodology to proportion Regional Storm flows to the by-pass channel and SPA area. Figure 1 provides the cross section location plan and 2012 Regulatory floodplain. The refinements to the hydraulic model improved the numerical estimate of theoretical conveyance of the bypass channel by 5% (163 m^3/s +/- to 171.3 m^3/s) versus the previous modelling efforts. Table 3.2 summarizes the flow proportioning from the Greck 2012 study.

Table 3.2: Flow Proportioning at Spill Location – Church Street (m^3/s)		
Total	**By-pass Channel**	**SPA3**
306.0	171.3	134.7

Considering both hydrologic and hydraulic updates, the changes in peak flow and by-pass channel conveyance capacity translate into a 32% reduction in the spill flow (rate-based) which would be conveyed through the Downtown area (194 m^3/s to 134.8 m^3/s). It is noted that the significant reduction in Regional Storm spill flow does not translate into a similar reduction in Regional Storm flood extents through the Downtown SPA; this observation is related to the relatively defined valley feature (i.e. comparatively steep side slopes) through the downtown area. However, the reduced spill flow significantly reduces flood elevations through the Downtown SPA (generally 0.3 m to 0.6 m). The reduction in flood elevations are best described by the colour gradient visualizations developed by TRCA (re. Figure 3.2).



2010 Flood Depths (TRCA)



2012 Flood Depths (TRCA)

Figure 3.2: Flood Depths in SPA3 (Downtown Brampton)

The updated 2012 modelling has also determined that Regional Storm flood velocities through the Downtown SPA would decrease marginally by between 0.01 m/s and 0.40 m/s. It is however noted that these velocities represent an average ‘channel’ velocity, where the channel has generally been defined as the full extents of conveyance through the Downtown SPA valley feature (note: approximate building obstructions have been included). Localized changes in velocity, and magnitude of velocity, could vary significantly across the floodway.

The updated studies have also determined that, based on refined flows, the 350 year event would based on the updated flows be contained in the main branch of the Etobicoke Creek and no spill would impact the Downtown SPA (Note: under 2010 modelling this event spilled into the Downtown SPA). This is particularly relevant considering the policies for SPA3 require flood protection to the 350 year event, at a minimum. It is noted that although the Downtown SPA has now been demonstrated to be flood free to the 350 year event, under SPA3 policies, development is still required to provide flood protection for Regional Storm conditions where technically practical. The revised flood depths will, based on the updated flows, enable future development to provide a comparatively greater flood protection level and thereby reduced flood risk versus the previous 2010 flood depths.

3.3 Hydraulic Modelling Update

As part of the current study, Amec Foster Wheeler completed a review of the TRCA 2012 HECRAS model and concluded that elements of the 2012 model could be improved in order to better reflect the actual field conditions (See Section 1.3 Data Gaps). The main area of concern was identified as the representation of the by-pass channel in the model (cross sections). A comparison of the channel inverts upstream of the bridge structures within the by-pass channel between the model and available design drawings (ref. James E. McLaren Associates, April 1950, Appendix 'B') has demonstrated significant differences in some locations. In addition, the shape of the channel geometry, specifically the low flow portion, was identified as another area of concern. It appeared the cross section geometry in the 2012 model applied the 5x5 m^2 resolution DEM (considered to be too coarse to appropriately represent a channel with a bottom width of 2 m) and did not consider the available design drawings.

Amec Foster Wheeler completed a geodetic survey in July 2013 which captured the following physical features considered to be critical in establishing the spill flow to the SPA and resulting water surface elevations accurately:

- By-pass channel profile from the inlet at Church Street to the outlet downstream of the railway and proximate drop structure;
- By-pass channel geometry including low flow channel and concrete portion of the side slopes (the DEM is considered sufficiently accurate for top of bank);
- Bridge deck and soffit elevations/profiles
- Church Street profile from Union Street to Scott Street (establishes spill conveyance over Church Street)
- Top-of-bank profile of the south bank of the by-pass channel through Rosalea Park (establishes spill conveyance)

The 2012 model has subsequently been updated (2014 HECRAS model) with the geodetic survey and, due to changes to the channel geometry, it has been necessary to update the energy balance to re-establish the flow split between the by-pass channel and spill to SPA3 for the Regional Storm Event (ref. Table 3.3; the by-pass channel continues to have capacity for events up to and including the 350 year event).

Table 3.3: Flow Proportioning for Etobicoke Creek Spill into Downtown Brampton – Regional Storm (m^3/s)

Flow Proportion	TRCA-2012	2014 (Current)	Difference (%)
Total	306	306	-
By-pass	171.3	143.3	-16 %
Downtown Brampton (SPA3)	134.7	162.7	+21 %

The updated model has been executed using the new balanced flows for the Regional Storm event and water surface elevations have been determined accordingly. The revised geometry results in increases of up to 0.66 m in Regional Storm event water surface elevations within the by-pass channel, and 0.48 m upstream of Church Street. Appendix 'C' provides a detailed comparison of updated cross section geometry and resulting water surface elevations.

The updated 2014 HECRAS model has been used as the base hydraulic model for evaluation of flood mitigation alternatives for the current study.

3.4 Two-Dimensional Modelling Merits

The previous hydraulic modelling (and that for the current study) for Etobicoke Creek through the Downtown SPA has applied a one-dimensional (1D) simulation approach. One-dimensional models, in this case HEC-RAS, calculate flow characteristics (i.e. flow velocity, depth, etc) assuming a singular longitudinal flow direction parallel to the main channel, or perpendicular to the cross section. The discretization of one-dimensional models tends to be coarse compared to that of two-dimensional models given the requirement for the user to interpret appropriate flow paths and cross section locations. Flood depth mapping generated from one-dimensional modelling is plotted using a continuous surface based on a digital elevation model (DEM) and in this way generates more discrete flood depth information between cross sections.

Two-dimensional (2D) models represent the terrain as a continuous surface based on a DEM through a finite element mesh where flow can be conveyed longitudinally or laterally between adjacent mesh elements (vertical flow depth is generally held constant over the individual element; varying vertical flow is reflective of a three-dimensional model). With the application of a continuous mesh, flood characteristics (flow, velocity and depth) can be calculated at a high resolution. Two-dimensional models are considered better suited than one-dimensional models to calculating divergent flows typically found floodplains (i.e. out of the main channel) and are specifically adept to flood inundation applications.

Insofar as the application of two-dimensional modelling in the SPA3, its merits for application depend on:

- The usefulness of spatially discrete data on depth and velocity in guiding future development, designing/specifying flood proofing measures, and assessing flood risk; and,
- The expectation that two-dimensional modelling will provide substantially different results than one-dimensional modelling.

In terms of the difference in results, the extent of flood inundation, as well as depth and velocity variation across the SPA must be considered. Considering the relatively defined nature of the valley feature through the Downtown SPA, it is expected the extent of flood inundation would not vary meaningfully. Similarly, and considering flood depths in this application are based on the application of steady state conditions, it is not expected that the calculated range of flood depths would vary substantially, however spatial distribution of depths would be expected to vary. Flood velocities have the potential to range substantially between one and two-dimensional modelling techniques.

Velocities calculated by HEC-RAS (one-dimensional) represent an average ‘channel’ velocity, in the case where the channel has generally been defined as the full extents of conveyance through the Downtown SPA valley feature (as per the approach for Downtown Brampton). Notwithstanding, the magnitude of actual velocities within the ‘channel’ would be expected to range considerably (both above and below the average) as flow is conveyed through and around obstructions in the floodway (i.e. buildings, walkways, depressions, etc). This can be evaluated to some extent in HEC-RAS; velocity profiles can be generated across a cross-section and velocity would vary based on surface roughness and obstructions. However two-dimensional modelling would be able to account for these localized variations in velocity more discretely by accounting for divergent flow conditions and directions. By extension it could potentially be a more effective tool for defining zones of higher and lower risk. It is noted however, that the accuracy of the two-dimensional modelling is highly dependent on the available DEM, the size of the individual elements (grid), as well as the detail in which obstructions are coded (the DEM is generally ground surface only and does not include buildings and other anthropogenic features hence these would need to be represented in some fashion).

Special Policy Area 3, Policy IV specifically requires development in flood affected areas to consider threat-to-life (based on Provincial criteria) as well as the integrity of the structure based on local flood conditions; two-dimensional modelling would enhance the ability to more effectively distinguish variation in depths and velocities for a specific development. Furthermore, modelling of proposed development in a two-dimensional model could also be used to more accurately determine the impact on flood depth and velocity to adjacent property and rights-of-way. Additionally, the planning and design of the river walk could be more accurately assessed with a two-dimensional model in terms of the risk to pedestrians (i.e. depth and velocity).

Further, through simulation of various scenarios for the current study (i.e. updated existing conditions geometry and several flood mitigation scenario summarized in Section 4), it is Amec Foster Wheeler’s observation that the by-pass channel capacity and resulting spill to SPA3 are relatively sensitive to changes in channel geometry, especially under alternatives where the spill is mitigated and the full Regional Storm peak flow is conveyed by the by-pass channel. The sensitive nature of hydraulic conditions is not considered critical to the assessment of the *feasibility* of flood mitigation options for the current study, however future study should consider the application of more advanced hydraulic modelling tools (i.e. two-dimensional) or a detailed sensitivity analysis considering physical geometry, peak flows, hydraulic parameters and bridge modelling methodologies.

3.5 Other Modelling Considerations

Currently, hydraulic modelling for the Downtown SPA has applied steady-state flow conditions which do not consider variation in flow rates over time, as well as the impact of attenuation related to floodplain storage and obstructions. It also explicitly implies infinite flood volume is available to generate the steady state water surface elevation. Another modelling consideration for this assessment relates to the application of unsteady-state modelling which routes a time varying hydrograph (flood wave) through the hydraulic model. In this approach a finite flood volume is available based on the hydrograph calculated in the hydrologic model and, as this hydrograph is routed through the floodway, it is impacted by obstructions and storage volume in the floodplain.

It is possible that the runoff volume required to generate the steady state water surface elevation reported by the current modelling is not actually present in the storm response; an unsteady-state model does not have this limitation. Notwithstanding, as TRCA staff are likely aware, the unsteady state approach does tend to be less conservative. It is noted that steady state hydraulic modelling is the convention for determining the Regulatory floodplain in Ontario, given its conservative assumptions. It is however noted that unsteady-state modelling has been applied for determining the Regulatory floodplain in cases where substantive storage volume and flow constrictions are present (i.e. valley storage upstream of a culvert). This specific condition does not appear to be present in the Downtown SPA in terms of storage volume, however the spill is a result of a constrained conveyance condition at the Church Street bridge which could affect the spill flow magnitude in an unsteady-state simulation. In addition, the spill flow is conveyed through the Main Street and Union Street railway underpasses which could also cause artificially high water surface elevations under a steady-state simulation. The magnitude of the impact on water surface elevations through application of unsteady-state modelling is not expected to be significant. It is noted that the unsteady-state simulation could be completed in the existing one-dimensional HEC-RAS model or in a potential future two-dimensional model.

3.6 Pedestrian Risk Tolerance

One of the objectives of the *Downtown Brampton Urban Design and Land Use Study* is to develop a preferred alternative for a potential Etobicoke Creek ‘riverwalk’ through the Downtown SPA. As the owner of the existing by-pass channel and the policy manager with respect to flood hazard lands in the Downtown SPA, TRCA, with support of the current study, provides input to the risk management perspective for the conceptual design of any potential riverwalk related to pedestrian use. As part of this process, TRCA has indicated concern about the potential liability of attracting pedestrian traffic to a flood conveyance structure, in regards to any alternative that aligns the riverwalk proximate to, or within the by-pass channel.

TRCA has developed a flood risk management protocol as part of the Flood Protection and Remedial Capital Works Program (AMEC, 2014). This work considers flood risk to people but only as it relates to occupancy in buildings, open roads and bridges or in vehicles, it does not specifically address pedestrians in park and open space land uses. It is noted that park and open spaces would appear to have a reduced risk to people during a significant storm event given the lack of shelter (people tend not to remain outside and away from buildings during storm events), however risk persists prior to a storm or during snow melt events with respect to high flows. If the future riverwalk is sited in, or proximate to, the by-pass channel this is a specific concern.

Risk to pedestrians can be described on the basis of the return period of flooding, the depth and velocity of flooding and the vulnerability of the hazard area, with respect to flood warning including:

Rainfall Design Event

Several recent community planning studies have considered pedestrian trail planning adjacent to watercourses. Often trails are planned on either side of the valley feature, generally outside of the 25 year to Regulatory floodplain, however with regular connections through and across floodplains which introduce a similar element of risk as that of the Downtown Brampton riverwalk. Where these connections cross the watercourse, pedestrian bridges are often designed for the 2 year event. It is recommended that any pedestrian trails be sited outside of the 25 year floodplain, at minimum.

Depth & Velocity

Risk tolerance for pedestrians, in terms of current policy in Ontario, is best expressed by Ontario Ministry of Natural Resources' Threat to Life criteria in the Flood Hazard Limit Technical Guide (2002). MNR establishes Threat to Life based on three criteria: flood depth, velocity and the product of depth and velocity.

The flood depth criteria relates to consideration of a buoyant force on the exposed person until the force is greater than the individual's mass and the person floats. Flood flows also apply a lateral force on an exposed person by the force generated from flow velocity. The forces associated with velocity act against the shear force of friction between the person and the ground surface. It follows that the shear force of a person acting against the force associated with velocity is reduced as water depth and associated buoyant forces increase, hence the consideration of the depth-velocity product. The ability of an individual to resist flood forces also vary by the person's mass.

MNR guidelines suggest the maximum flood depth before an individual floats is 0.98 m +/- and 1.37 m +/- for young children and teenage children/adults, respectively. The force exerted by velocity is dependent on an individual's size, the ground surface and flood depth and as such the product of depth and velocity is considered the preferred measure of risk. MNR suggests that the maximum product of depth and velocity to ensure 'low risk' to any individual is 0.4 m^2/s, where depth is less than 0.8 m and velocity is less than 1.7 m/s; therefore any pedestrian trails should satisfy these parameters for the selected design event.

Area Vulnerability

Although no specific measure of area vulnerability is provided in Provincial regulations, it can be reasonably assumed that pedestrian trails adjacent to the Etobicoke Creek and by-pass channel would be considered to have a similar vulnerability compared to any other valley system trail network, but relatively higher vulnerability to trail systems in urban flood fringe areas. The implementation of a riverwalk should consider the following to reduce the area vulnerability, or risk to pedestrians: communications infrastructure to provide flood warning to pedestrians; multiple ingress/egress locations for pedestrians to vacate the riverwalk where it is immediately adjacent to the channel; incorporation of physical/vegetated barriers areas within the design floodplain (e.g. below 25 year floodline); and, placement of on-site rescue equipment (e.g. flotation devices).

One measure of area vulnerability is the speed of onset of flooding, or the time-to-peak for the watershed. This has been calculated for the Etobicoke Creek by-pass channel through analysis of long-term flow records (November 2003 to March 2009) at the Water Survey Canada Church Street gauge location in combination with rainfall records at the Environment Canada Pearson gauge (closest gauge with overlapping period of record, 2004 to 2007). Time-to-peak has been calculated for a selection of nine (9) of the largest rainfall events in the period of record. This data is compared to time-to-peak calculated for the 2, 25, 100 and Regional storms (simulated in TRCA's Visual OTTHYMO model for Etobicoke Creek, MMM 2012) and presented in Table 3.4.

Table 3.4: Summary of Storm Event Time-to-Peak and Duration of Flooding at Church Street; Etobicoke Creek (hours)

Variable	Return Period (Years)				
	Flow Gauge (Average)[2]	2[3]	25[3]	100[3]	Regional[4]
Time-to-Peak	1 – 3 (1.9)	6.5	6.5	6.3	47.3
Duration of Flooding[1]	N/A	21.8	25.3	26.5	69

Note: [1] Where flow rate is greater than 2 m^3/s – approximately equivalent to the capacity of the low flow channel
[2] Water Survey Canada Church Street gauge (November 2003 to March 2009)
[3] Based on 12 Hour AES Design Storm (Toronto City gauge)
[4] Based on 48 hour Hurricane Hazel hyetograph

This data provides an indication of the available time to disseminate flood warning to the Etobicoke Creek by-pass area, which could include pedestrians on a potential riverwalk, as well as an indication of the duration the area would be at an elevated risk, which can be important to understand when pleasant weather following a storm event brings pedestrians out while flow conditions remain high.

Additional Information

Literature review been conducted to understand pedestrian/public risk assessment approaches in other provinces and countries, specifically with regard to planning pedestrian trails relative to a design storm floodplain. No guidelines or regulations were found which sited this type of requirement. Some related information was found on calculating pedestrian risk within the United Kingdom and is summarized in Appendix 'B'.

4.0 FLOOD MITIGATION ALTERNATIVES

A wide range of flood mitigation measures are available to address urban riverine-based flooding. These measures generally aim to either eliminate the actual flood condition in the developed area, or manage/minimize the flooding impacts and associated risks to development. The preferred method is typically eliminating the flood condition, however in an urban setting, several constraints often limit the feasibility of this objective (available land, impact to existing development, capital cost, etc), and as such, the approach generally optimizes attainable levels of flood protection.

The Flood Characterization assessment for this study, which has relied on the review of available desk-top information, has determined that the flooding in Downtown Brampton relates to two mechanisms: a spill condition from Etobicoke Creek at Church Street and just downstream through Rosalea Park (upstream limit of SPA3), as well as a backwater condition downstream of the railway (downstream limit of the SPA3). Based on this, flood mitigation alternatives have been considered which have the potential to address one or both of these mechanisms.

Several of the alternatives considered for the current study have previously been assessed, at varying levels of detail, in previous studies as follows:

- Ken Whillans Drive Extension and Downtown Drainage Improvements Class Environmental Assessment (City of Brampton, Aquafor Beech, 2011)
- Downtown Drainage Study (City of Brampton, Aquafor Beech, 2006)
- Feasibility Assessment, Naturalization of Brampton Diversion Channel, Etobicoke Creek (Dillon, January 29, 2003)

The assessment as part of this study has been conducted as a feasibility study, whereby the results of the previous studies (with respect to the feasibility of certain mitigation alternatives), have been used as appropriate, along with supporting technical analyses, to establish the feasibility/efficacy of previously considered alternatives, including several new alternatives and combinations of alternatives, not previously assessed.

4.1 Assessment of Long-List of Flood Mitigation Alternatives

Considering the foregoing, the current study has evaluated the following flood mitigation alternatives to address the current flood condition in Downtown Brampton:

- **Alternative ‘A’: Conveyance Improvements**
  - A1. Church Street Flood Berm
  - A2. Rosalea Park Flood Berm
  - A3. Flood Protection Landform
  - A4. Bridge Improvements
  - A5. Lower By-pass Channel
  - A6. Widen By-pass Channel
  - A7. Downstream Channel Improvements
  - A8. Tailwater Flood Protection Landform
  - A9. Clarence Street Bridge Improvements

- **Alternative 'B': Flood Control**
  - B1. Online Flood Storage
  - B2. Offline Flood Storage
  - B3. Greenfield Stormwater Management
- **Alternative 'C': Floodproofing**
- **Alternative 'D': Land acquisition**
- **Alternative 'E': Diversions**
- **Combinations of the above**

Flood Protection Evaluation Criteria & Considerations

The long-list of flood mitigation alternatives has been assessed in terms of ***functional*** flood hazard benefits and ***regulatory*** (policy) based benefits. Functional flood hazard benefits describe the potential for a reduction to flood risk (i.e. frequency of flooding), flood levels (depths) and flood impacts. The functional benefit must then be considered in the policy framework, specifically, the flood protection method proposed under the alternative (i.e. conveyance improvement, dam, dyke, etc) and how it is categorized in the MNR's Technical Guide for River and Stream Systems: Flood Hazard Limit (i.e. the relevant policy).

Specifically MNR categorizes flood protection structures as either ***permanent*** or ***non-permanent***. Permanent flood protection measures remove the protected lands from the Regulatory flood hazard (in this case the Regional Storm floodplain); examples include flood protection landforms, valley walls, diversions or channelization. Non-permanent flood protection does not remove the protected lands from the flood hazard due to the potential for these measures to fail; examples include dykes/flood walls, dams and stormwater management facilities. Under MNR guidelines, non-permanent structures allow for the protected lands to be classified as 'flood-fringe' under a 2-Zone flood hazard policy (floodway and flood-fringe). Under this type of policy, the flood fringe would be considered developable, if development can be flood-proofed to the governing flood standard (i.e. Regulatory Event). If floodproofing to the flood standard is not feasible, Special Policy Area status can be requested; this is the case for the Downtown Brampton SPA3.

Downtown Brampton presents a unique situation for the application of non-permanent flood protection since it already has Special Policy Area status. Based on MNR policy, the application of any non-permanent flood protection would offer no additional Regulatory flood hazard benefits to development potential in the SPA3 lands, and any future development protected by non-permanent structures would continue to require floodproofing to the flood standard specified in SPA3 Policy ii and iii (i.e. floodproofing for the Regional Storm; or where floodproofing for the Regional Storm is technically impractical, the 350 year storm). The following summarizes the permanent and non-permanent flood protection alternatives considered for the current study:

Permanent	Non-Permanent
Alternative A3: Flood Protection Landform	Alternative A1: Church Street Flood Berm
Alternative A4: Bridge Improvements	Alternative A2: Rosalea Park Flood Berm
Alternative A5: Lower By-pass Channel	Alternative B1: Online Dam
Alternative A6: Widen By-pass Channel	Alternative B2: Offline Stormwater Management
Alternative A7: Downstream Channel Improvements	Alternative B2: Offline Stormwater Management
Alternative A8: Tailwater Flood Protection Landform	
Alternative A9: Clarence Street Bridge Improvements	

In summary, the alternatives classified as *permanent* measures, have the potential to provide flood protection benefits under MNR policy (reduce flood standard and associated levels), whereas the *non-permanent* alternatives would only provide *functional* flood protection (reduce flood risk, however development (existing or proposed) must continue to protect to the governing flood standard).

In the following sections, general discussion is provided on the feasibility of the alternative in the technical, natural, social and economic environments, as well as identifying related opportunities and constraints.

4.1.1 Alternative 'A': Conveyance Improvements

Conveyance improvements include alternatives that increase the hydraulic capacity of the existing riverine drainage system, in this case Etobicoke Creek reaches upstream of, through, and downstream of the Downtown Brampton by-pass channel. In this regard, eight (8) alternatives have been evaluated related to improving conveyance and are summarized in the following.

4.1.1.1 Alternative A1: Church Street Flood Berm

This alternative was originally introduced in the Downtown Drainage Study (Aquafor Beech, 2006) and more recently refined, and advanced as the Preferred Drainage Alternative, for the Ken Whillans Drive Class EA (Aquafor Beech, 2011). Two options have been identified as part of this alternative including raising the profile of Church Street or raising the profile of Ken Whillans Drive; in either case the objective would be to eliminate or minimize the existing spill condition at Church

Street. Detailed assessments of each option were completed for the Ken Whillans Drive Class EA which ultimately determined that raising Ken Whillans Drive was preferred from a social perspective, citing less property impacts related to acquisition, land use and access to residential properties during construction.

The existing low point on Church Street, immediately west of the intersection with Ken Whillans Drive, would be raised from approximately 213.3 m +/- to 215.5 m +/- the conveyance system performance has been re-assessed as part of this study accordingly (ref. Figure 2). Elevation 215.5 m is considered to be the maximum crest elevation allowing the berm to tie into existing grades on the adjacent condominium property at 58 Church Street. This elevation is also approximately equivalent to the existing high points on Church Street, west (of Union Street) of the proposed berm; any increase in berm height above this elevation would therefore not contain any additional flow.

In order to assess the potential increase in conveyance capacity, as well as evaluate any impacts to upstream water surface elevations, the existing conditions HEC-RAS model for Etobicoke Creek has been updated at cross sections upstream and downstream of Church Street (sections 26.74 and 26.73, respectively). The following summarizes the results of the updated hydraulic modelling, as well as regulatory considerations and potential environmental and social impacts.

Functional Flood Protection Benefits

- Capacity of the by-pass channel would remain unchanged at 143.3 m^3/s, greater than the 350 year design event (128.9 m^3/s) and below the Regional Storm peak flow (306.0 m^3/s)
- The Regional Storm would continue to spill downstream of Church Street, through Rosalea Park
- This alternative would have no function flood benefit with respect to either the spill or backwater conditions (based on the parameters assumed for the assessment of this alternative stated herein)

Regulatory Flood Protection Benefits

- The Church Street Flood Berm would be considered *non-permanent* flood protection and therefore future development in the SPA3 would continue to require floodproofing to the governing flood standard as specified in the policies. It is noted however that no functional benefit has been demonstrated.

Technical, Environmental, Social and Economic Impacts

- Regional Storm water surface elevations upstream of the proposed works would increase by up to 2 m
- Fill would be required in the floodplain (for construction of the berm) and would represent a minor loss of floodplain storage
- Minor impact (loss of trees) to the existing woodlots on the northwest and northeast side of Church Street and Ken Whillans Drive
- Minor impacts to adjacent private property (grading within currently open spaces)
- This alternative would have a relatively low capital cost

4.1.1.2 Alternative A2: Rosalea Park Flood Berm

Alternative A2 proposes the construction of a flood control berm along the west side of the by-pass channel to increase the hydraulic capacity through Rosalea Park (ref. Figure 2). Flow from Etobicoke Creek spills from this location under events greater than the 350 year storm. It is noted that the spill at Church Street occurs first (i.e. under lower flow) and as such it has been assumed that this alternative would only be implemented in combination with Alternative A1.

The maximum crest elevation of the proposed berm has been set equal to the Church Street berm (Alternative A1) 215.5 m +/-. The berm would essentially eliminate the existing low point along the west bank of the by-pass channel between Church Street and Scott Street and thereby increase capacity of this reach.

In order to assess the potential increase in conveyance capacity, as well as evaluate any impacts to upstream water surface elevations, the existing conditions HEC-RAS model for Etobicoke Creek has been updated at cross sections through Rosalea Park and Church Street (sections 26.71 to 26.74). The following summarizes the results of the updated hydraulic modelling, as well as regulatory considerations and potential environmental and social impacts.

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 97 % from 143.3 m^3/s to 282 m^3/s
- The Regional Storm would continue to spill over Church Street; spill through Rosalea Park would be eliminated
- The spill into Downtown Brampton during the Regional Storm would be reduced by 88 % from 162.7 m^3/s to 20 m^3/s
- This alternative would have no impact on flooding in the southern limit of the SPA3 caused by backwater in Etobicoke Creek

Regulatory Flood Protection Benefits

- The Rosalea Park Flood Berm would be considered *non-permanent* flood protection and therefore development in the SPA3 would continue to require floodproofing to the governing flood standard specified in the policies.

Technical, Environmental, Social and Economic Impacts

- Regional Storm water surface elevations upstream of the proposed works would increase by up to 2 m (no significant impact for other design events)
- Loss of floodplain storage resulting from fill in the floodplain and reduced spill flow to SPA3 (see Section 5.2.2 for further discussion)
- Minor impact (loss of trees) to the existing woodlots on the northwest and northeast side of Church Street and Ken Whillans Drive
- Minor (non structural) impacts to adjacent private property (grading within currently open spaces)
- Minor impact to existing park uses in Rosalea Park
- This alternative would have a relatively low capital cost

4.1.1.3 Alternative A3: Flood Protection Landform

From a functional perspective a flood protection landform (FPL) would provide identical flood mitigation as Alternative A2 by providing a continuous berm with a crest elevation of 215.5 m +/- to reduce spill flow to SPA3. The important difference is that by meeting specific design criteria that eliminate the potential failure modes that berms (dykes) are susceptible to (overtopping, saturation, boils), a flood protection landform is classified as a *permanent* structure by the Province, and as such provides Regulatory flood protection from a policy perspective. In other words, a flood protection landform has the potential to reduce or eliminate the Regulatory floodplain associated with the spill condition in SPA3.

Draft Flood Protection Landform Criteria (ref. Memorandum Greck-Haley, February 20, 2013, in Appendix ‘B’) outline the special design/siting considerations for FPLs which are paraphrased as follows:

- The FPL must fully mitigate flood risk to existing flood vulnerable areas; for the current study this means eliminating the Regional Storm spill into SPA3;
- The FPL must maintain the conveyance capacity of the existing river system;
- The FPL cannot have any unmitigated impact on upstream or downstream flood levels;
- To manage the integrity of the FPL, any intrusions into the core of the FPL should be restricted/regulated (e.g. services, deep rooted vegetation);
- The crest of the FPL shall provide a minimum 0.3 m of freeboard above the Regional Storm water surface elevation (this is incorporated into the proposed 215.5 m crest elevation); additional freeboard shall be provided considering for climate change (NOTE: this has not been incorporated into the current conceptual layouts);
- Fill slopes on the wet side (river side) of the flood protection landform should be designed with fill slopes of 5-10%, with a maximum of 15% in localized areas when approved by TRCA. The dry side fill slopes should be designed with gradients of 1.5-2.5% with a maximum of 5% in localized areas, when approved by TRCA;
- A minimum 3-5m crest is required;
- Local drainage (minor and major) shall be directed away from the crest of the FPL;
- No hydraulic connection between the wet and dry sides of the FPL. Where unavoidable due to brownfield development, an analysis of risk and potential impacts must be completed and approved by TRCA; and,
- No structure or foundation shall be supported on or within the FPL (use of piles supported by bedrock below the FPL may be approved).

Through consultation with the JSC, three (3) conceptual FPL options have been developed through this study. The options are differentiated by the upstream tie-in location to the existing valley wall and as such are named accordingly (ref. Figure 3):

Option 1: Church Street
Option 2: Alexander Street
Option 3: Ellen Street

In terms of flood mitigation, all options would be identical. The upstream flood impact would be expected to vary, however not substantially, and for the purpose of screening for feasibility, Option 3 has been hydraulically modelled as it requires the most fill in the floodplain and accordingly has the highest potential for upstream impact. The options vary significantly in terms of impact to private property and natural environment due to their spatial footprint; it is these considerations that are expected to ultimately lead to the selection of a preferred option.

Using Alternative A2 as a starting point for the development of a flood protection landform due to similar restrictions on the crest elevation, the existing low point on Church Street, immediately west of the intersection with Ken Whillans Drive, has for modelling purposes been raised from approximately 213.3 m +/- to 215.5 m +/-. For Option 1, elevation 215.5 m continues to be considered to be the maximum crest elevation allowing the berm to tie into existing grades on the adjacent condominium property at 58 Church Street. This elevation is also approximately equivalent to the existing high point on Church Street, west (of Union Street) of the proposed crest; any increase above this elevation would therefore not contain any additional flow. It is noted that for Flood Protection Landform Options 2 and 3, which do not tie-in to Church Street, there may be the opportunity to optimize this elevation through subsequent studies, however based on conceptual grading exercises completed as a part of this study, Option 2 and 3 are expected to be constrained at, or below, the same crest elevation (215.5 m +/-), as the toe of the dry side would encroach on the condominium structure at 58 Church Street (ref. Figure 3).

In order to assess the potential increase in conveyance capacity, as well as evaluate any impacts to upstream water surface elevations, the existing conditions HEC-RAS model for Etobicoke Creek has been updated at cross-sections through Rosalea Park and Church Street (sections 26.71 to 26.74). Hydraulic Modelling has been based on Option 3 as it requires the most fill in the floodplain and accordingly has the highest potential for upstream impact. The following summarizes the results of the modelling, policy considerations and environmental and social impacts.

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 97 % from 143.3 m^3/s to 282 m^3/s
- The Regional Storm would continue to spill over Church Street; spill through Rosalea Park is eliminated
- The spill into Downtown Brampton during the Regional Storm would be reduced by 88 % from 162.7 m^3/s to 20 m^3/s
- This alternative would have no impact on flooding in the southern limit of the SPA3 caused by backwater in Etobicoke Creek

Regulatory Flood Protection Benefits

- A flood protection landform is considered to be *permanent* flood protection and therefore would remove any flood impact and risk in the SPA3 associated with the existing spill condition.

- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) in SPA3 would be reduced by up to 1.7 m +/-.

Technical, Environmental, Social and Economic Impacts

- Regional Storm water surface elevations upstream of the proposed works would increase by up to 2 m
- Loss of floodplain storage resulting from fill in the floodplain and reduced spill flow to SPA3 (see Section 5.2.2 for further discussion)
- Minor to significant impact to the existing woodlots on the northwest and northeast side of Church Street and Ken Whillans Drive is expected, depending on the preferred option; Option 3 would require the full removal of the woodlot on the west side
- Minor to significant impacts to local minor drainage systems are expected on the dry side of the FPL, depending on the preferred alternative:
    - Option 1 would require the protection or diversion of two (2) existing local storm sewer systems that outlet to the by-pass channel through Rosalea Park; this option would not substantially alter local drainage patterns and would not introduce additional drainage area to the SPA3
    - Option 2 and 3 introduce additional local drainage area to SPA3 (i.e. the dry side of the FPL, north of Church Street) and as such would be expected to require a dry side minor storm sewer to drain the toe of the FPL; this system could outlet to Etobicoke creek through the FPL (if permittable) or immediately south of the southern terminus of the FPL (if space permits) or to existing storm sewer systems in SPA3 (this is expected to require either stormwater management or storm sewer upgrades)
- Significant impacts to existing services and utilities:
    - An existing 1200 mm diameter sanitary sewer on the west side of Etobicoke Creek would require mitigation either by relocation, notionally it could be moved to the east side of the creek or, since the sewer would not create a hydraulic connection between the wet and dry side of the FPL, it may be able to be protected in place, below the core of the FPL; further assessment and consultation with TRCA and the City of Brampton would be required during future studies
    - Mitigation of local watermains along Church Street and Ken Whillans Drive would be required, either by protection in place or relocation or a combination; further assessment and consultation with TRCA and the Region of Peelwould be required during future studies
    - Other impacts to existing utilities (hydro, bell, cable, etc) would be expected
- Moderate to severe impacts to adjacent private property are expected, depending on the preferred option:
    - Option 1 would require the acquisition of several commercial and residential lots south of Church Street, most significantly 53 Church Street which would require the demolition of the existing 6 story apartment building; further investigation and negotiation would be required with the owner to determine the feasibility of this from a cost and legislative perspective

- o Option 2 would require the acquisition of 58 Church Street (among other less significant commercial lots south of Church Street) and demolition of the existing 13 story condominium building; this is not considered feasible and as such Option 2 has been screened
- o Option 3 would require the acquisition of commercial lots south of Church Street and would have grading impacts on 58 Church Street and the Central Public School which would have to be negotiated with the owners and any impact to existing structures mitigated; the existing City works building at the end of Ellen Street would have to be relocated

- Significant impact to existing park uses in Rosalea Park; based on concepts developed by the Downtown Brampton Urban Design and Land Use Study Team (TPP/City of Brampton), it is expected that all FPL options can be integrated into the urban fabric in such a way that the City of Brampton's vision for the downtown core is maintained or enhanced
- This alternative would have a relatively high capital cost

Valley Wall Structure

The Draft Flood Protection Landform Criteria (Greck, February 20, 2013) also outline guidelines for the specification of a '*valley wall*' structure. A valley wall is constructed with even gentler dry side slopes than a flood protection landform such that risks related to failure modes (saturation and boils) are reduced and similar to a natural valley wall. A valley wall provides the benefit of reduced restrictions for development on the structure (versus a flood protection landform) as the structure is becomes subject only to the typical Valley and Stream Corridor Management practices. Generally, a valley wall must meet the criteria for a flood protection landform with the following differences:

- The dry side slopes on a valley wall must be predominantly less than 1.5%, with a 1% gradient preferred (versus 1.5 – 2.5% for a FPL);
- The predominant dry side gradient must extend from the crest of the FPL bank to a distance of 3x the width of the required equivalent FPL footprint at a maximum of 1-1.5 % gradient;
- Minor and major system drainage must be directed away from the proposed valley wall. Where this cannot be achieved or a variance to this is allowed, drainage to or over the wet side of the FPL will be minimized or designed to ensure no impact; and,
- The 'core' of the structure is to be constructed as per the fill and compaction requirements of a FPL within the area as defined by the 2.5% dry side gradient.

Due to the changes in dry side grading, a valley wall footprint would be larger than those that have been presented for an FPL (ref. Figure 3). Based on the significant impact on local private property caused by the various FPL options, and the general desire to minimize these impacts as they represent a feasibility constraint, a valley wall option has not specifically been prepared for the current study. It is noted however that if future study demonstrates that the benefit of reduced development restrictions associated with a valley wall out-weigh the additional impacts to adjacent property, this option provides the same function and regulatory flood benefits as described herein for an FPL. Social and environmental impacts would vary in accordance with the larger footprint.

4.1.1.4 Alternative A4: Bridge Improvements

Alternative A4 has involved the assessment of the potential benefit to conveyance capacity in the by-pass channel generated by increasing the conveyance capacity of the Church Street, Scott Street, Queen Street and railway bridges (ref. Figure 4). The existing bridges offer significant clearance over Regulatory water surface elevations and as such increasing the capacity would be achieved by replacing the existing bridges with larger span structures.

In order to assess the potential increase in conveyance capacity under this alternative, the Church Street, Scott Street, Queen Street and railway bridges have been removed from the existing conditions HEC-RAS model for Etobicoke Creek, which in effect would provide a maximum or upper limit to hydraulic improvements under this alternative.

Functional Flood Protection Benefits

- The hydraulic assessment has determined that the Regulatory water surface elevations would decrease nominally within the by-pass channel with the existing bridges removed from the model. This alternative would have no impact on flood elevations in SPA3. It has therefore been determined that replacement of the structures would have minimal impact on conveyance capacity and thereby replacing them offers minimal flood protection benefit. It is noted however that this is based on the existing flow distribution between the by-pass channel and SPA area, should the full Regional Storm peak flow be contained by the channel through other flood mitigation works, bridge upgrades may have a more substantial impact. This combined scenario has not been explored within this study, as other more economical combinations of alternatives have been advanced.
- Capacity of the by-pass channel would remain above the 350 year design event (128.9 m^3/s) and below the Regional Storm (306.0 m^3/s)

Regulatory Flood Protection Benefits

- The improvements would be considered *permanent* flood mitigation, however no functional flood protection benefit is generated

Technical, Environmental, Social and Economic Impacts

- Minor impacts to the natural environment would be expected
- This alternative would have a relatively high capital cost

4.1.1.5 Alternative A5: Lower By-Pass Channel

Alternative A5 considers lowering the bypass channel by 1.5 m throughout its length (ref. Figure 4). A review of existing City municipal service layers (storm, sanitary, water) has been completed to identify any potential conflicts that may limit channel lowering opportunities. The only significant conflict identified is a trunk sanitary sewer crossing the by-pass channel at the railway bridge. Lowering the channel 1.5 m has been based on providing 1 m +/- cover to the obvert of the sanitary pipe. Additional conflicts would be expected however no additional significant conflicts have been identified. This alternative would generate additional conveyance capacity and remain within the existing banks of the by-pass channel by increasing the grade of side-slopes as required. The depth of lowering could be reduced as necessary (i.e. due to conflicts, or combination with other flood mitigation alternatives).

In order to assess the potential increase in conveyance capacity, as well as any impacts to upstream water surface elevations, the existing conditions HEC-RAS model for Etobicoke Creek has been updated at cross sections throughout the by-pass channel (section 26.74 to 26.60).

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 102 % from 143.3 m^3/s to 289 m^3/s
- Capacity of the by-pass channel would remain above the 350 year design event (128.9 m^3/s) and below the Regional Storm (306.0 m^3/s)
- The spill into Downtown Brampton during the Regional Storm would be reduced by 90 % from 162.7 m^3/s to 17 m^3/s

Regulatory Flood Protection Benefits

- By-pass Channel Improvements are considered to be *permanent* flood protection, and as such would directly reduce the flood hazard in SPA3
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) in SPA3 would be reduced by up to 1.8 m.

Technical, Environmental, Social and Economic Impacts

- Water surface elevations immediately upstream of the proposed works (i.e. upstream of Church Street) would decrease (over existing) by up to 1.3 m for the Regional Storm, thereby providing a potential flood hazard benefit to existing properties within the floodplain upstream of SPA3; these benefits approach zero proximate to Vodden Street
- The potential for additional infrastructure, services and utility conflicts is high for this alternative
- While the capital cost of channel lowering is relatively high, it is noted that City of Brampton initiatives to rehabilitate the channel as part of the vision for Downtown Brampton may introduce overall cost efficiencies to this alternative that should be considered in the economic assessment and ultimate selection of a preferred flood mitigation alternative

4.1.1.6 Alternative A6: Widen By-Pass Channel

Widening the Downtown Brampton by-pass channel could take several forms and a wide range of ultimate widths. The following options are considered at a high level under this option:

- Modifications to the channel within the limits of the existing banks;
- Widen the overall channel including the top width while maintaining a concrete channel in the low flow portion; and,
- Naturalize the by-pass channel.

Alternative A6 was originally considered as a naturalized channel in the Feasibility Assessment, Naturalization of Brampton Diversion Channel, Etobicoke Creek (Dillon, 2003) and also considered as an alternative in the Ken Whillans Class EA. In both of these studies, the existing concrete by-pass channel was considered for replacement with a naturalized channel and valley feature. Naturalizing the channel, while also increasing the capacity would necessarily require a wider channel (due to decreased conveyance efficiencies related to roughness) and given the proximate development, would also require land acquisition. The Dillon Feasibility Study assumed that the existing 22 metre (top width) channel would be widened to the west, presumably to provide a more linear floodplain and minimize the number of residential properties impacted. Three options were considered which widened the channel by 2, 3 and 4 times the existing top width, up to a total width of 88 metres +/-. The capacity of each option was not explicitly reported but it is logical to conclude that capacity for the Regional Storm event was generated under the widest condition. Generally, the greater the capacity achieved by naturalizing the channel, the greater the impact to adjacent property, in terms of acquisition requirements. The Dillon Feasibility Study reported that naturalizing the channel (88 metres) could require the acquisition of up to 20 residential properties, 2 commercial properties and a health centre, as well as the replacement of 4 bridge structures (Church Street, Scott Street, Queen Street, CN railway). The Ken Whillans Class EA has estimated the cost of this alternative at $53.6 million +/-. The width required for full naturalization based on the Dillon Study (88 m+-) is illustrated on Figure 4; it is shown to the west to be consistent with the Dillon Study, however widening to the east would also be feasible from a functional perspective.

Consultation with the City/TPP through the JSC has been undertaken to determine the widest feasible widening scenario from the perspective of impact to existing property and urban fabric. The City's widening limits are most restrictive at the Scott Street and railway bridges and do not permit widening the top of the channel at these locations (ref. Figure 4); essentially eliminating the opportunity to naturalize the by-pass channel while improving the capacity. Therefore the 'best case' widening scenario has examined the application of vertical channel walls through these bridges (maintaining 1.2 m cover over the toe of the bridge foundation, ref. Figure 4.1), and widening the remaining reaches of the by-pass channel by 10 m +/- (top width) while maintaining the original side slopes to keep conveyance capacity consistent throughout.

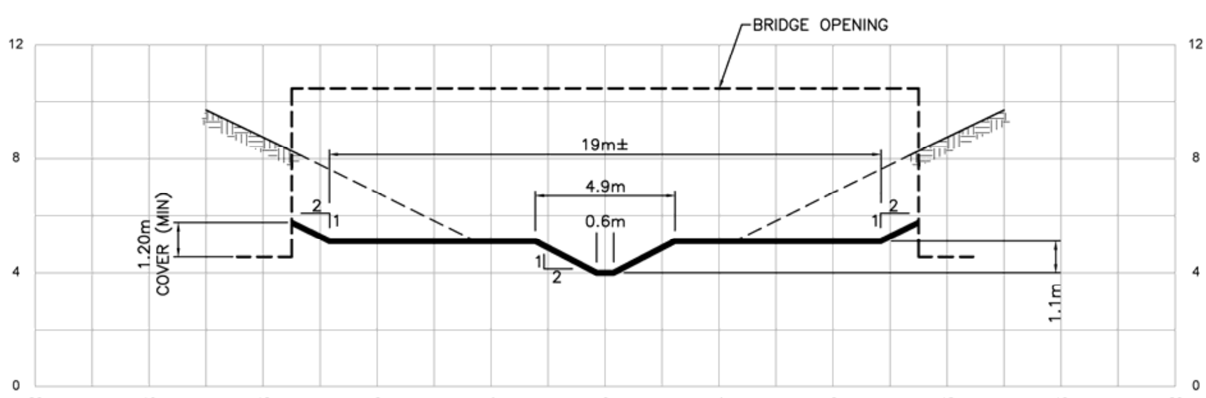


Figure 4.1: Alternative A6: Widen By-pass Channel – Cross section under bridge (typical)

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 33 % from 143.3 m^3/s to 190 m^3/s +/-
- Capacity of the by-pass channel would remain above the 350 year design event (128.9 m^3/s) and below the Regional Storm (306.0 m^3/s)
- The spill into Downtown Brampton during the Regional Storm would be reduced by 29 % from 162.7 m^3/s to 116 m^3/s

Regulatory Flood Protection Benefits

- By-pass channel improvements are considered to be permanent flood protection, and as such would directly reduce the flood hazard in SPA3
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) in SPA3 would be reduced by up to 0.4 m +/-.

Technical, Environmental, Social and Economic Impacts

- Water surface elevations immediately upstream of the proposed works (i.e. upstream of Church Street) would decrease by up to 0.6 m for the Regional Storm, thereby providing a potential flood hazard benefit to existing properties within the floodplain upstream of SPA3; these benefits approach zero proximate to Vodden Street
- Loss of floodplain storage resulting from reduced spill flow to SPA3 (see Section 5.2.2 for further discussion)
- The capital cost of channel widening is relatively high. Similar to Alternative A5, it is noted that City of Brampton initiatives to rehabilitate the channel as part of the vision for Downtown Brampton may introduce cost efficiencies to this alternative that should be considered in the economic assessment and ultimate selection of a preferred flood mitigation alternative

4.1.1.7 Alternative A7: Downstream Channel Improvements

Alternative A7 proposes to increase the capacity of the Etobicoke Creek downstream of SPA3; this alternative was originally considered in the Downtown Drainage Study and updated in the Ken Whillans Class EA. Based on a review of the Regional Storm floodplain, this reach appears to constrict flow in a narrower valley form. Increasing the floodplain capacity by widening the valley through this reach has the potential to reduce backwater that impacts flood levels in SPA3. Figure 4 depicts the conceptual cut zone proposed under this alternative. The areas of cut have been considered to generate a top width (at the existing Regional Storm flood elevation) more consistent with upstream and downstream reaches while minimizing impact to existing development. It is noted however that the improvements may require relocation of the existing recreation centre on Mary Street. Further, it is understood that a historic landfill site may exist along the west bank of Etobicoke Creek in the area of potential channel improvements. It is noted that the presence, extents and characteristics of this potential landfill site will dramatically impact the implementation cost of this alternative. These details have not been made available from the City of Brampton at the time of this study; assumptions for landfill mitigation have been included in the capital cost estimate (ref. Section 4.2.1).

To assess the potential reduction to the flood hazard in SPA3, the existing conditions HEC-RAS model for Etobicoke Creek has been updated at cross sections downstream of the by-pass channel (section 26.34 to 26.32).

Functional Flood Protection Benefits

- The capacity of the by-pass channel would not be directly impacted by this alternative
- The proposed works would decrease water surface elevations in SPA3 by up 0.52 m for the Regional Storm event. The greatest reduction in water surface elevations would occur at near Wellington and Mary Streets and the benefit would be reduced to near zero by Main Street. It is noted that additional reductions in water surface elevations could likely be achieved by optimizing the channel improvements through more detailed assessment
- The frequency of flooding would remain the same throughout the SPA3 due to the spill at Church Street and Rosalea Park

Regulatory Flood Protection Benefits

- Downstream channel improvements are considered to be *permanent* flood protection, and as such would directly reduce the flood hazard in SPA3
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) would be reduced in the downstream area of SPA3

Impacts and Other Considerations

- Increase in available floodplain storage resulting from earth cut. This alternative could be used in combination with other alternatives which result in a loss of floodplain storage to reduce/eliminate net impact
- This work would be expected to have significant impacts to the natural environment in the Etobicoke Creek valley corridor
- The work would impact Natural Area of Interest #1278 (ref. Appendix B)
- Minor conflicts with existing services and utilities would be expected
- The presence of a landfill site within the limit of proposed works would be expected to significantly impact capital cost and feasibility of this alternative
- The capital cost of channel widening is relatively high

4.1.1.8 Alternative A8: Tailwater Flood Protection Landform

Alternative A8 proposes a flood protection landform (FPL) at the southeast limit of SPA3 to protect the area from backwater from Etobicoke Creek during the Regional Storm (ref. Figure 5). For a detailed description of a flood protection landform see Section 4.1.1.3. The landform would have a crest elevation of 210.45 m (+/-) and tie-in to either side of the historic valley with the wet side toe aligned with the west bank of the existing Etobicoke Creek, downstream of the by-pass channel. Although an FPL in this location would be very effective at eliminating the backwater from entering SPA3 from Etobicoke Creek, it would also prevent local major system (overland) drainage from leaving SPA3. A local minor storm sewer also outlets at this location. In order to provide a minor/major system outlet, a major system pipe would need cross the FPL. This would introduce two conditions which do not explicitly satisfy TRCA's draft FPL guidelines: overland drainage is conveyed towards the dry side, and a hydraulic connection across the FPL. These issues put feasibility of this alternative in question and would require further consultation with TRCA staff in subsequent studies. Further, it is noted that the major/minor system storm sewer would not provide an outlet during the Regional Storm due to tailwater in the Etobicoke Creek. Therefore, flooding behind the FPL would be generated by local drainage. Further analysis is required in subsequent studies to determine whether the local drainage based flood condition provides any improvement on the existing riverine based flooding condition. It is also noted that backwater prevention valves would be required on any connection across the FPL. In addition, the implementation of Alternative 8 would require the full mitigation of the spill condition at Church Street/Rosalea Park for the reasons discussed herein.

The tailwater FPL would have no impact on the capacity of the existing Etobicoke Creek valley, and by extension the by-pass channel, as it essentially occupies ineffective flow area in the historic valley. To confirm this, the existing conditions HEC-RAS model for Etobicoke Creek has been updated by removing the cross sections associated with the SPA area, effectively eliminating the available floodplain storage volume they provide.

Functional Flood Protection Benefits

- The capacity of the by-pass channel would not be directly impacted by this alternative
- Flooding in the southeastern portion of SPA3 caused by backwater from the Etobicoke Creek during the Regional Storm event would be eliminated, however local flooding would be introduce; detailed analyses would be required to determine if any net benefit is provided by this alternative

Regulatory Flood Protection Benefits

- A flood protection landform is considered to be permanent flood protection and as such any benefit to depth of flooding would directly reduce the flood hazard in SPA3, however the functional flood benefit has not been established by this study
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) would be reduced in the downstream area of SPA3 if any functional benefit is demonstrated

Technical, Environmental, Social and Economic Impacts

- Loss of floodplain storage resulting from fill in the floodplain and reduced elimination of backflow into SPA3 (see Section 5.2.2 for further discussion)
- This work would be expected to have relatively significant impacts to the natural environment in the Etobicoke Creek valley corridor
- The work would impact Natural Area of Interest #1278 (ref. Appendix B)
- Minor conflicts with existing services and utilities would be expected
- The presence of a landfill site within the limit of proposed works would be expected to significantly impact implementation cost and feasibility of this alternative
- The capital cost of channel widening is relatively moderate

- Moderate to severe impacts to adjacent private property are expected. The acquisition of three (3) residential lots on the east side of Moore Court would be required at a minimum; impacts related to local flooding may require additional acquisitions

4.1.1.9 Alternative A9: Clarence Street Bridge Improvements

Alternative A9 proposes to increase the span and capacity of the Clarence Street bridge, which is approximately 800 m +/- downstream of the by-pass channel (ref. Figure 4). The bridge currently causes backwater during the Regional Storm which extends upstream and impacts flood levels in the southeast portion of SPA3.

To assess the potential for a reduction to the flood hazard in SPA3, the existing conditions HEC-RAS model for Etobicoke Creek has been updated with a 48 m span bridge at Clarence Street (existing bridge is 23 m span).

Functional Flood Protection Benefits

- The capacity of the by-pass channel would not be directly impacted by this alternative
- The proposed works would decrease water surface elevations in SPA3 by up to 0.17 m +/-during the Regional Storm. The reduction in water surface elevations is generally limited to east of Chapel Street.
- The frequency of flooding would remain the same throughout the SPA3 due to the spill at Church Street and Rosalea Park

Regulatory Flood Protection Benefits

- Bridge improvements are considered to be permanent flood protection, and as such would directly reduce the flood hazard in SPA3
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) would be reduced as described above

Technical, Environmental, Social and Economic Impacts

- This work would be expected to have minor impacts to the natural environment in the Etobicoke Creek valley corridor, proximate to the bridge
- The work would impact Natural Area of Interest #1278 (ref. Appendix B)
- The capital cost of Clarence Street bridge replacement is relatively low

4.1.2 Alternative 'B': Flood Control

Flood control includes alternatives that reduce the peak flow rates within the existing riverine drainage system, in this case Etobicoke Creek upstream of Church Street. In this regard, three (3) alternatives have been evaluated related to improving conveyance and are summarized in the following.

4.1.2.1 Alternative B1: Online Flood Control

Alternative B1 proposes to provide flood protection to SPA3 by way of three (3) flood control dams in the headwaters of the Etobicoke Creek. The dams have been conceptually located outside of the existing urban boundary and within defined valley sections on the three largest headwater tributaries (ref. Figure 6). Flood protection would be provided by storage of runoff and attenuation of peak flows, targeting a reduction in the peak flow at Church Street, the existing spill location at the upstream limit of SPA3.

In order to assess the potential reduction to the flood hazard in SPA3, the future land use conditions Visual OTTHYMO model for Etobicoke Creek has been updated to include three ROUTE RESERVOIRS (i.e. storage-discharge rating curves representing the dams). Potential flood storage has been determined from the available Digital Elevation Model (DEM) assuming approximately 1.5 m freeboard to the top of valley. Discharge from the dams has included both a low flow ordinate (orifice control) and an overtopping ordinate. The low flow ordinate has been adjusted to minimize the peak flow at Church Street. Table 4.1 summarizes the characteristics of each of the conceptual dams.

Table 4.1: Conceptual Dam Characteristics

Dam (ref. Figure 6)	Drainage Area (ha)	Storage (m^3)
1	1300	433,298
2	2379	523,764
3	978	151,532
Total	4657	1,108,594

Initial assessments focused on storing and discharging the Regional Storm without overtopping in order to maximize peak flow attenuation at the outlet of the dam. The assessment indicated that the available natural storage would not be sufficient to produce a significant peak flow attenuation at either the dam outlet or at Church Street. Table 4.2 summarizes the peak inflow and outflow at each dam.

Table 4.2: Conceptual Dam Performance - Regional Storm Event			
Dam (ref. Figure 6)	**Inflow (m^3/s)**	**Outflow (m^3/s)**	**Reduction (%)**
1	106	71	34
2	152	120	21
3	68	56	18

Under this configuration, the existing Regional Storm peak flow at Church Street would be reduced by only 5 % +/-, from 306 m^3/s to 291 m^3/s.

Additional assessments have demonstrated that the peak flow at Church Street would actually be minimized when the dams were allowed to overtop. This approach has resulted in minimal peak flow attenuation at the dam outlet as overtopping would generally be occurring as the peak flow passes through the dam. However the resulting shift in the rising limb of the hydrograph would provide timing benefits which would result in a peak flow reduction at Church Street of 22 % +/-, from 306 m^3/s to 240 m^3/s. This effect is a result of ‘slowing’ the runoff response from the headwaters of Etobicoke Creek, and reducing its impact/influence on the peak flow from the downstream development area (ref. Appendix ‘C’ for hydrographs).

Further analyses completed for Alternative B2: Offline Storage have determined that a minimum of 3.1 million m^3 of offline storage would be required to eliminate the peak flow. The required online volume would be expected to be greater due to the inefficiencies associated with online valley storage. It is not considered feasible to generate this volume of storage.

Functional Flood Protection Benefits

- Regional Storm peak flows through the by-pass channel could be reduced by up to 22%
- The peak spill flow under the Regional Storm would be reduced by approximately 22% +/- from 162.7 m^3/s to 143.2 m^3/s (a hydraulic energy grade balance required to confirm)
- Capacity of the by-pass channel would remain above the 350 year design event and below the Regional Storm

Policy Perspectives

- Dams are considered *non-permanent* flood protection and therefore development in the SPA3 would continue to require floodproofing to the governing flood standard specified in the policies
- Dams create additional flood risk associated with potential dam failure. A dam break analysis has not been completed as part of this study. A dam break scenario could

potentially increase the flood risk (frequency, extent, depth) in SPA3 if the resulting flood condition were used to delineate the hazard conditions

- MNR guidelines for dam design generally require the dam to provide freeboard for the design flood meaning overtopping would be prevented; this would potentially limit the efficacy of this alternative to a 5% reduction in Regional Storm peak flow at Church (per discussion above)

Technical, Environmental, Social and Economic Impacts

- This work would be expected to have significant impacts to the natural environment within the associated tributary valleys in the Etobicoke Creek.
- Property acquisition may be required to manage the flood impacts upstream of the dam structures.

4.1.2.2 Alternative B2: Offline Flood Control

Alternative B2 proposes to provide flood protection to SPA3 by way of several offline flood control facilities along the Etobicoke Creek valley corridor, in the urban core from Mayfield Drive to Church Street. The opportunity for offline facilities notionally exists in open spaces proximate to the valley (ref. Figure 6). In order for these facilities to be effective, they would be required to provide a connection to the existing floodplain, and provide sufficient storage to attenuate peak flow rates. Preliminary assessments have estimated the required storage volume to mitigate the Regional Storm spill to be 3.1 million m^3, while the estimated volume that could be generated by offline storage identified in Figure 6 is 700,000 m^3 (assumes 36 ha open space, 3 m storage depth, 3:1 side slopes). Clearly Alternative B2 could not mitigate flooding as a stand-alone solution. Further, it is suggested that the significant social (loss of park use, etc), environmental and economic impacts of fully exploiting the available offline storage would render this alternative infeasible.

Functional Flood Protection Benefits

- Regional Storm peak flows through the by-pass channel and the peak flow spill into SPA3 could be reduced by a relatively small margin (the actual magnitude has not been determined by this study due to the significant modelling effort required by several offline facilities).
- Capacity of the by-pass channel would remain above the 350 year design event and below the Regional Storm.

Policy Perspectives

- Flood control facilities (stormwater management) are considered *non-permanent* flood protection and therefore development in the SPA3 would continue to require floodproofing to the flood standard specified in the policies.

Technical, Environmental, Social and Economic Impacts

- This work would be expected to have significant impacts to the natural and social environment along the Etobicoke Creek valley and adjacent urban areas.

- Property acquisition may be required at several locations.
- The technical feasibility if individual offline facilities has not be evaluated by this study.

4.1.2.3 Alternative B3: Greenfield Stormwater Management

Future development is proposed in the headwaters of Etobicoke Creek associated with the Mayfield West Phase 2 development area in the Town of Caledon (ref. Figure 6). This development presents an opportunity to 'over-size' stormwater management and reduce peak flows below existing land use conditions for the benefit of the SPA3 lands.

The land area in Mayfield West Phase 2 that drains to Etobicoke Creek is approximately 70 hectares +/- and makes up approximately 1 % of the drainage area to the Downtown Brampton by-pass channel. As such, the opportunity to reduce peak flows is considered very limited. Notwithstanding there may be additional opportunities for greenfield flood management through the development of the White Belt lands, however this potential would be in the extreme long term and hence this alternative has not been considered feasible at this time.

Functional Flood Protection Benefits

- Minimal reduction in peak flows to Church Street, the spill flow into SPA3, and associated flood depths
- Capacity of the by-pass channel would remain above the 350 year design event and below the Regional Storm

Regulatory Flood Protection Benefits

- Stormwater management is not generally accepted as permanent flood protection and as such would not provide any flood hazard benefit to the SPA3 lands under current Provincial policy

Technical, Environmental, Social and Economic Impacts

- The alternative would have minimal natural and social environment impacts
- Capital cost for this alternative is expected to be relatively low, however as noted it would also provide a negligible benefit

4.1.3 Alternative 'C': Floodproofing

Floodproofing offers flood protection through incorporating structural techniques into the design of individual buildings to reduce or eliminate potential damage caused by flooding. Development that has advanced within SPA3 in recent years has incorporated floodproofing measures, generally by raising the first occupied floor, through stairs and streetscaping.

Floodproofing is implemented in two ways: active and passive. Active floodproofing requires specific measures to be taken with an impending flood, for example sand bagging or closing flood doors. Passive floodproofing is preferred, as it does not require action before or during the flood event, for example raising first floor elevations.

Floodproofing has not been evaluated from a technical perspective for the current assessment. Floodproofing is required to the Regulatory flood standard under the current SPA3 policies. The level (depth) of floodproofing, or the required flood standard for floodproofing could be reduced by any permanent flood protection offered by the alternatives discussed herein. If the Regulatory spill condition cannot be mitigated, floodproofing will continue to be required for any new development in SPA3.

4.1.4 Alternative 'D': Land Acquisition

Land acquisition considers removing flood risk from existing development by purchasing the property at risk and re-purposing it. This alternative has not been explicitly evaluated for the current assessment. Land acquisition is not considered a feasible alternative in a downtown urban core, especially in the context of current development pressure in SPA3. That said, certain alternatives summarized herein would require some level of land acquisition for the greater benefit of the overall SPA3.

4.1.5 Alternative 'E': Diversions

Diversions transfer flood flows from one conveyance system to another to reduce flood risk. The by-pass channel itself is a form of local diversion that was implemented to mitigate riverine flooding in Downtown Brampton, as described in Section 1.1. A key constraint associated with diversions is the resulting flood impact on the receiving system, where existing flood damage centres often exist. For this reason, diversions are often not supported by conservation authorities and accordingly, opportunities to divert flow out of the main branch of Etobicoke Creek have not explicitly been assessed by this study.

4.1.6 Combinations

Ultimately, a combination of several alternatives which addresses both flooding mechanisms affecting SPA3 (spill and backwater), and provides floodproofing of any remaining flood condition, may be required to minimize flood risk. The assessment of individual alternatives has effectively established that no single alternative will fully mitigate flood risk in SPA3. Further, no single alternative can fully mitigate the Regional Storm spill at Church Street/Rosalea Park. Due to the substantial area of existing development and development potential impacted, the spill at Church Street is considered the primary concern for flood mitigation. In addition, the preference is for an alternative that provides *permanent* flood protection under Provincial criteria. As such, the combinations of alternatives considered herein have focussed on mitigating the spill condition with *permanent* flood control works.

4.1.6.1 Combination 1: Alternative A3 + A4 + A6

Combination 1 evaluates the combination of a flood protection landform (Alternative A3) with widening of the Church Street bridge (Alternative A4) and widening of the by-pass channel (Alternative A6) through the bridge and Rosalea Park. Figure 7 illustrates this combination with FPL Option 3, which is the preferred FPL option from the perspective of minimizing impacts to private property, however it is noted that the flood mitigation performance of Combination 1 would be identical under all FPL options with the exception of minor differences in upstream impacts on flood elevations. Notionally, this alternative aims to increase the existing capacity of the by-pass channel through the Church Street bridge improvements and localized channel widening in an attempt to contain the Regional Storm peak flow with the previously determined maximum FPL elevation of 215.5 m (ref. Section 4.1.1.3). The Church Street bridge has been widened from 22 m to 52 m under this scenario; the top-width of the by-pass channel has been widened accordingly.

Combination 1 comes very close to fully mitigating the spill condition during the Regional Storm. More detailed hydraulic modelling (2D and/or non-steady state) may sufficiently refine the assessment such that full containment of the Regional Storm peak flow can be demonstrated. The functional and policy flood protection benefits are summarized below; Technical, Environmental, Social and Economic Impacts are summarized under each of the individual alternatives.

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 107 % from 143.3 m^3/s to 296 m^3/s
- The Regional Storm would continue to spill over Church Street; spill through Rosalea Park is eliminated
- The spill into Downtown Brampton during the Regional Storm would be reduced by 94 % from 162.7 m^3/s to 10 m^3/s
- This combination would have no impact on flooding in the southern limit of the SPA3 caused by backwater in Etobicoke Creek

Regulatory Flood Protection Benefits

- A flood protection landform and bridge and channel improvements are all considered to be *permanent* flood protection and therefore there would be a reduction in flood impact and risk in the SPA3 associated with the existing spill condition. As noted above, a minor spill persists.
- The depth of flooding, and associated requirement for floodproofing (i.e. first floor elevations, etc) in SPA3 would be reduced by up to 2.0 m +/-.

4.1.6.2 Combination 2: Alternative A3 + A5

Combination 2 evaluates the combination of a flood protection landform (Alternative A3) with by-pass channel lowering (Alternative A5). Figure 8 illustrates this combination with FPL Option 3, which is the preferred FPL option from the perspective of minimizing impacts to private property, however as was noted for Combination 1, the flood mitigation performance of Combination 2 would be identical under all FPL options with the exception of minor differences in upstream impacts on flood elevations. Preliminary modelling iterations have indicated that the maximum FPL elevation of 215.5 m (ref. Section 4.1.1.3) combined with the maximum channel lowering of 1.5 m (ref. Section 4.1.1.5) would generate conveyance capacity in excess of the Regional Storm. Therefore, in order to determine the range in variation for this combination, two options have been generated: Combination Option (i) provides a minimized FPL (crest elevation 214.6 m +/-) with maximum channel lowering (1.5 m), Option (ii) includes the maximum FPL (crest elevation 215.5 m +/-) with minimized channel lowering (0. 8 m).

Both options provide full mitigation of the Regional Storm spill with permanent flood protection. By minimizing the FPL crest elevation and associated footprint, Option (i) may prove simpler to integrate into the existing urban area; it also provides a greater benefit to existing structures in the floodplain upstream of Church Street (see Regulatory Flood Protection Benefits below). On the other hand Option (ii) requires less channel lowering and therefore may encounter fewer conflicts with existing services and utilities along the by-pass channel. The functional and policy flood protection benefits are summarized below; Technical, Environmental, Social and Economic Impacts are summarized under each of the individual alternatives

Functional Flood Protection Benefits

- Capacity of the by-pass channel would increase by 114 % from 143.3 m^3/s to 306 m^3/s
- The spill into Downtown Brampton during the Regional Storm would be eliminated
- This combination would have no impact on flooding in the southern limit of the SPA3 caused by backwater in Etobicoke Creek

Regulatory Flood Protection Benefits

- A flood protection landform and channel improvements are all considered to be *permanent* flood protection and therefore would remove any flood impact and risk in the SPA3 associated with the existing spill condition.
- Accordingly, the need for floodproofing would be eliminated other than area effected by backwater in the southeast area of SPA3
- Regional Storm water surface elevations immediately upstream of the proposed works (i.e. upstream of Church Street) would decrease by up to 0.96 m and 1.19 m for Option (i) and (ii), respectively, thereby providing a potential flood hazard benefit to existing properties within the floodplain upstream of SPA3; these benefits approach zero proximate to Vodden Street

4.1.7 Summary of ‘Long-List’ of Alternatives and Related Screening

The current study has focused on developing technically feasible and effective alternatives to mitigate flooding in SPA3. As such, the primary screening criteria for the long-list of alternatives relates to the effectiveness of each alternative to reduce flood levels and flood risk from both functional and policy perspectives. Although this study has not completed an exhaustive evaluation of environmental, social and economic impacts and opportunities, they have been considered at a high level. Therefore, where an alternative is technically feasible but provides a *minimal* flood mitigation benefit and either high environmental, social or capital costs, it has been screened on the basis of a low cost-benefit ratio. Generally, any alternative that provides a significant flood protection benefit has been short-listed regardless of the associated costs. This is due to the expectation that the potential value of development in Downtown Brampton may justify significant capital outlays for flood protection. Therefore, any subsequent screening of the short-list alternatives would require a comprehensive evaluation of all environmental, social and economic impacts and opportunities, and would require consultation with all potential stakeholders including development proponents and municipal partners.

Table 4.3 summarizes the efficacy of each alternative from a functional and Regulatory flood reduction perspective and provides a relative cost-benefit ranking. For the purpose of the current feasibility assessment cost benefit has been assigned based on the reduction in flood depth in the SPA, whether flood protection is permanent, and the estimated relative capital cost. Cost benefit has been scored as either *satisfactory*, *low* or *zero*; the latter scores resulting in screening of the alternative. Each alternative is either screened or short-listed; the reasons for screening an alternative are also provided.

Table 4.3: Screening of the Long-List of Alternatives

Alternative	Flood Mechanism Addressed	Reduction in Regional Storm Spill Flow (%)	Reduction in SPA Flood Depths (m)	Permanent Flood Protection?	Expected Cost-Benefit	Short-Listed / Screened	Reason for Screening
A1: Church Street Flood Berm	Spill	0	0	No	Zero	*Screened*	Provides no flood protection benefit while increases flooding upstream
A2: Rosalea Park Flood Berm	Spill	88	0.3 – 1.7	No	Satisfactory	*Short-Listed*	
A3: Combined Flood Protection Landform	Spill	88	0.3 – 1.7	Yes	Satisfactory	*Short-Listed*	
A4: Bridge Improvements	Spill	0	0	Yes	Zero	*Screened*	No benefit as stand-alone alternative Church St widening advanced as part of Combination 1
A5: Lower By-pass Channel	Spill	90	0.3 – 1.8	Yes	Satisfactory	*Short-Listed*	
A6: Widen By-pass Channel	Spill	30	0.01 – 0.4	Yes	Low	*Screened*	No benefit as stand-alone alternative Localized widening advanced as part of Combination 1
A7: Downstream Channel Improvements	Backwater	0	0.5 *Backwater only*	Yes	Satisfactory	*Short-Listed*	
A8: Tailwater Flood Protection Landform	Backwater	0	Requires further study *Backwater only*	Yes	Satisfactory	*Short-Listed*	Further study required to demonstrate feasibility
A9: Clarence Street Bridge Improvements	Backwater	0	0.17 *Backwater only*	Yes	Satisfactory	*Short-Listed*	
B1: Online Flood Control	Spill & Backwater	<5	Minimal	No	Low	*Screened*	Significant capital cost & environmental/social impacts while providing minimal non-permanent flood protection
B2: Offline Flood Control	Spill & Backwater	<5	Minimal	No	Low	*Screened*	Significant capital cost & environmental/social impacts while providing minimal non-permanent flood protection. Further study required to establish actual benefit
B3: Greenfield Stormwater Management	Spill & Backwater	~0	~0	No	Low	*Short-listed*	Minimal flood protection benefit, however any new greenfield development in Etobicoke Creek watershed should consider Regional Storm flood controls/over-control so not to exacerbate the existing flood condition
C: Floodproofing	Spill & Backwater	0	0	No	Satisfactory	*Short-Listed*	
D: Land Acquisition	Spill & Backwater	0	0	Yes	Low	*Screened*	Land acquisition as stand-alone flood risk mitigation conflicts with growth objectives of the City. May be required

Table 4.3: Screening of the Long-List of Alternatives

Alternative	Flood Mechanism Addressed	Reduction in Regional Storm Spill Flow (%)	Reduction in SPA Flood Depths (m)	Permanent Flood Protection?	Expected Cost-Benefit	Short-Listed / Screened	Reason for Screening
							to implement other alternatives or to offset impacts of other alternatives
E: Diversions	Spill & Backwater	0	0	Yes	Undetermined	*Screened*	The by-pass channel itself is a local diversion providing flood mitigation to SPA3. Diversions are generally not supported and have not explicitly been evaluated by this study.
Combination 1: A3 + A4 + A6	Spill	-94	0.3 - 2.0	Yes	Satisfactory	*Short-Listed*	
Combination 2: A3 + A5	Spill	100 *Spill eliminated*	Only backwater flooding remains	Yes	Satisfactory	*Short-Listed*	

Based on Table 4.3, nine (9) alternatives have been advanced to the short-list.

It is expected that the development community would be primarily motivated by alternatives which provide a flood protection benefit related to the governing policy perspective, that is those alternatives which eliminate flood risk in SPA3 up to the governing flood standard (Combination 2 only), or those that reduce flood standard depths and the associated level of floodproofing required (Alternatives A3 to A9, Combination 1 & 2). These alternatives would directly increase the available land for development/intensification and/or reduce the magnitude of floodproofing measures required, and the associated costs and impact to the streetscape/urban form.

Combination 2 (Alternative A3 + A5) provides the only solution that eliminates the spill condition at Church Street/Rosalea Park and is therefore the preferred solution from the flood mitigation perspective (i.e. without full consideration for environmental, social and economic factors). Combining one or more of the alternatives that address backwater in the southeast area of SPA3 (i.e. Alternative A7, A8, A9) with Combination 2, would minimize the flood risk in SPA3 overall.

Alternative A2: Rosalea Park Berm does not provide *permanent* flood protection, however it has also been short-listed recognizing its *functional* flood protection benefit (i.e. reduction in flood risk under operating conditions) is equivalent to the more preferred Alternative A3: Flood Protection Landform. Should Alternative A3 be screened in future study (due to capital cost, or social impacts associated with the larger footprint area), Alternative A2 could be considered in the general interest of protection of public safety and private property, in accordance with the mandate of TRCA.

Although it is recognized that Alternative B3 does not mitigate flood risk in SPA3 as a stand-alone alternative, it has been advanced as it represents the potential to mitigate Regional Storm flood impact associated with future development in the headwaters of Etobicoke Creek and further considers that Regional Storm controls may be considered in the development of future flood hazard limits according to information from the Central Lake Ontario Conservation Authority (ref. Appendix B).

4.2 Short-List

Based on the evaluation in Table 4.3, the short-list of feasible flood protection alternatives for Downtown Brampton SPA3 is as follows:

- A2: Rosalea Park Flood Berm
- A3: Combined Flood Protection Landform
- A5: Lower By-pass Channel
- A7: Downstream Channel Improvements
- A8: Tailwater Flood Protection Landform
- A9: Clarence Street Bridge Improvements
- B3: Greenfield Stormwater Management
- C: Floodproofing

Combination 1: A3+A4+A6
Combination 2: A3+A5

The objective of the current study has been to advance a short-list of feasible flood mitigation alternatives. The current study has not evaluated the natural, social and economic environments in detail, as is typical of a Class Environmental Assessment, and as such a preferred alternative has not been advanced by the current study. Rather, the short-list represents the feasible alternatives that should be considered by future study.

Capital cost estimates and implementation timelines have been developed for the short-listed alternatives in Section 4.2.1 and 5.1, respectively.

4.2.1 Capital Cost

Capital cost estimates have been generated for the short-listed alternatives and are summarized in Table 4.4. Appendix D includes itemized cost estimates for each alternative along with notes on significant factors affecting the estimated cost.

Table 4.4: Preliminary Cost Estimates
Estimates include 15% Engineering, 25% Contingency

Alternative	**Option** (if any)	**Capital Cost**
Upstream - Alternatives to Mitigate Flood Spill into SPA at Church Street		
A2: Rosalea Park Berm		*TBD*
A3: Flood Protection Landform	Option 1 - Church Street FPL	$41,935,750
	Option 3 - Ellen Street FPL	$23,265,750
A5: Lower Bypass Channel		$9,160,000
Combination 1 A3: Flood Protection Landform + A4: Church St Bridge Widening + A6: Widen Bypass Channel (Church St Only)	Option 1 - Church Street FPL	$64,870,050
	Option 3 - Ellen Street FPL	$38,732,050
Combination 2 A3: Flood Protection Landform + A5: Lower Bypass Channel	Option 1 - Church Street FPL	$69,228,250
	Option 3 - Ellen Street FPL	$43,613,850
Downstream - Alternatives to Mitigate Backwater into SPA		

Table 4.4: Preliminary Cost Estimates *Estimates include 15% Engineering, 25% Contingency*		
Alternative	**Option** (if any)	**Capital Cost**
A7: Downstream Channel Improvements		$13,832,000
A8: Tailwater Flood Protection Landform		$10,941,595
A9: Clarence Street Bridge Improvements		$4,900,000

It is recommended that future study include a comprehensive cost-benefit assessment which considers:

- Capital cost of flood protection works including any rehabilitation of natural systems
- A real estate assessment that generates market rates for properties impacted by the proposed flood protection works as well as an assessment of the value of potential future development realized by the proposed flood protection works
- An assessment of cost savings associated with flood damage reduction associated with any proposed flood protections works
- If Alternative A5: Channel Lowering is recommended for implementation in future study, future capital cost estimates should consider efficiencies realized by the integration this alternative with the City's channel rehabilitation initiatives as well as consider current and predicted operations and maintenance costs and design life expectancy

4.2.2 Integration with Urban Design & Land Use Study

As noted in Section 4.2, a preferred alternative has not been advanced by the current study, however it is noted that Combination 2: Flood Protection Landform + Lower By-pass Channel is the only alternative that fully mitigates the Regional Storm spill condition at Church Street and is therefore understood to be the preferred alternative from the City's perspective due to the corresponding best-case scenario for mitigation of Regulatory flood risk and potential for meeting growth objectives. From the perspective of integrating the flood protection works into the future land use fabric and into the vision for Downtown Brampton, the flood protection landform presents the greatest challenge due to the substantial footprint required for implementation and the associated development restrictions summarized in Section 4.1.1.3. The Downtown Brampton Urban Design and Land Use Study (City of Brampton, TPP) has considered these restrictions along with the City's land use objectives and generated a conceptual urban design that integrates a flood protection landform into Rosalea Park and the surrounding area. The City and TPP have also generated conceptual cross sections for a rehabilitated by-pass channel which incorporates a riverwalk feature as well as accommodating the channel lowering required under Combination 2. Further study should analyze in detail the proposed cross-section geometry and materials, to confirm hydraulic capacity is not reduced. This study has recommended that any pedestrian features included in the by-pass channel rehabilitation be sited above the 25 year event flood level; future study should confirm a design objective in this regard.

The Downtown Etobicoke Creek Revitalization Study (City of Brampton) provides a summary of the integration of selected flood protection works into the urban design for Downtown Brampton.

Base Flow Augmentation

As noted, an objective of the Downtown Etobicoke Creek Revitalization Study (City of Brampton) is re-focussing passive recreation and urban design towards the Etobicoke Creek (the by-pass channel) through Downtown Brampton. Related to this, a concern was raised by the JSC was that summer time flows were perceived to be lower than ideal for creating an aesthetic river setting and the question was asked of flows could be 'increased'. Two conceptual alternatives were identified.

The first involves creating online pools to increase the 'wet' area in the creek; concerns with this option relate to creating issues with stagnant water and fish barriers.

The second involves augmenting baseflow by storing excess runoff during storm conditions (i.e. drawing runoff off of Etobicoke Creek and storing offline) and releasing it during low flow conditions. To assess the feasibility of this option at a conceptual level, an assessment was completed using available observed flow data for Etobicoke Creek upstream of Church Street (Water Survey Canada Gauge 02HC017, November 2003 – March 2009) for the summer months of July and August (i.e. seasonal period of low flow). The assessment determined the following:

- Average summer low flow = 0.13 m3/s
- For the years on record (with the exception of 2007), sufficient runoff volume exists during periods of high flow to maintain baseflow at a rate of 0.3 m3/s; this flow generates a depth of approximately 0.3 m in the existing by-pass channel
- For the years on record (with the exception of 2008), sufficient runoff volume does not exist during periods of high flow to maintain baseflow at a rate of 0.5 m3/s
- In order to provide sufficient volume to augment baseflows at 0.3 m3/s for the driest periods during the years on record, 120,000 m3 to 430,000 m3 (average of 220,000 m3) of storage would be required

The volume of storage required to fully augment baseflows as described above would represent a substantial cost, however at a conceptual level, the assessment herein has demonstrated its feasibility. Should base flow augmentation become a priority for the City of Brampton, further detailed study based on a longer period of record is recommended.

4.3 Future Stressors on System

The analysis of hydraulic performance of the alternatives considered in this study has been based on mitigating flooding in Downtown Brampton for the Future (Official Plan) land use Regional storm peak flows based on preliminary estimates (available in 2012) from the ongoing Etobicoke

Creek Hydrology Update Study, prior to its finalization in 2013. As this study advanced, the hydrologic model for Etobicoke Creek was completed and finalized as referenced in the Etobicoke Creek Hydrology Update Study (MMM, 2013). The finalized model has resulted in a change in Future land use peak flows (ref. Table 4.5) due to revised subcatchment delineation and parameterization, and improved calibration. Future and Ultimate land use conditions peak flows have also been developed as part of this study.

Table 4.5: Etobicoke Creek Land Use Scenarios

Land Use Scenario	Flow Node	Drainage Area (ha)	Regional Flow (m^3/s)	Change Relative to Existing 2012 (%)
Future Preliminary (MMM, 2012)	2.14	6912	306	-
Existing (MMM, 2013)	2.14	6912	290	-5%
Future[1] (MMM, 2013)	2.14	6889	279	-9%
Ultimate[2] (MMM, 2013)	2.14	6889	342	+12%

[1]Assumes current Official Plan buildout
[2]Assumes buildout of Whitebelt lands; Environmental Protection Areas and Greenbelt lands remain in their existing condition

The 2013 Future land use scenario peak flow summarized in Table 4.5 demonstrate a reduction in Regional storm peak flow (ref. MMM, 2013 for discussion) relative to the preliminary estimates upon which the flood mitigation opportunities were assessed for this study. This indicates that the current assessment and conceptual design of flood mitigation opportunities is likely to be conservative.

It should be noted that 2013 Ultimate land use peak flows show a significant increase over both of the 2012 (preliminary) and 2013 Future peak flows. Although stormwater management will be required and designed to ensure no increase in peak flows for the 2 to 100 year return period events, current Provincial policy does not allow for consideration of stormwater controls in the management of Regulatory flows (Regional Storm in Etobicoke Creek) and the establishment of the Regulatory flood hazard (i.e. floodlines). In other words, future development associated with the Ultimate build-out of the White Belt, would result in increases in Regional Storm peak flows in Etobicoke Creek in Downtown Brampton, which would have flood implications for SPA3, and the design of any associated flood mitigation opportunities.

Considering the foregoing, future assessment of flood mitigation alternatives and selection of the preferred alternative for SPA3 should consider the implication of the 2013 hydrology update, and most notably, the Ultimate land use Regulatory peak flows, while also monitoring the status of developments in Regulatory storm controls in southern Ontario.

5.0 RECOMMENDATIONS AND IMPLEMENTATION

5.1 Flood Mitigation – Short and Long Term

The short-listed alternatives have been divided into short and long term solutions considering for the expected planning and design timeframe for implementation. Short term and long term alternatives are considered to have the potential to be implemented in less than 10 years and greater than 10 years, respectively. It is noted that all alternatives are not necessarily recommended to be implemented and as noted in Section 4.2, selection of a preferred alternative would be the subject of future study. Implementation of combinations of alternatives should consider the associated upstream flood impacts and phasing should minimize or eliminate these impacts; this is discussed further in Table 5.1.

Table 5.1: Implementation Timeline for Short-Listed

Alternative	Implementation Timeline	Reasons
A2: Rosalea Park Flood Berm	Short Term	• Could be implemented as a temporary measure to provide flood protection to SPA3 until property constraints associated with A3 can be mitigated • Requires A5 to implemented first to avoid flood impact upstream
A3: Combined Flood Protection Landform	Long Term	• Depending on the preferred option, negotiation with affected landowners is expected to require significant time and effort • Complex design and approval process
A5: Lower By-pass Channel	Short Term	• Relatively straight forward design process and is not expected to require any property acquisition • The City of Brampton and TRCA are expected to be joint proponents considering the City's motivation to rehabilitate the channel from urban design and recreational access perspectives and TRCA's current ownership of the channel and current responsibility for maintenance and operation. The City and TRCA are also the two primary agencies providing approval for such a project (DFO/MNR consultation although required, is not expected to results in any significant constraints/delays) • Provides immediate benefits to existing structures in the floodplain between Church Street and Vodden Street • If Combination 2 is to be implemented in full, Alternative A5 should be implemented before Alternative A3: Flood Protection Landform to avoid causing flood impacts to property and structures upstream of Church Street
A7: Downstream Channel Improvements	Long Term	• Potential presence of landfill could result in significant design and permitting process
A8: Tailwater Flood Protection Landform	Long Term	• Negotiation with affected landowners is expected to require significant time and effort • Complex design and approval process
A9: Clarence Street Bridge Improvements	Short Term	• Relatively straight forward design process and is not expected to require any property acquisition
B3: Greenfield Stormwater Management	Long Term	• Requires incorporation into Secondary Planning process • Development time frame for White Belt areas is long term/unknown
C: Floodproofing	Short/Long Term	• Can be implemented for existing development immediately • May form part of short and long term solution, depending on which alternative(s) are implemented
Combination 1: A3+A4+A6	Long Term	• See discussion under A3 • Church Street bridge widening and associated channel widening could be implemented in the short term
Combination 2: A3+A5	Long Term	• See discussion under A3

5.2 Future Study

5.2.1 Class Environmental Assessment Approach

The current study has demonstrated that there are several feasible flood protection alternatives (permanent and non-permanent) available to either mitigate or reduce the existing flood risk in Downtown Brampton. For any of the short-listed flood protection alternatives to be implemented, the planning and design process would be required to fulfill the provisions of the Environmental Assessment Act and comply with the Class Environmental Assessment (EA) process. The Class EA process requires that the implementation of a qualifying project (e.g. flood protection works) consider all functional, natural, social and economic impacts and opportunities, which necessitates an understanding of these environments. The current study has primarily focussed on the functional environment while identifying at a high-level, the natural, social and economic constraints and opportunities. A Class EA is recommended to refine the functional assessments completed herein and incorporate the detailed characterization studies for the natural, social and economic environments. A Class EA would also necessarily include consultation with a broader range of stakeholders than were consulted for the current study including potentially interested agencies (MNR, MOE, DFO, MTC, MOAA, Region of Peel), development proponents, directly impacted land owners, local interest groups and the public at large, in addition to the City of Brampton and TRCA.

A future Class EA could be carried out under either the Conservation Authority Class EA or Municipal Class EA process. The selected process would also dictate the primary proponent; for example if the Conservation Authority Class EA were selected, TRCA would be the primary proponent. However, as noted previously, the mandate of TRCA (or any conservation authority) is the reduction of flood risk to existing development, and accordingly the Conservation Authority Class EA process specifically states that flood protection works provide *remedial* protection only, as follows:

“Remedial Flood and Erosion Control Projects refer to those projects undertaken by Conservation Authorities, which are required to protect human life and property, in previously developed areas, from an impending flood or erosion problem. Such projects do not include works which facilitate or anticipate development. Major flood and erosion control undertakings which do not suit this definition, such as multipurpose projects, lie outside the limits of this Class and require an Individual Environmental Assessment” (ref. Section 2.3, Conservation Authority Class Environmental Assessment for Remedial Flood and Erosion Control Projects, September 2009)

The Municipal Class EA process does not include this restriction and as such flood protection works can also be considered to benefit potential future development. Given that future growth in the Downtown core is one of the key objectives of the City of Brampton in the implementation of any flood protection works for SPA3, it follows that a future Class EA should likely follow the Municipal Class EA process. It is noted that in this case, the TRCA will serve as a central partner and stakeholder in the study given its aligned goals for existing flood mitigation, role as an approval agency from both the flood and environmental management perspectives, and also as the current owner/operator of the existing by-pass channel. In this regard, dual proponency is allowed under the Municipal Class EA process and could be considered to more effectively address the combined needs of the City and TRCA. A future Municipal Class EA undertaking to provide area flood protection would be expected to be classified as a Schedule B based on the following available project types (ref. Municipal Engineers Association Municipal Class Environmental Assessment, 2011):

- # 15: Construct berms along a watercourse for purposes of flood control in areas subject to damage by flooding;
- #17: Works undertaken in a watercourse for the purposes of flood control or erosion control, which may include:
    - bank or slope re-grading
    - deepening the watercourse
    - relocation, realignment or channelization of watercourse.

Depending on overall project complexity the study proponent may wish to undertake a Schedule C project which would then require additional consultation, considering that several diverse stakeholders are expected to be engaged by this future study.

5.2.2 General Recommendations

The following recommendations should be addressed by future study:

i. Future assessment of flood mitigation alternatives and selection of the preferred alternative for SPA3 should consider the implication of Ultimate land use Regulatory peak flows, while also monitoring the status of developments in Regulatory controls in southern Ontario;
ii. Future greenfield development in the Etobicoke Creek watershed should consider Regional Storm flood control through appropriate stormwater management (regardless of whether the Province recognizes a formal reduction in Regulatory peak flow);
iii. Any pedestrian features included in the by-pass channel rehabilitation should notionally be sited above the 25 year event flood level. Future study should complete an updated literature review to identify any new design standards or precedents and confirm a design standard that adequately considers pedestrian risk in a riverine setting;
iv. Depending on the ultimate implementation timeline, design of any flood protection works should consider application of a calibrated hydrologic model, should sufficient observed data be available at the time of design;
v. The hydraulic assessment of existing flood conditions and future flood protection works has demonstrated that the current HEC-RAS model is relatively sensitive to changes in by-pass channel geometry, peak flows, and the methodology for determining the split flow (ref. Greck-Farrell, February 24, 2012, Appendix B). It is recommended that future hydraulic assessment consider the following:
    a) Detailed sensitivity analysis of hydraulic parameters, geometry, peak flows, bridge modelling methodologies, flow splitting methodologies, etc.;

b) Refinement of the existing model with additional cross sections through the by-pass channel and upstream of Church Street;

c) Simulation of un-steady state flows – this methodology would be expected to provide less conservative but more realistic results; results could either be used directly or as a point of comparison to the current and more traditional steady-state approach; and,

d) Potential for the Application of 2-dimensional modelling as the methodology is considered more appropriate for modelling the complex hydraulic conditions (divergent flow) that oc6cur at the Church Street/Rosalea Park flow split and throughout the SPA3 area (due to several obstructions, low flow depths, etc). The additional rigour required for 2-D modelling is considered warranted as improving the accuracy and confidence of the flood characterization will provide a better to tool to manage the significant existing flood risk in SPA3 and the potential for future development;

vi. The development of hydrologic and hydraulic tools to assess the local SPA drainage system will be required for the design of certain flood protection works, specifically a flood protection landform. This model would be required to consider minor and major system hydraulics and local catchments, SWMM5 based models (e.g. PC-SWMM) would be particularly suited to such an assessment. A 2-D model could potentially integrate riverine and local flood assessments in a single model;

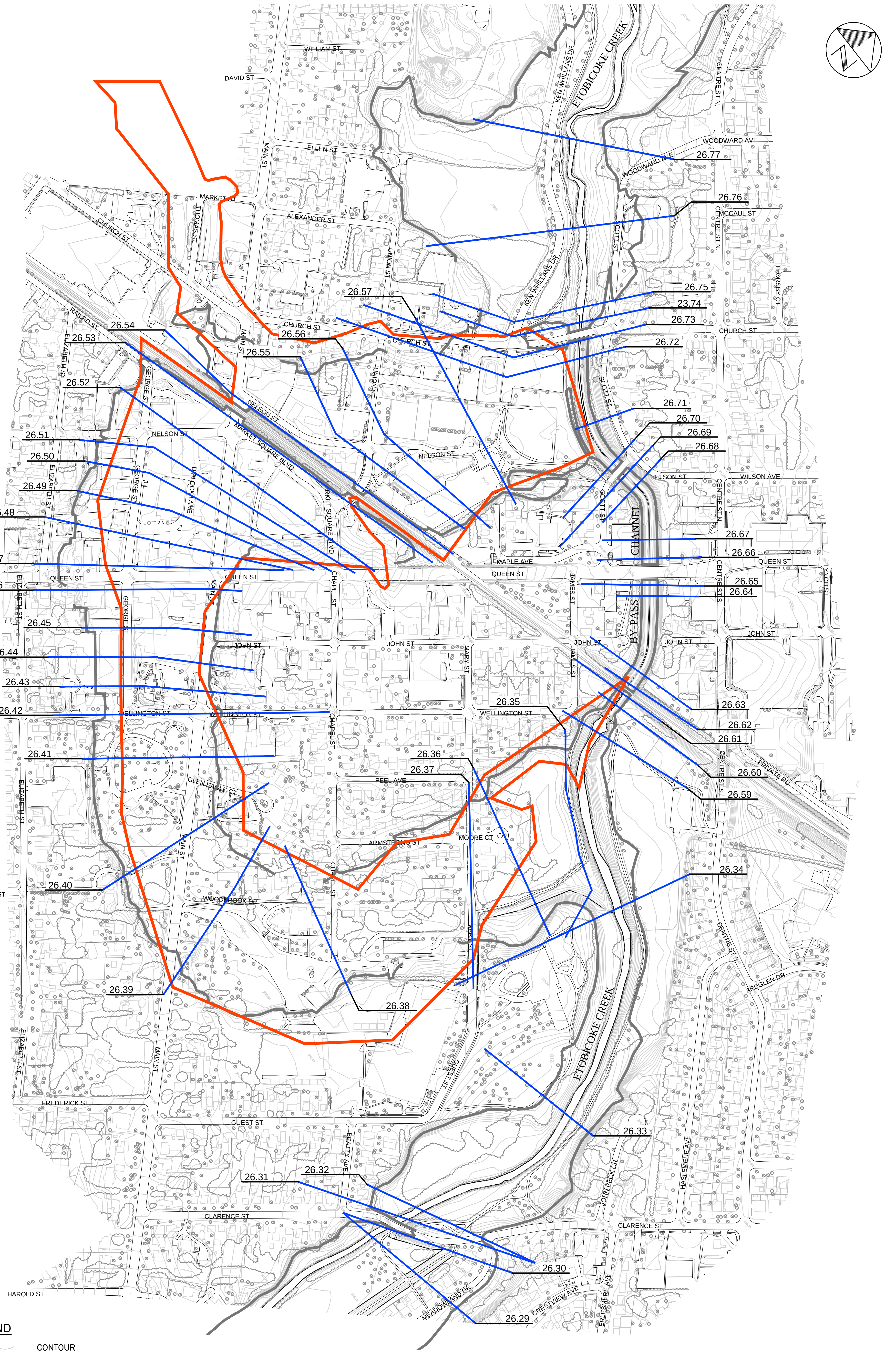
vii. Loss of floodplain storage will result from any flood protection measure that reduces flow to SPA3 (downtown Brampton has greater storage volume potential than the by-pass channel). Eliminating the spill will result in a substantial loss in floodplain storage. It is noted that downstream peak flows do not consider this volume and associated attenuation, nevertheless, a functional impact is expected. Future study should characterize this impact and consider any policy implications;

viii. It is recommended that future study include a comprehensive cost-benefit assessment which considers:

- Capital cost of flood protection works including any rehabilitation/restoration of natural systems;
- A real estate assessment that generates market rates for properties impacted by the proposed flood protection works as well as an assessment of the value of potential future development realized by the proposed flood protection works;
- An assessment of cost savings associated with flood damage reduction associated with any proposed flood protections works; and,
- If Alternative A5: Channel Lowering is recommended for implemented in future study, future capital cost estimates should consider efficiencies realized by the integration this alternative with the City's channel rehabilitation initiatives as well as consider current and predicted operations and maintenance costs and design life expectancy

ix. Several potential permitting constraints have been identified for the flood protection landform alternatives identified by this study. Further consultation with TRCA staff should be undertaken to determine how these potential constraints will be managed at the design stage. Potential constraints include:

- Alternative A3: Flood Protection Landform
  - Mitigation of existing 1200 mm diameter sanitary sewer on the west side of Etobicoke Creek; the current study identified options to either protect in place or re-locate to the east side
  - Mitigation of local watermains and utilities
  - Interface of the dry-side toe with existing structures (e.g. 58 Church Street condominium)
  - The outlet of a dry side minor storm sewer creates a hydraulic connection across the FPL; this is not preferred but can be considered where unavoidable due to brownfield development
- Alternative A8: Tailwater Flood Protection Landform
  - A minor/major storm sewer outlet will be required to cross the FPL, creating a hydraulic connection; this is not preferred but can be considered where unavoidable due to brownfield development
  - Detailed hydrologic/hydraulic analysis will be required to evaluate local and riverine flood conditions to determine the impact of this alternative on overall flood risk



LEGEND

CONTOUR

REGULATORY FLOODLINE (2012)

SPECIAL POLICY AREA

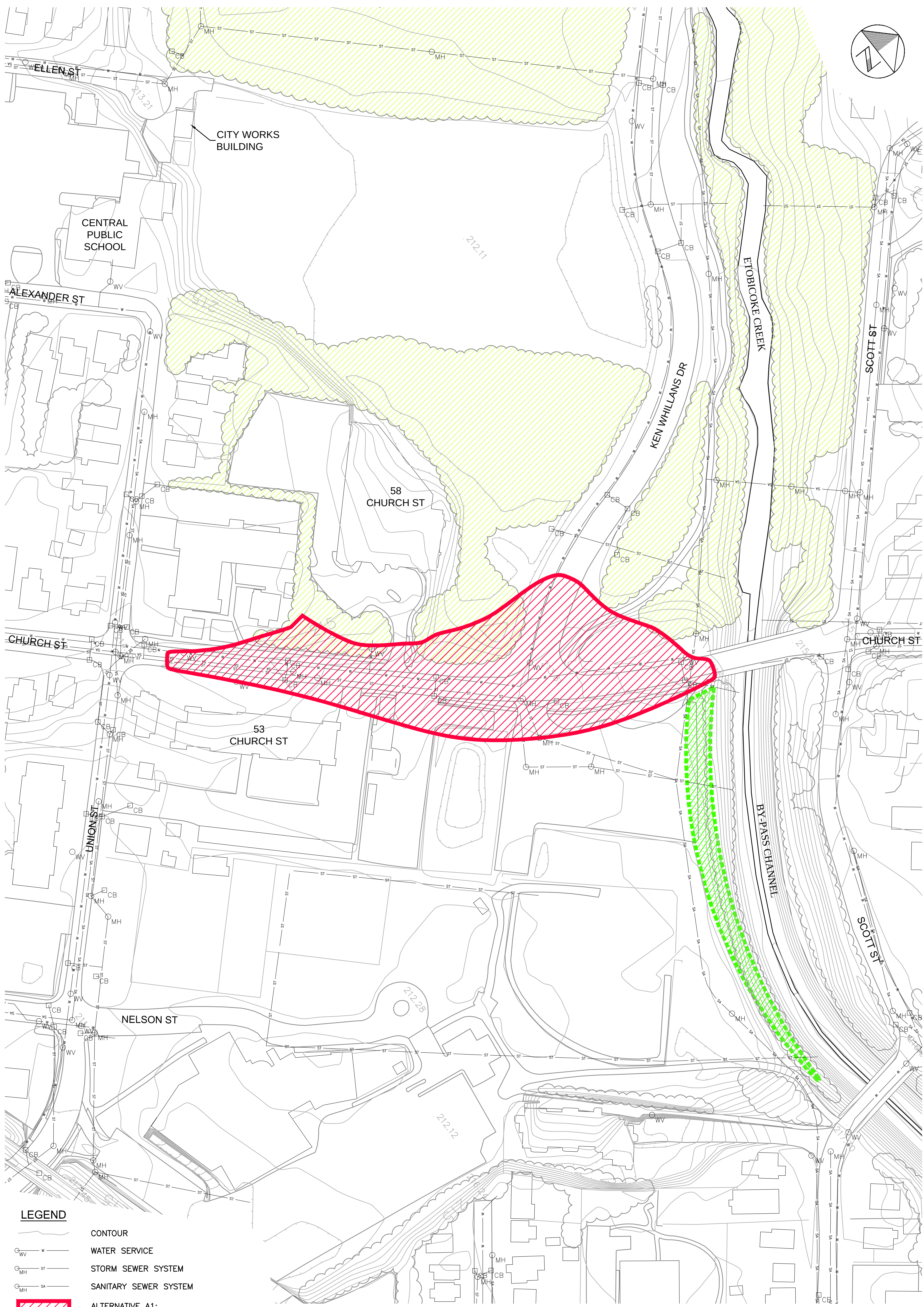
CROSS SECTION NUMBER

26.37

CROSS SECTION LOCATION

SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	CROSS SECTION LOCATION PLAN	amec	Scale 1:2500 (0 25 50 100) Consultant File No. TP112151 Figure No. 1



DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY

TORONTO REGION CONSERVATION AUTHORITY

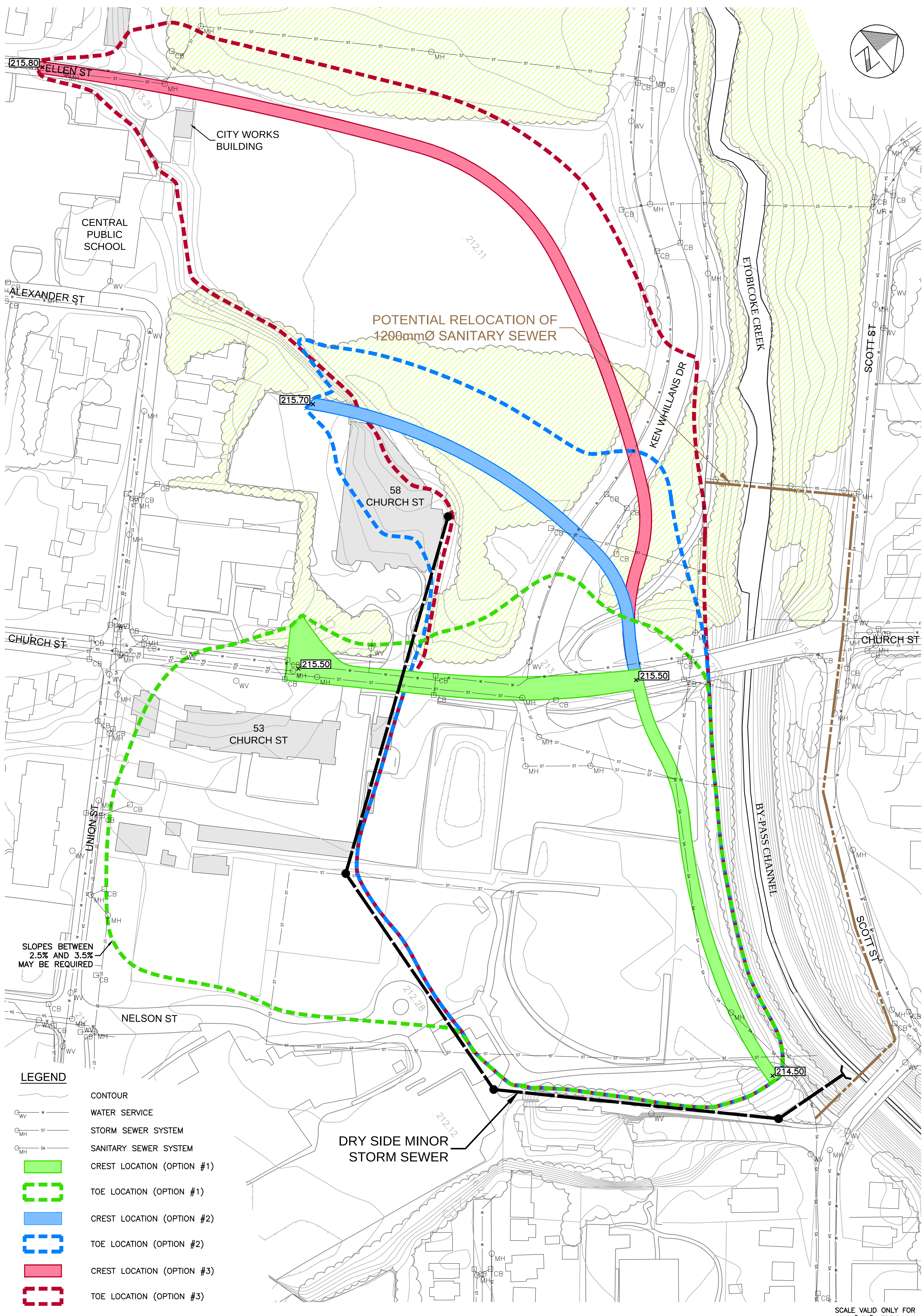
ALTERNATIVES A1 AND A2

amec

Scale 1:750

Consultant File No. TP112151

Figure No. 2



DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY
TORONTO REGION CONSERVATION AUTHORITY

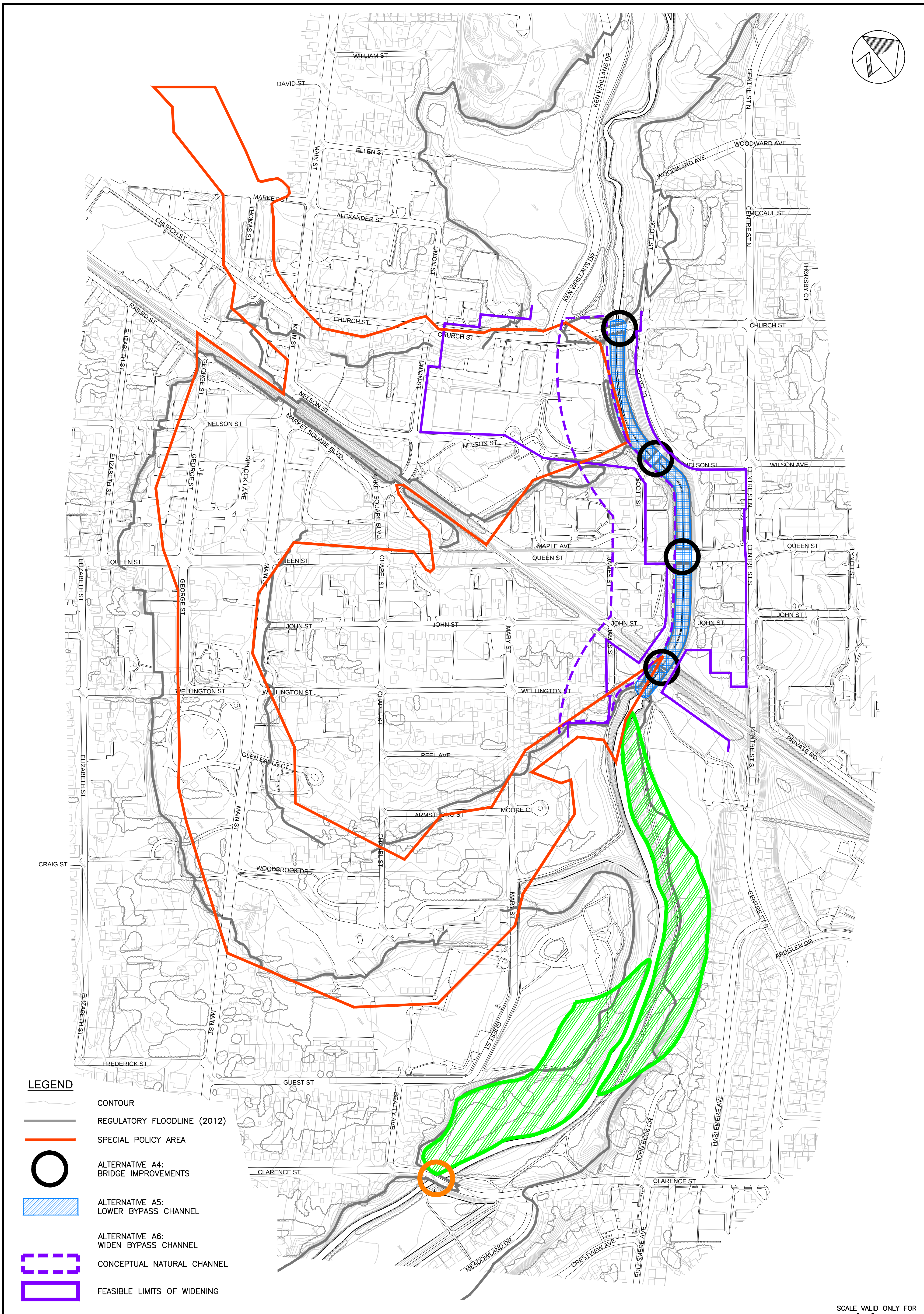
ALTERNATIVE A3: FLOOD PROTECTION LANDFORM

amec

Scale 1:750 (0 7.5 15 30)

Consultant File No. TP112151

Figure No. 3



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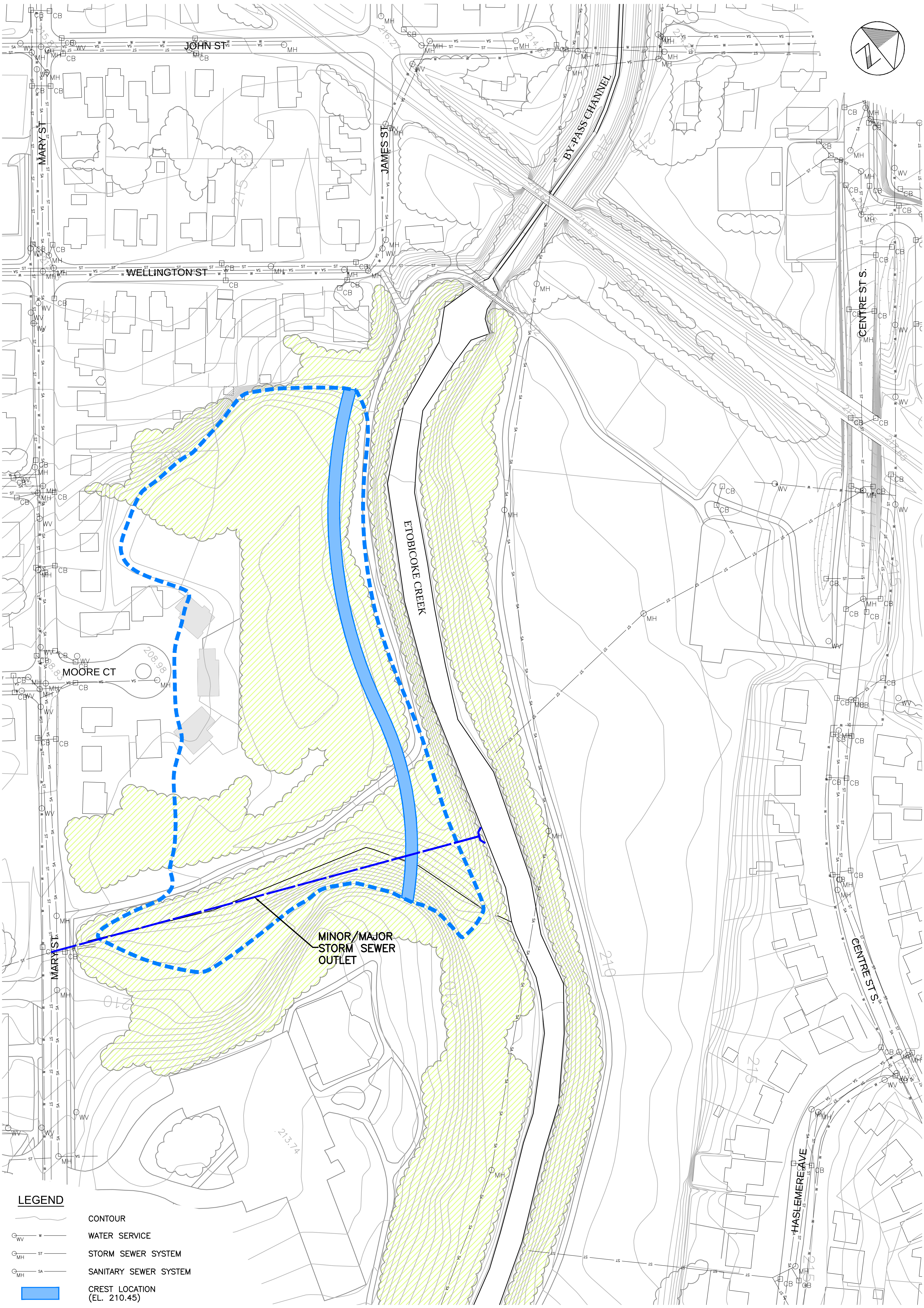
Last Saved By: richard.bortolo
Last Saved: 2014-03-14

SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	ALTERNATIVES A4, A5, A6, A7 AND A9	amec	Scale 1:2500 (0 25 50 100) Consultant File No. TP112151 Figure No. 4



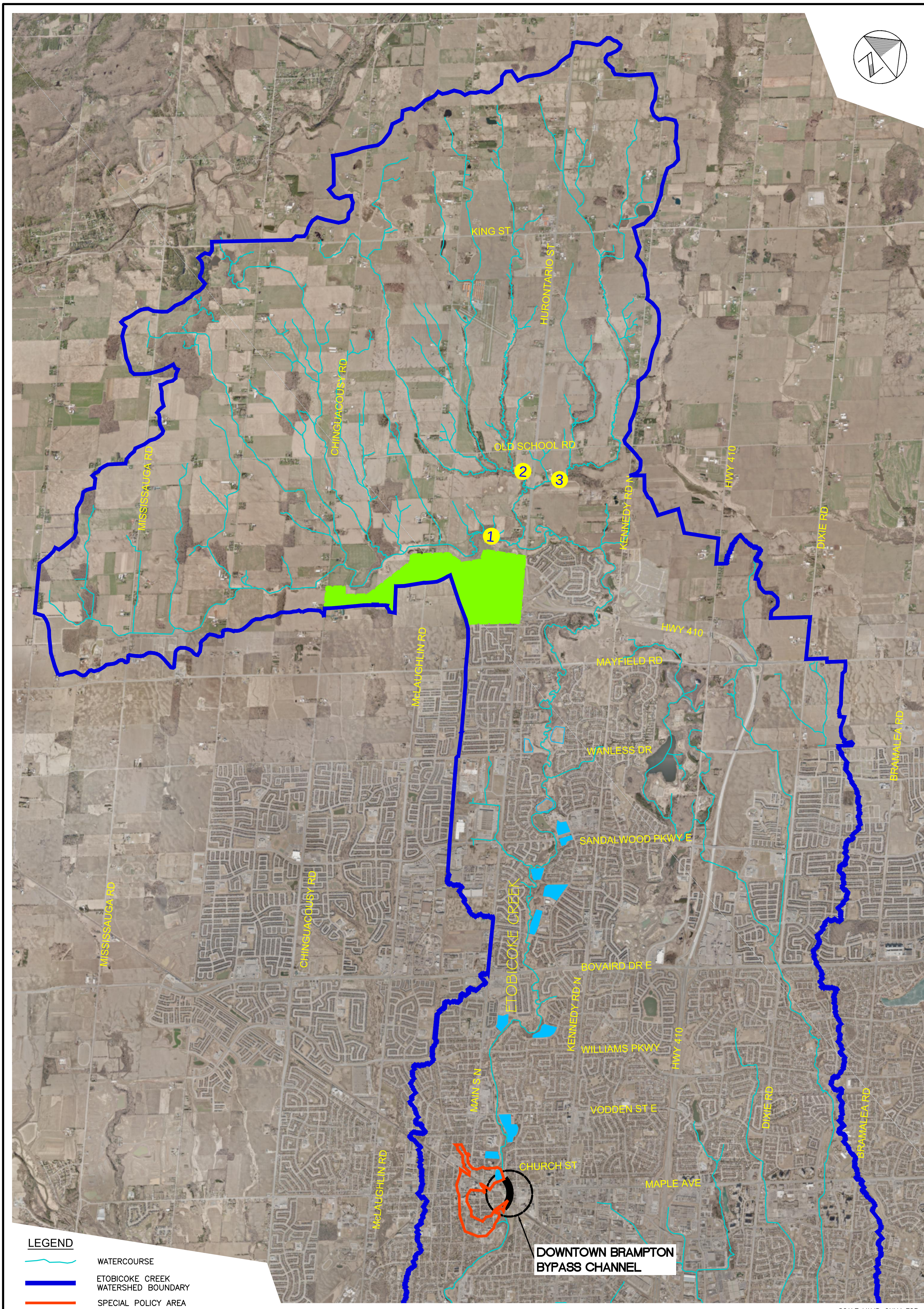
LEGEND

- CONTOUR
- WATER SERVICE
- STORM SEWER SYSTEM
- SANITARY SEWER SYSTEM
- CREST LOCATION (EL. 210.45)
- TOE LOCATION
- IMPACTED BUILDING
- EXISTING WOODLOT

SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	ALTERNATIVE A8: TAILWATER FLOOD PROTECTION LANDFORM	amec	Scale 1:750 (0 7.5 15 30) Consultant File No. TP112151 Figure No. 5

Path: P:\Work\TP112151\water\dwg\Mar2014(DrftRept)\Fig-5(Alt-A8).dwg
Plotted By: josh.seraj
Plotted: 2014-03-17
Last Saved By: richard.bartolo
Last Saved: 2014-03-13



SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON
FLOOD PROTECTION
FEASIBILITY STUDY
TORONTO REGION
CONSERVATION AUTHORITY

ALTERNATIVE B:
FLOOD CONTROL

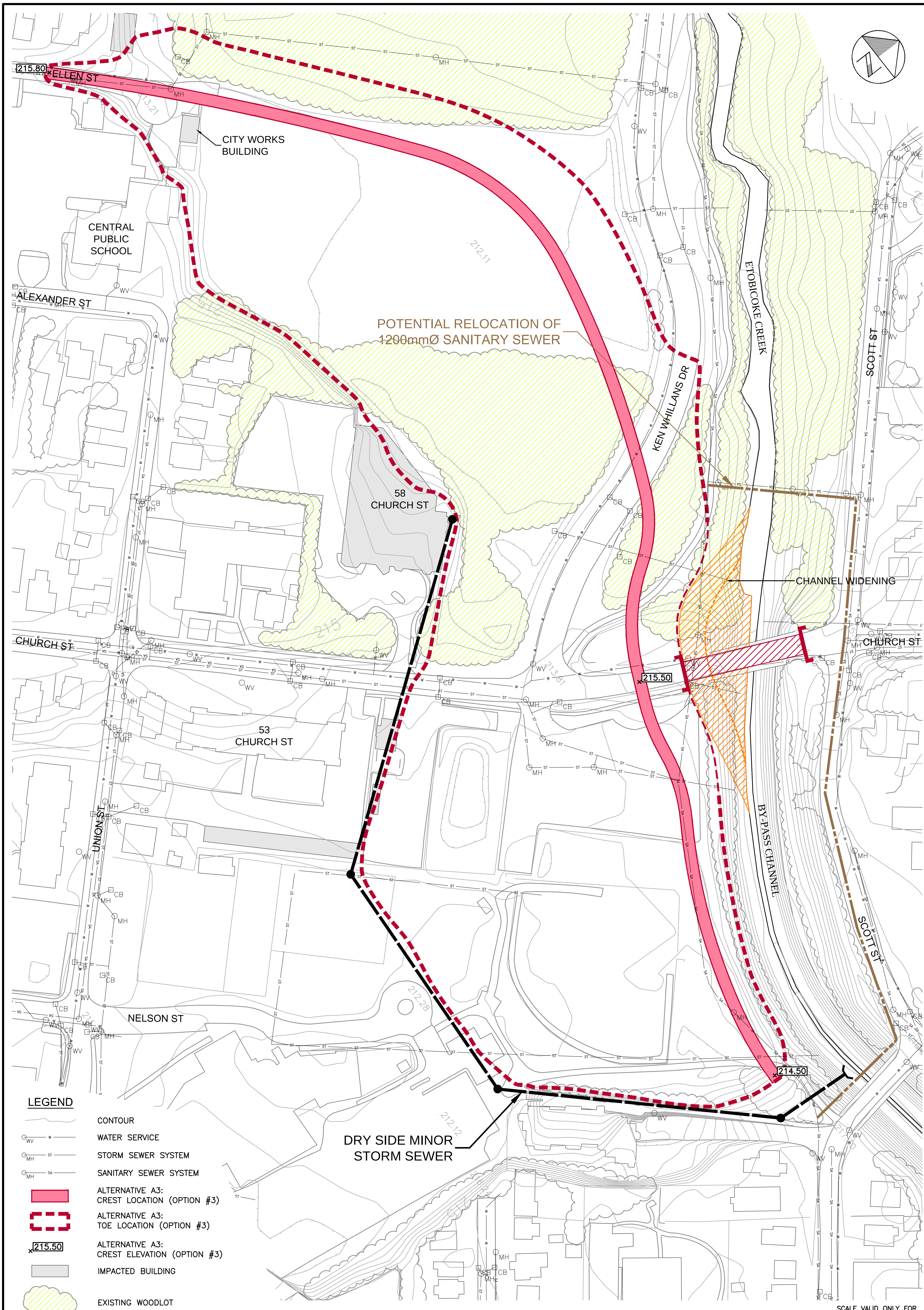
amec

Scale 1:25000
0 250 500 1000

Consultant File No.
TP112151

Figure No.
6

Path: P:\Work\TP112151\water\dwg\Mar2014(DrftRept)\Fig-6(Alt-B).dwg
Plotted: 2014-03-17 Plotted By: josh.seraj
Last Saved: 2014-03-13 Last Saved By: richard.bortolo



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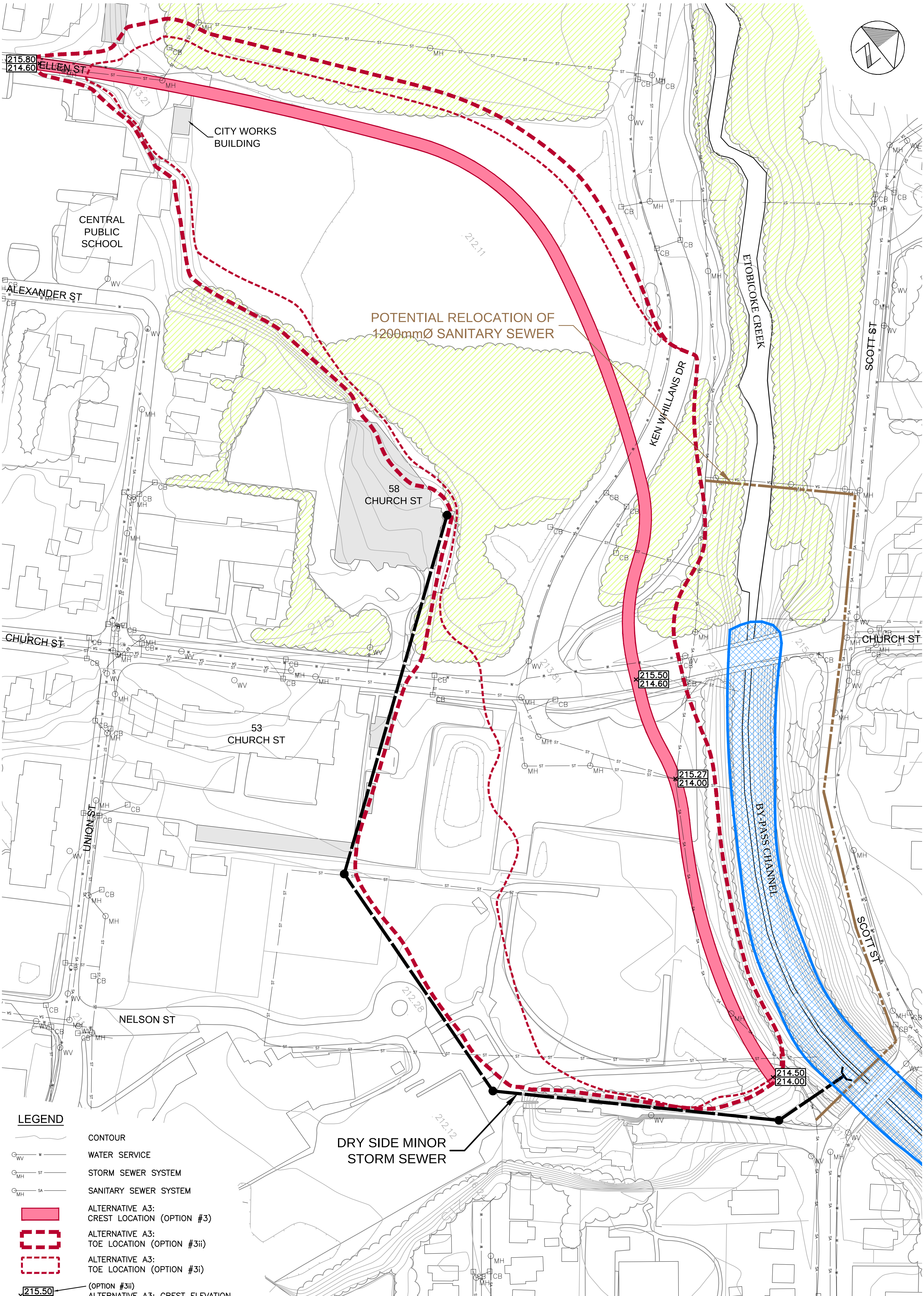
Plotted By: josh.seraj Plotted: 2014-03-17
Last Saved By: richard.bartolo Last Saved: 2014-03-13

SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	COMBINATION 1: ALTERNATIVES A3+A4+A6	amec	Scale 1:750 (0 7.5 15 30) Consultant File No. TP112151 Figure No. 7



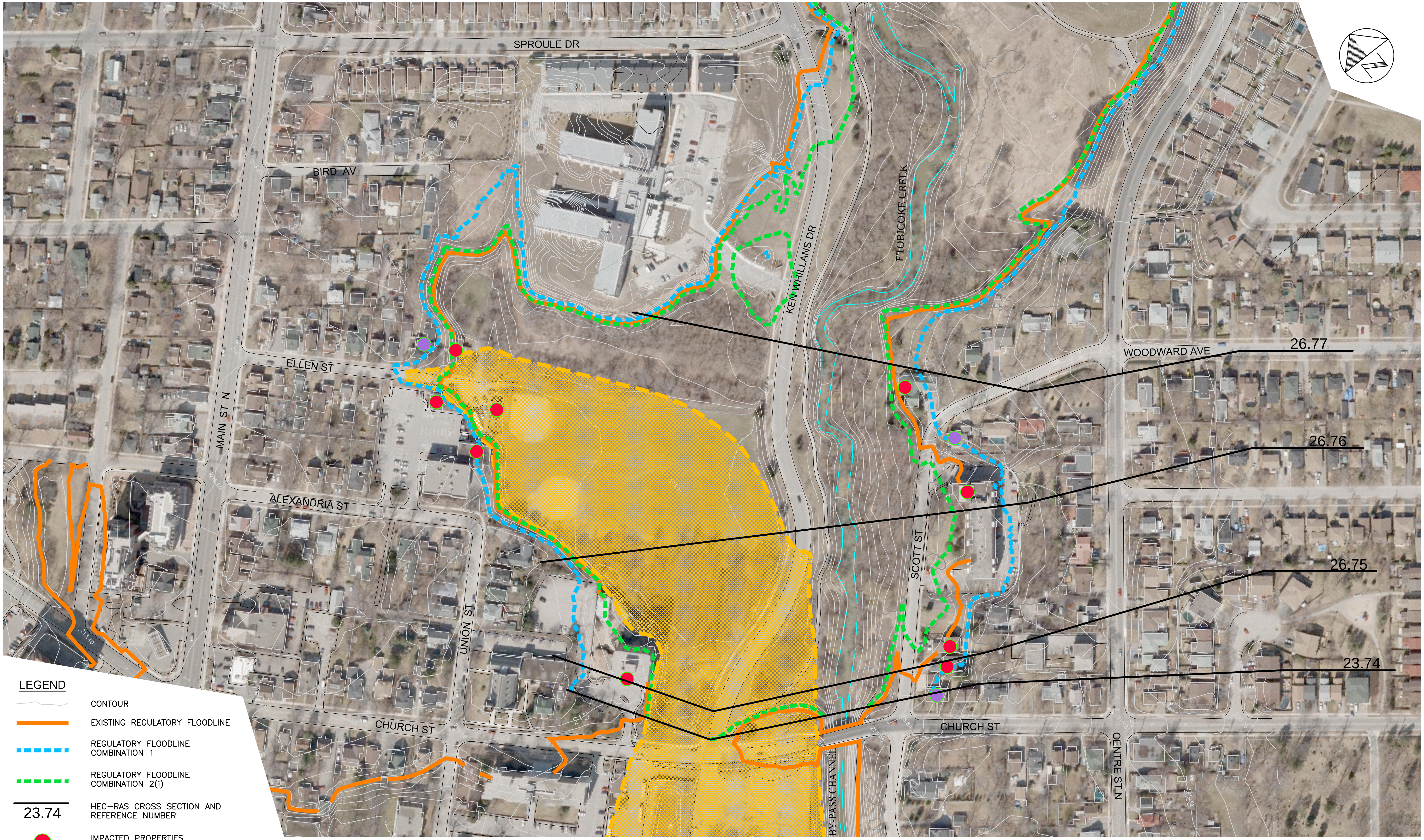
LEGEND

- CONTOUR
- WATER SERVICE
- STORM SEWER SYSTEM
- SANITARY SEWER SYSTEM
- ALTERNATIVE A3: CREST LOCATION (OPTION #3)
- ALTERNATIVE A3: TOE LOCATION (OPTION #3ii)
- ALTERNATIVE A3: TOE LOCATION (OPTION #3i)
- 215.50 (OPTION #3ii) / 214.60 (OPTION #3i) ALTERNATIVE A3: CREST ELEVATION
- IMPACTED BUILDING
- ALTERNATIVE A5: LOWER BY-PASS CHANNEL
- EXISTING WOODLOT

SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	COMBINATION 1: ALTERNATIVES A3+A5	amec	Scale 1:750 (0 7.5 15 30) Consultant File No. TP112151 Figure No. 8

Path: P:\Work\TP112151\water\dwg\Mar2014(DrftRept)\Fig-8(Combo2).dwg Plotted By: josh.seraj Plotted: 2014-03-17 Last Saved By: richard.bartolo Last Saved: 2014-03-13



SCALE VALID ONLY FOR 24"x36" VERSION

DOWNTOWN BRAMPTON FLOOD PROTECTION FEASIBILITY STUDY TORONTO REGION CONSERVATION AUTHORITY	UPSTREAM FLOOD IMPACTS	amec	Scale 1:1250 (0 12.5 25 50) Consultant File No. TP112151 Figure No. 9

Path: P:\Work\TP112151\water\dwg\Mar2014(DrftRept)\Fig-9(UpstrmFldImp).dwg

Plotted By: josh.seraj
Last Saved By: richard.bartolo

Plotted: 2014-03-17
Last Saved: 2014-03-14

Appendix A

Photographic Inventory

Looking north from Roselea Park parking lot

Looking south from Roselea Park parking lot

Spill path westerly along Church Street

Ken Whillans Drive looking northerly

Apartment Complex west of Ken Whillans Drive

Seniors Complex west of Ken Whillans Drive

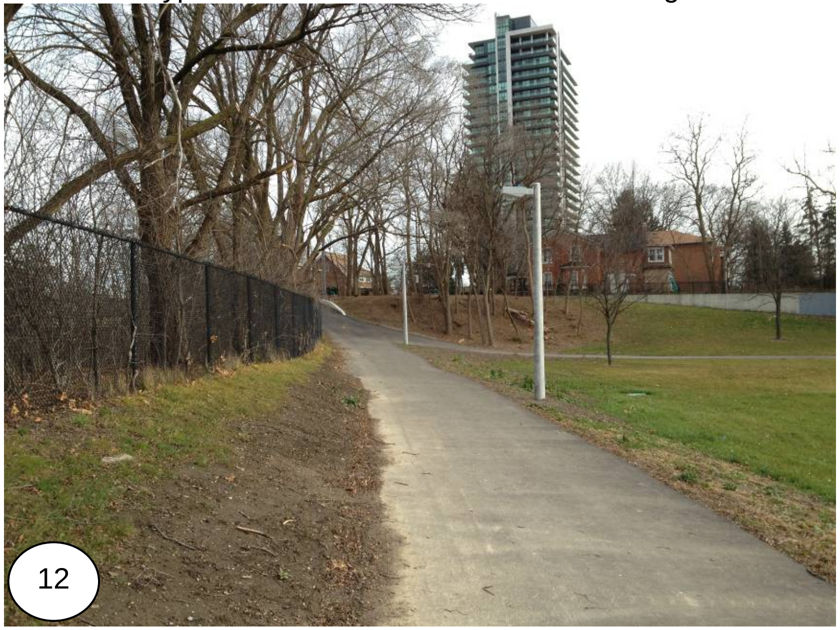
Etobicoke Creek downstream of Church Street

Etobicoke Creek downstream of Church Street

Church Street Bridge (upstream face)

Bypass channel from Church Street bridge

Berm on west side of bypass channel adjacent to Roselea Park



Berm and Trail adjacent to Roselea Park

Trail west of bypass channel looking north into Roselea Park

Scott Street bridge (upstream face)

Bypass channel upstream of Scott Street

Bypass channel downstream of Scott Street

Rose Theatre District from Queen Street

Rose Theatre District from Queen Street

George Street/Queen Street intersection looking north

Recent flood-proofed property on west side of George Street

Image of Historical Flood circa 1940’s

Image of Historical Flood circa 1940’s

Image of Historical Flood circa 1940’s

Image of Historical Flood circa 1940’s

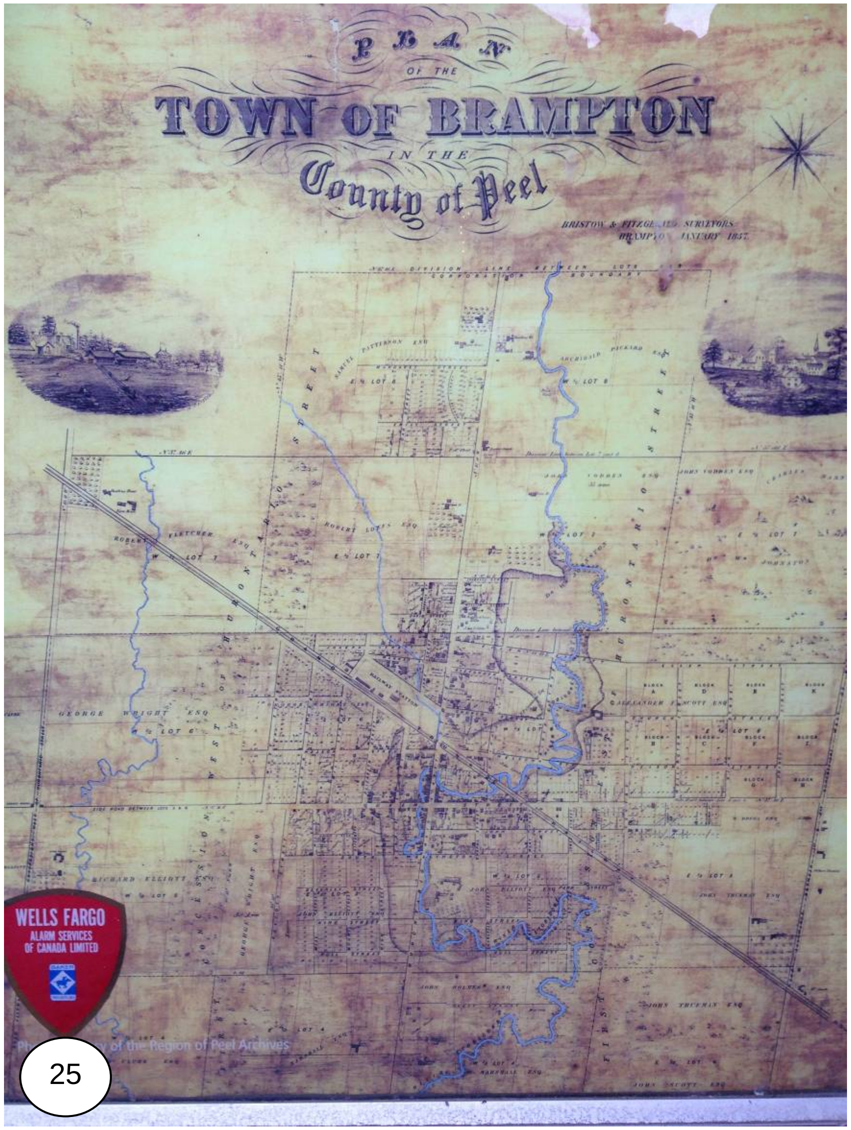


Image of former alignment of creek (pre-bypass)

Main Street southerly at Railway grade separation

Entrance to YMCA looking north on Union Street

Appendix B

Background Information

By-Pass Channel Drawings

G3-6-1

APPROVED MAY 1950.

CHIEF CONSERVATION ENGINEER,
DEPARTMENT OF PLANNING & DEVELOPMENT.

CONSULTANT
DEPARTMENT OF PLANNING & DEVELOPMENT.

ETOBICOKE - MIMICO
CONSERVATION AUTHORITY

BRAMPTON PROJECT

DIVERSION CHANNEL
NELSON ST. SECTION
STATION 13+00 N TO 5+00 N

G3-6-1

GORE & STORRIE
CONSULTING ENGINEERS
TORONTO

APRIL 15TH 1950

SCALE: 1" = 40'-0"

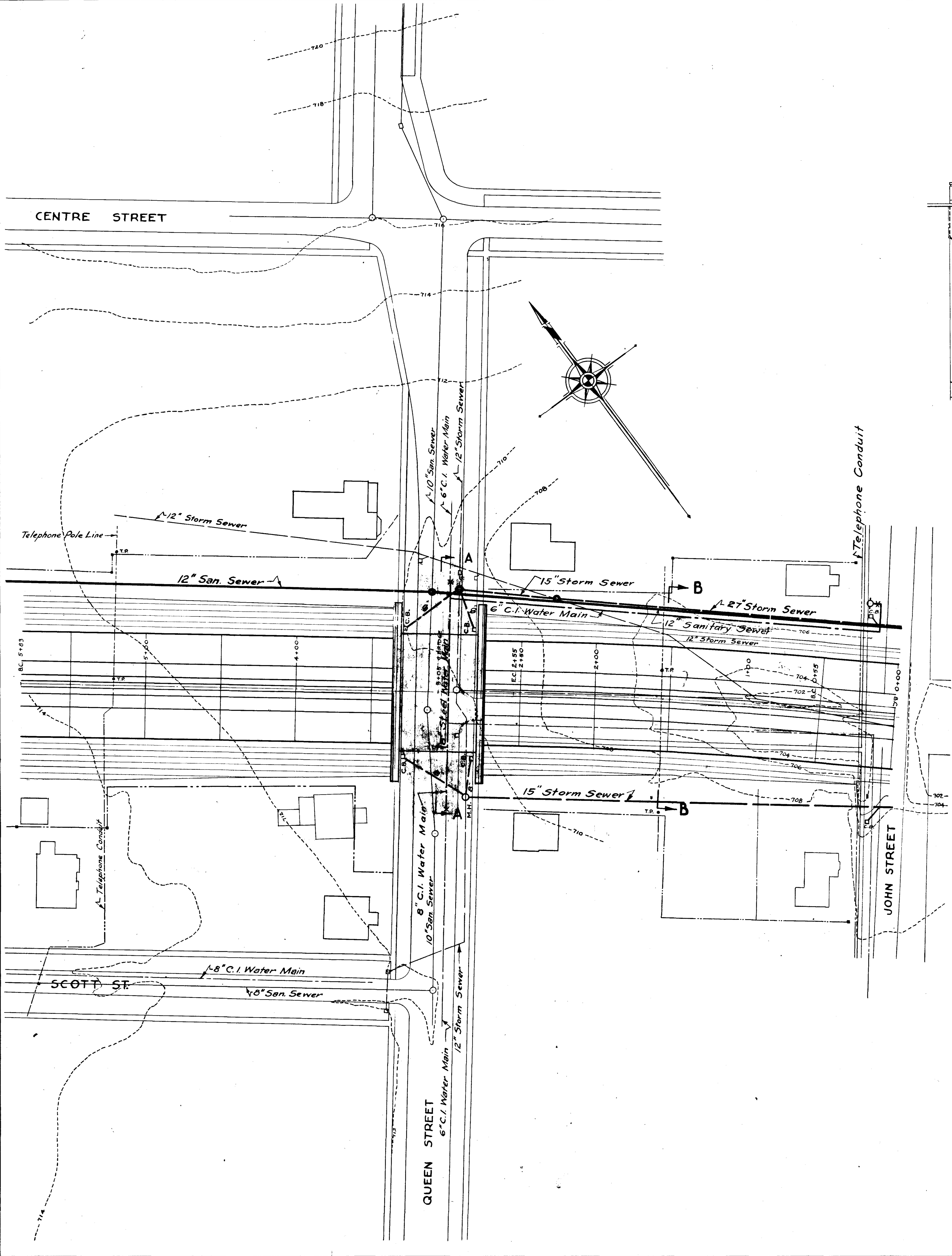
PLAN No 4

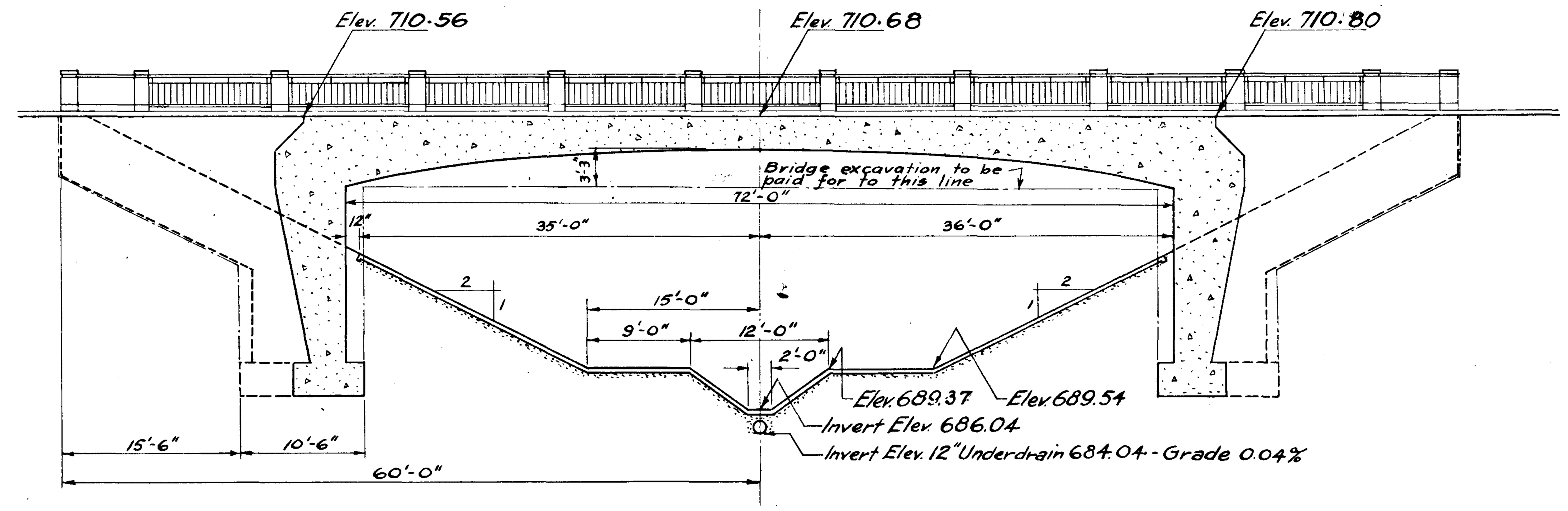
G3-6-2


SECTION A-A SHOWING INLET STRUCTURE
STATION 16+00 (NORTH)
Scale: 1" = 20'-0"
Elev. 705.0
Elev. Road Surface 708.0
Sidewalk
Elev. 705.0
Road Grade
Elev. 700.0
Elev. 686.50
Elev. 690.00
Finished ground
Bottom of Steel Piling
100'-0"
55'-0"
100'-0"
SECTION B-B
STATION 18+00 (NORTH)
Scale: 1" = 20'-0"
Scott St - Elev. 706.1
Existing Ground
Finished Ground
Grade 5.8%
Elev. 693.64
Elev. 690.14
Elev. 686.64
70'-0"
Rip Rap
SECTION C-C
SHOWING APPROACH TO CHURCH ST. BRIDGE
Scale: 1" = 20'-0"
℄ Church St. Bridge
Elev. 708.0
Station 14+67 (North)
Sidewalks
Finished Ground
Elev. 705.0
Elev. 708.0
Elev. 700.0
Existing Ground
Rip-rap
CHURCH ST.
SCOTT ST.
8" C.I. Water Main
12" Sanitary Sewer
Steel Sheet Piling
℄ CONCRETE LINED CHANNEL
ELEV. 705.0
24" CM PIPE
APPROVED MAY 1950
CHIEF CONSERVATION ENGINEER, DEPARTMENT OF PLANNING & DEVELOPMENT.
CONSULTANT DEPARTMENT OF PLANNING & DEVELOPMENT.
ETOBICOKE - MIMICO CONSERVATION AUTHORITY
BRAMPTON PROJECT
DIVERSION CHANNEL
INLET & CHURCH ST. SECTION
STATION 19+00 N TO 13+00 N
JAMES F. MacLAREN ASSOCIATES
CONSULTING ENGINEERS
TORONTO
APRIL 18th 1950
SCALE: 1" = 40'-0"
PLAN No.

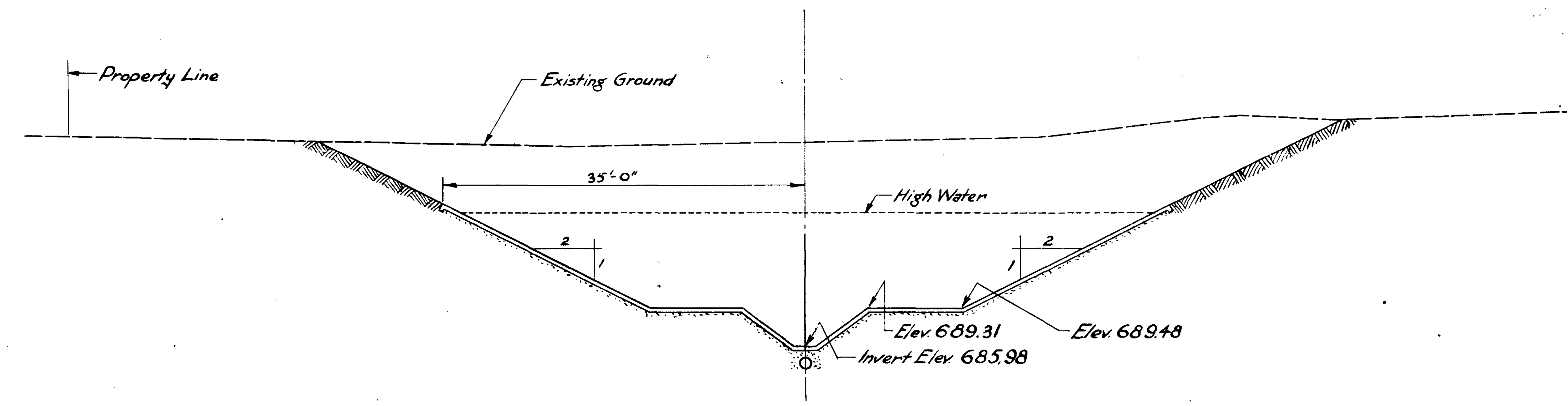
G3-6-2

G3-6-3





QUEEN STREET BRIDGE
SECTION A-A (3+05)
Scale: 1" = 10'-0"



SECTION B-B
(1+55)
Scale: 1" = 10'-0"

APPROVED MAY 1950.

CHIEF CONSERVATION ENGINEER,
DEPARTMENT OF PLANNING & DEVELOPMENT.

CONSULTANT,
DEPARTMENT OF PLANNING & DEVELOPMENT.

ETOBICOKE – MIMICO
CONSERVATION AUTHORITY

BRAMPTON PROJECT

DIVERSION CHANNEL
QUEEN ST. SECTION
STATION 5+00 N TO 0+00

GORE & STORRIE
CONSULTING ENGINEERS
TORONTO

APRIL 15TH 1950

SCALE: 1" = 40'-0"

PLAN No 5.

G3-6-3

G3-6-4

CHAINAGE STATIONS

Rip-Rap Channel	19+00	N
Inlet Structure	15+50	N
Channel Section	15+00	N
℄ Church St. Bridge	14+67	N
℄ Nelson St. Bridge	8+10	N
℄ Queen St. Bridge	3+05	N
℄ John St.	0+00	
Railway Property Line	1+71.6	S
℄ C.N.R. Bridge	2+26.6	S
Railway Property Line	3+14.6	S
Outlet Structure	3+16	S
Top of Spillway	3+51	S
Bottom of Spillway		S
End of Outlet Structure	4+51.6	S
End of Rip-Rap	7+95	S
End of Earth Channel	31+30	S

ETOBICOKE - MIMICO
CONSERVATION AUTHORITY

BRAMPTON PROJECT

SURVEY PLAN OF DIVERSION CHANNEL

JAMES F. MACLAREN ASSOCIATES
CONSULTING ENGINEERS
TORONTO

APRIL 15th 1950
SCALE: 1" = 100'-0" PLAN No 0

ETOBICOKE - MIMICO
CONSERVATION AUTHORITY

BRAMPTON PROJECT

DIVERSION CHANNEL PLAN & PROFILE

JAMES F. MACLAREN ASSOCIATES
CONSULTING ENGINEERS
TORONTO

SCALE: 1" = 40'-0" APRIL 18TH 1950 PLAN № 2

APPROVED MAY 1950. REVISED: SEPTEMBER 24, 1951.

CHIEF CONSERVATION ENGINEER,
DEPARTMENT OF PLANNING & DEVELOPMENT.

CONSULTANT
DEPARTMENT OF PLANNING & DEVELOPMENT

ETOBICOKE - MIMICO
CONSERVATION AUTHORITY

BRAMPTON PROJECT

PLAN OF ETOBICOKE CREEK
& DIVERSION CHANNEL

APPROVED MAY 1950

A. H. Richardson
CHIEF CONSERVATION ENGINEER,
DEPARTMENT OF PLANNING & DEVELOPMENT

G. Ross Lord
CONSULTANT,
DEPARTMENT OF PLANNING & DEVELOPMENT.

D-9

GORE & STORRIE
CONSULTING ENGINEERS
TORONTO

APRIL 18th 1950

SCALE 1" = 200'-0"

PLAN No. 1

CLOCA Correspondence

Cons Ont

Conservation
ONTARIO
Natural Champions

Eric Boysen, Director, Biodiversity Branch
Ministry of Natural Resources
5th Floor North
300 Water Street
Peterborough, ON K9J 8M5

Dan Marinigh, Director, Integration Branch
Ministry of Natural Resources
300 Water Street, P.O. Box 7000
Peterborough, ON K9J 8M5

May 13, 2011

RE: Addressing Urbanization and the Regulatory Flood Hazard

This letter is being sent at the direction of Conservation Ontario Council, who passed the following resolution at their meeting on April 18, 2011:

WHEREAS it is now understood that upstream urbanization has the potential to increase flood risk in downstream areas,

And WHEREAS the technical guidance provided by the province for the establishment of flood hazard limits specifically prohibits the consideration of stormwater management facilities in the establishment of flood hazard limits,

AND WHEREAS Conservation Ontario supports that such facilities, in conjunction with other measures and mechanisms such as land acquisition and flood remedial works in affected downstream areas, could be implemented by municipalities, with support from conservation authorities and the province and as part of a risk-based, watershed-scale approach to the mitigation of impacts from development on the regulatory flood hazard,

And WHEREAS design standards and methodologies for stormwater management detention facilities, whose function could be recognized in the delineation of flood hazard limits, must be developed in partnership with the province and affected municipalities and incorporated into an update of the 2002 MNR Technical Guide,

THEREFORE BE IT RESOLVED THAT the Ministry of Natural Resources be requested to initiate appropriate steps, in conjunction with conservation authorities, municipalities and other key stakeholders to develop a feasible and cost-effective solution to this issue in a timely manner.

P.O. Box 11, 120 Bayview Parkway Newmarket Ontario L3Y 4W3
Tel: (905) 895-0716 Fax: (905) 895-0751 Email: info@conservationontario.ca

www.conservationontario.ca

The resolution was the result of Council's consideration of the attached paper entitled, "Issue Exploration- Urbanization and Regulatory Flood Hazard", authored by Toronto and Region Conservation Authority (TRCA) staff with input from a number of conservation authorities. The Issue Exploration examines the effect that urbanization is having on flood hazards, particularly in light of the Province's policy regime of growth planning and intensification.

As it is now understood that upstream urbanization has the potential to increase flood hazard limits in downstream areas, the purpose of this letter is to request that the Province provide specific direction on how to address the flood impacts which are occurring as a result of urbanization. The issue has been raised verbally at a number of provincial and CA tables and the attached paper documents the issue and is intended to provide the necessary detail and sufficient context to facilitate the ability of the Ministry of Natural Resources to confirm and initiate appropriate next steps.

Conservation Ontario considers it critical that multiple stakeholders including conservation authorities, municipalities and other interested parties (e.g. Ministry of the Environment, Ministry of Municipal Affairs & Housing) be involved in the resolution of the issue. Conservation Ontario would be pleased to identify appropriate CA staff to assist in this regard. It is noted that while not specifically a Greater Golden Horseshoe (GGH) Growth Plan Area issue, several active planning initiatives in the GGH Growth Plan area are predicted to impact regulatory flooding as described in the attached paper, thus creating a more urgent need for collaborative action on this issue.

Thank you in advance for your consideration of this issue and I'd appreciate an opportunity to further discuss next steps and your timing at the earliest opportunity.

Sincerely,

Don Pearson
General Manager

c.c. CAOs/GMs of Conservation Authorities

P.O. Box 11, 120 Bayview Parkway Newmarket Ontario L3Y 4W3
Tel: (905) 895-0716 Fax: (905) 895-0751 Email: info@conservationontario.ca

www.conservationontario.ca

Urbanization Impacts on Regulatory Flood Hazard and Floodplain Management

In areas of Ontario served by conservation authorities, regulatory flood hazard limits for rivers and streams are defined based on either a 100-year return period flood or the flood resulting from the rainfall actually experienced during a major historic storm. The magnitudes of peak flood discharges associated with historic storms (and sometimes for the 100-year return period flood depending on the jurisdiction) are calculated via hydrological modeling, using methodologies prescribed by the Ministry of Natural Resources. The current technical guidance from the MNR is found in the 2002 MNR document *Technical Guide - River and Stream Systems: Flooding Hazard Limit.* The resulting peak flood discharges calculated through hydrologic simulation are then input in hydraulic modeling analyses to establish the depth and extent of flooding along the subject river and stream systems and to delineate the resulting regulatory floodplain. Conservation authorities periodically update the hydrologic models used to calculate the peak regulatory flood discharge for a number of reasons, including improving model calibration, upgrading to state-of-the-art hydrologic modeling software, and reflecting land use changes in subject watersheds.

For most of southern Ontario, in an area that includes the jurisdiction of 19 of the province's 36 conservation authorities, the Ministry of Natural Resources requires that the regulatory floodplain be determined based on the peak flood discharge resulting from Hurricane Hazel. Hazel was the 1954 storm that delivered almost 300 mm of rain to the southern part of the province over 2 days, with the majority falling in the last 12 hours. It should be noted that MNR requirements for the area actually state that the greater of the Hurricane Hazel peak flood discharge and the 100-year flood discharge is to be used, but the Hurricane Hazel discharge is larger for virtually all watercourses and is therefore used almost universally. Because soil conditions were completely saturated at the beginning of the majority of the Hurricane Hazel rainfall, the Ministry of Natural Resources and conservation authorities have historically taken the position that the resulting peak flood discharge would be essentially unaltered by land use change and urban development, *based on an assumption that impervious surfaces would have essentially the same runoff response as saturated soils on agricultural lands or natural areas.* However, conservation authorities that have experienced development over a large portion of their watershed areas have seen substantial and continuing increases to calculated peak flood flow discharges as they update their hydrologic simulations of Hurricane Hazel. This is likely because more recent hydrological modeling software is able to simulate the changes in both the quantity and timing of runoff volume that occur from impervious surfaces in developed areas as compared to exposed soils and vegetated surfaces, even under the saturated conditions that preceded Hurricane Hazel. As a result, the historic assumption that urban development would not increase peak flood flows from Hurricane Hazel has proven false, at least from a hydrologic modeling perspective.

Many conservation authorities in the area for which Hurricane Hazel is utilized to determine the regulatory flood hazard limit, particularly those in the Golden Horseshoe area where increasingly significant portions of jurisdictional area are developed, are now faced with the need to update their regulatory floodplain mapping to reflect a larger flood hazard limit resulting from urban development. This creates obvious difficulties in explaining to downstream landowners and municipalities that their lands have been "relocated" into the floodplain with all of the attendant restrictions on the use of those lands.

It is important to note that while this issue has come to light in the context of Southern Ontario conservation authorities where the regulatory flood standard is dictated by Hurricane Hazel, this issue is potentially independent of the flood standard applied and thus increases to regulatory flood discharges may also be an issue of current or potential future concern for the other conservation authority jurisdictions in Ontario that use either the 100-year flood or the Timmins storm to delineate the regulatory flood hazard.

Addressing Urbanization Impacts on Regulatory Flood Hazard

Beginning in the 1980's, conservation authorities and their partner municipalities have worked to assess and manage the impacts of urban development on downstream flood risk for some conditions. Such management approaches have typically addressed "return-period" rainfall events up to and including the 1 in 100 year storm, and have not considered development impacts to peak flood discharges from a larger flood standard event like Hurricane Hazel or the Timmins storm. This is in part because of the assumption that land use change would not affect those peak discharges as described above. Management of the increased rate and volume of runoff from urban areas for these events of 100-year return period magnitude or less has generally been accomplished through the use of stormwater detention ponds, which detain runoff and release it at a reduced rate which allows, in theory, for peak flood discharges in receiving watercourses to be maintained at pre-development levels.

The use of stormwater management detention facilities, albeit with significantly larger volumes and footprints, would be in most cases the most practical and/or feasible approach for mitigating the now-understood impacts of urban development on peak flood discharges from Hurricane Hazel. However, the technical guidance provided by the province specifically prohibits the consideration of stormwater management facilities in the establishment of flood hazard limits (River and Stream Systems: Flooding Hazard Limit, sections 4.1 and 4.6). Therefore, even if municipalities, with guidance from conservation authorities, were to design and construct such facilities to mitigate the impacts of urban development on increased downstream peak regulatory flood discharges, their benefits cannot be reflected in the delineation of the regulatory floodplain. As a result, the current constraints imposed in the provincial technical standards require conservation authorities to expand the regulatory floodplain to reflect development impacts, regardless of any attempts to mitigate the issue through stormwater management controls. This has left conservation authorities with a very small number of alternatives to the management of the impacts of urban development on the downstream regulatory flood hazard, which includes:

1. Restricting development in watersheds where analysis of the cumulative impacts of future development indicates increases in downstream regulatory flood risk.

2. Continuing to permit development to occur despite known downstream impacts, with ongoing incremental expansion of the regulatory floodplain as hydrologic modelling is updated by conservation authorities to reflect land use changes.

3. Implementing, in partnership with constituent municipalities, stormwater management facilities to control increases to the regulatory peak flood discharge, and reflecting the function of those facilities in the delineation and mapping of flooding hazard limits in contravention of provincial technical standards.

Conservation authorities do not find any of these approaches acceptable. The first cannot be achieved without substantial conflict with municipal and provincial growth planning, and the second creates great difficulty in explaining and managing the new land use restrictions imposed on downstream landowners. The third alternative creates the potential for liability to the individual conservation authorities if provincial technical standards for flood hazard management are ignored, and would also set a precedent implying those standards are flexible and detract from the credibility of other aspects of conservation authority floodplain management programs that are based on those provincially prescribed methodologies. As such, there has been increasing consensus among southern Ontario conservation authorities that design standards and methodologies for stormwater management detention facilities, whose function can then be recognized in the delineation of flood hazard limits, must be developed in partnership with the province and affected municipalities and incorporated into an update of the MNR *Technical Guide*. Such facilities could then be implemented by municipalities, with support from conservation authorities and the province and as part of a risk-based, watershed-scale approach to the mitigation of impacts from development on the regulatory flood hazard, which could also include other measures and mechanisms such as land acquisition and flood remedial works in affected downstream areas.

Conclusion and Next Steps

While not specifically a Greater Golden Horseshoe Growth Plan Area issue, several active planning initiatives in this area put forth by municipalities through provincial land use planning direction are predicted to impact regulatory flooding and have created an urgent need for action and direction on this issue. This perceived conflict must be resolved for municipalities to achieve provincial growth planning objectives, including pending conservation authority approvals, in an expeditious manner. It is recommended that Conservation Ontario bring this matter to the Ministry of Natural Resources, as the provincial lead for natural hazards, to confirm and initiate appropriate next steps to resolve this issue, in partnership with conservation authorities and affected municipalities.

C LOCA

CENTRAL LAKE ONTARIO CONSERVATION AUTHORITY

DATE: November 7, 2011
FILE:
S.R.: 5001-11

APPROVED BY C.A.O. ________

MEMO TO: Chair and Members, CLOCA Board of Directors

FROM: R. Perry Sisson, Director, Engineering and Field Operations
Amber Langmuir, Water Resources Engineer

SUBJECT: **Regulatory Flood Control Facilities**

The Regulatory floodline is one component that determines the Regulated area within CLOCA and assists in determining development setbacks. The Regulatory floodline for creeks in our jurisdiction is defined by the peak flows resulting from the greater of a 100-year return period storm or Hurricane Hazel. As a component of our development review we also assess and manage the impacts of urban development by investigating the change in peak flows produced from "return-period" rainfall events up to and including the 100 year storm. Traditionally, we, along with other authorities have not considered development impacts from a larger flood standard event like Hurricane Hazel. This is in part because of the assumption that land use change would not affect peak flows. The assumption is based on the fact that when Hurricane Hazel occurred soils were completely saturated. It is assumed that impervious surfaces would produce the same runoff response as saturated soils on agricultural lands or natural areas.

Our watershed has seen tremendous urbanization over the past years and the urban limits are expanding, and will continue to expand to the allowable limits. Our watersheds have developed from the outlets at Lake Ontario, northerly, into the headwater areas. As we update our hydrologic models to reflect these current and future land use changes we are finding that there is in fact an increase in the Regulatory peak flows. Conversations with other Conservation Authorities are revealing that we are not alone in our findings. Across the GTA, the latest hydrologic models are consistently showing that upstream urban development is causing increases of regulatory peak flow through the watersheds. This, in turn, results in a swelling of the Regulatory floodplain, putting downstream landowners into hazard areas.

Stormwater management facilities are used to mitigate the impacts for the "return period" rainfall events but the technical guidance provided by the MNR prohibits the use of stormwater management facilities in the establishment of flood hazard limits (River and Stream Systems: Flooding Hazard Limit, sections 4.1 and 4.6). This leaves us, as well as other CA's in a difficult position. In order to protect downstream landowners from flood hazards, we must restrict development which causes significant conflict with municipal planning initiatives. If development is not restricted we will be continuing to permit development knowing that it is causing downstream impacts.

TRCA has prepared an explanatory memo (attached) and the issue was put forward from Conservation Ontario to the provincial government (May 13, 2011 letter from Don Pearson, attached) in hopes of receiving provincial guidance on the acceptance of Regulatory Flood Control Facilities to reduce Regulatory peak flows. It appears that a response from the province is not forthcoming in the near future, yet we are currently dealing with several urban development related flood impact issues at the current time. We are aware that other Conservation Authorities in the Greater Toronto Area are moving forward, accepting stormwater management facilities for relief of potential flooding impacts. In absence of provincial direction, we believe the acceptance of stormwater management facilities as a means of controlling regulatory flooding is the most feasible solution to flooding impacts from new development.

cont'd.......2

RECOMMENDATION:

THAT Staff Report #5001-11 be received for information, and circulated to member municipalities;
AND THAT the Ontario Ministry of Natural Resources be requested to respond to Conservation Ontario's request , and initiate the necessary discussion that will lead to a consistent provincial direction for managing flood risk in association with urban development;
AND THAT CLOCA staff work with municipal partners to develop design standards for stormwater/flood management facilities;
AND THAT, in the absence of MNR direction, CLOCA recognize stormwater/flood management facilities as being an effective flood management tool to mitigate the impact of urban development on downstream flood limits.

RPS/AL/klt
Attach.
s:\reports\sr5001-11.docx

Draft Flood Protection Landform Guidelines

Toronto and Region Conservation for The Living City

MEMORANDUM

TO:	Don Haley	DATE:	February 20, 2013
FROM:	Rob Grech	CFN:	
RE:	Draft FPL Criteria		
CC:	Sameer Dhalla		

This document is draft, intended for review purposes to begin formulating a policy on flood protection landforms (FPL) throughout TRCA's jurisdiction. In order to fully understand the technical aspects of such a feature, this document lays out the differences between a flood dyke and a FPL and goes on to explain the criteria required to incorporate such a feature into TRCA's regulation mapping. The document then goes on to explain the differences between a FPL and a valley wall – which would allow development to occur much closer to the top of bank of the feature (as per TRCA's current Valley and Stream Corridor policies).

FPL Criteria – Differences between a Flood Dyke and a Flood Protection Landform

A flood protection landform (FPL) is an earthen berm that fulfills the provincial requirements as a permanent structure. The criteria for a FPL was laid out as part of the West Don Lands EA process (approved October 2005), which specifically addresses the differences between a flood dyke and a FPL. Some of the sections outlined in this criteria document were taken verbatim from that document.

The *Provincial Natural Hazards Policy* which includes flooding is implemented using the *Rivers and Streams Performance Standards and Technical Guidelines*, published by the Ministry of Natural Resources in April of 2001. This guideline document clearly states that an earth fill dyke, or similar structure, is not considered as a form of permanent flood control and that if used, additional flood protection, such as flood proofing of individual structures, would be necessary behind the dyke. This position is based on the risk related to the failure modes that are inherent in the typical design of a dyke structure.

With a dyke, three principal modes of failure exist:

i) Dyke overtopping - floodwaters can overtop the structure and erode its dry side, leading to the potential failure of the fill;

ii) Dyke saturation - the movement of water through or under the dyke can result in the saturation of the dyke and failure; or,

iii) Boils - the movement of water through or under the dyke can produce what are termed boils, which develop at the toe of the dry side of the dyke as water re-surfaces, creating an ever increasing flow as fines beneath the dyke are removed, and finally resulting in failure of the fill.

The risk of failure due to the modes described in *ii)* and *iii)* above can be aggravated by either man made or natural intrusions into the earth fill, by burrowing animals, deep rooted vegetation, buried servicing (sewers) and building foundations.

The dimensions required for the earth fill landform to protect against the three modes of failure are significant such that it no longer resembles a typical dyke structure, and hereinafter will be referred to as a ***flood protection landform (FPL)***.

The TRCA will only entertain the use of an FPL when it is a component of a Regulatory flood protection remedial works utilized to provide complete flood risk removal to existing flood vulnerable areas. The use of an FPL to facilitate new development in a previously undeveloped flood plain will not be allowed.

In summary, the following outlines the design criteria/principles associated with the flood protection landform alternative that would ensure a permanent solution is achieved in accordance with the requirements agreed upon by the various levels of government:

- The location of the toe of the landform and all additional fill required must be set back from the edge of the river in order to maintain or improve the existing hydraulic conveyance properties of the existing river/creek system. The design and layout of the landform and all additional fill required must have due regard for lost floodplain storage. The inclusion of the structure may have no upstream or downstream impacts on flood levels, on either a measured or cumulative impact basis, as per the requirements under a two zone policy; (add reference to MNR Tech Guidelines)

- To ensure the integrity of the earth fill, locating buried utilities (e.g., storm and sanitary sewers) within the flood protection landform should be restricted and regulated. In addition, the placement of deep-rooted vegetation should also be avoided. Any proposed works within the footprint of the flood protection landform shall be subject to the approval of the Toronto and Region Conservation Authority;

- Any services located in additional fill above the FPL must be designed to minimize any risks related to failure and if feasible to ensure that no impact to FPL will occur in the event of a failure;

- A minimum engineering design freeboard of 0.3m should be included in the design of the landform, to be measured upward from the Regional Water Surface elevation or regional energy grade line expected against the structure. An additional freeboard will be required to account for the potential impacts of climate change. Current indications related to a changing climate tend to reflect the potential for a higher Regulatory Flood, the amount of additional freeboard will be determined based upon watershed and local conditions as dictated by the TRCA. The design of the flood protection landform should also be flexible in allowing for adaptation through an increase in its height, if required at some time in the future, should surrounding grades allow.

- Fill slopes on the wet side of the flood protection landform should be designed with fill slopes of 5-10%, with a maximum of 15in localized areas when approved by TRCA. The dry side fill slopes should be designed with gradients of 1.5-2.5% with a maximum of 5% in localized areas, when approved by TRCA.

- A minimum 3-5m crest is required at the top of the FPL.

- The crest of the FPL is to be a high point of the local drainage system. Major and minor systems are to be directed away from the wet or river side of the FPL. Localized changes in this regard may occur with approval from the TRCA. In all cases every effort will be made to minimized drainage directed onto or over the wet side of the FPL.

- No hydraulic connections (storm, sanitary, utility, etc.) can be implemented that connect the wet side of the floodplain to the dry side. Where these connections are unavoidable due to brownfield related issues, the design must include an analysis of impacts related to risks related to the Regional Floodplain and incorporates appropriate mitigation measures as approved by TRCA.

- The concern of water traveling beneath the fill is a more complex issue. An understanding of underlying soil conditions and geology will be a pre-requisite of the FPL design to ensure long term geotechnical and operational stabiilty.

  To determine the extent of movement both under and along any existing infrastructure, a review of the hydraulic conditions must be undertaken. The review must include the following:

  - Due regard for existing stormwater outfalls and/or conduits that may provide a failure mechanism for the FPL – either with flow through or around the outside of the pipe
  - Determination of the frequency that the water level is expected to be above the toe of the FPL
  - Review of the hydrograph to determine the maximum amount of time that the water level will be above the toe of the FPL
  - Determine the expected distance of penetration of floodwaters beneath or into the FPL
  - Estimate the level of risk associated with this method of failure, based on the distance of penetration expected, and the design width of the FPL

- The materials used in the construction of the FPL must meet specific grading criteria. In addition, the materials contain less than 0.5% organic matter.

- The FPL is to be constructed in 200mm lifts and compacted to a minimum 95% standard Proctor maximum dry density. Where the finished slope gradient exceeds 15%, the degree of compaction is increased to a minimum of 98%. The FPL core shall be at 98% standard Proctor density.

- An FPL is not meant to support any structural load. No structure or foundation shall be supported on or within the FPL. No deep foundation shall transmit any loading to the FPL, or cause the FPL to settle. Therefore any known components of design related to additional loading approved to be on the FPL must be included in the design to ensure stability and flood protection function.

- No services or utilities shall be installed within the clay core or the wet side of the FPL.

Valley Wall Criteria – Differences Between a Valley Wall and a Flood Protection Landform

The relatively gentle slopes that are required as part of the dry side of the FPL (1.5-2.5% with up to 5% in localized areas) may create problems for development because of the relatively large footprint that is required to contain the structure, and the very strict criteria for what can be constructed on the dry side of the FPL. In some cases, servicing and other development related issues may actually require that significant amounts of fill are required beyond the toe of the dry side of the FPL, meaning that much gentler slopes on the dry side are achievable. Under these conditions, the modes of failure associated with saturation and boils (flow through and flow under) have significantly lower associated risks – at acertain point in terms of extended filling, the structure will begin to function similar to a natural valley wall, with similar associated risks. The key difference between a FPL and a valley wall is the reduced predominant dry side gradient, and increased width requirement for the minimum gradient to be maintained. While individual site conditions will vary, a typical reduced dry side slope creates a structure with a base width in the range of– 3x the width of the equivalent required FPL. In these cases, from a policy perspective, it is recommended that the typical Valley and Stream Corridor Management practices are applied to areas where a width of additional filling creates a structure of 3 or more times the required standard FPL width.

In this context, for a valley wall to be constructed, a structural ‘core’ of the feature will still be required and will be subject to the same criteria as the FPL.

The following differences exist between the FPL criteria and for a valley wall:

- All criteria associated with the wet side of the FPL also apply to the implementation of the wet side of a valley wall;

- The dry side slopes on a valley wall must be predominantly less than 1.5%, with a 1% gradient preferred.

- The predominant dry side gradient must extend from the crest of the FPL bank to a distance of 3x the width of the the required equivalent FPL footprint at a maximum of 1-1.5 % gradient. Additional fill on crest may be required to achieve the equivalent width required. The top of the valley wall must be the high point in the system, as per the requirements of the FPL. Minor and major system drainage must be directed away from the proposed valley wall. Where this can not be achieved or a variance to this is allowed, drainage to or over the wet side of the FPL will be minimized or designed to ensure no impact.

- The ‘core’ of the structure is to be constructed as per the fill and compaction requirements of a FPL within the area as defined by the 2.5% dry side gradient;

Please feel free to call me should you have any questions or concerns,

Regards,

Rob Grech, P. Eng
Ex. 5220

HECRAS Peer Review

24 February 2012 Reference: 207

Toronto Region Conservation Authority
5 Shoreham Drive
Downsview, Ontario
M3N 1S4

DRAFT

Attention: Ms. Laurian Farrell, P. Eng.
Reference: Peer Review of the Etobicoke Creek 350 Year Flood Analysis Prepared by Aquafor Beech Limited for the City of Brampton

Dear Laurian,

The following report summarizes the peer review completed by Greck and Associates Limited (GAL) for flood hazard analyses completed by Aquafor Beech Limited (ABL) for the City of Brampton. The review focussed on the technical analyses and specifically the Hec Ras hydraulic modelling of the 350 return period storm in Etobicoke Creek and its potential for spilling into the designated Flood Damage Centre (FDC) in downtown Brampton.

In general we found the model to be consistent with the coding practices used to develop a hydraulic model using the Hec Ras program. The modelling results suggest that the Brampton FDC would receive a peak flow rate of 3.2 m^3/s for the 350 year return period storm event. This quantity of spill is based on a total flow of 100.8 m^3/s in Etobicoke Creek upstream of the spill location. Based on our review of the model, the analytical assumptions incorporated into the model and the 350 year return period flow rate used we would agree with findings of this analysis.

Further details of our review procedures and review comments are provided in the following sections.

Review Procedures

To complete our review the hydraulic model was obtained directly from ABL. Our review examined the Hec Ras model with the project file name: “EtobicokeCreek_Brampton FDC-0.prj”, dated the 19 August 2011. This hydraulic model and the associated files were provided to GAL by email from Mr. Greg Frew, P. Eng. with ABL on 12 January 2012, copy of email attached. There was no formal supporting documentation or report provided describing the work completed, or summarizing the analytical results. A brief note was provided in Mr. Frew's email. Mr. Frew was contacted on one occasion to discuss the source of the data used for the bypass channel in the hydraulic model.

The analytical procedures and assumptions used by ABL were discussed between Mr. Greg Frew, P. Eng and Mr. Brian Greck, P. Eng. Various components of the Hec Ras model were reviewed including plan geometry, flow data, river section data, junction data, bridge data, and output tables. Since GAL had prepared the Hec Ras model for the Regulatory flood event, the ABL model was compared to the model used for the regulatory flood model. To further assess the ABL findings a subset of the regional storm event model was prepared to analyze the 350 year flood flows.

Interpreted Spill Process, Analytical Approach and Assumptions

Figure 1 has been prepared to illustrate what GAL believes to be the spill process upstream of the Brampton FDC. This understanding of the spill process was developed while preparing the flood analyses for the Regional storm event. This figure illustrates how flood waters would initially flow over the banks of Etobicoke Creek upstream of Church Street bridge. This flow into the floodplain occurs due to the natural limited capacity of Etobicoke Creek and the backwater effects caused by the flow capacity of the bypass channel.

Water in the floodplain flow will enter the play field at Central Park School and move south along Ken Whillans Drive. The flood water will pond upstream of the Church Street where it crosses with Ken Whillans Drive, as it acts a barrier or dam to overland flow. It will flow over the roadway at an elevation of slightly above 213m. The actual spill elevation is unknown. The flow across Church Street will spill towards the Brampton FDC area. At some flow rate the two roadway openings under the railway begin to create sufficient back water conditions resulting in a portion of the spilled water to re-enter the bypass channel. This in turn will further utilize the capacity of the bypass channel causing more flow to spill upstream of the bridge. For these reasons, the regional storm flood event spill was considered to occur downstream of the Church Street bridge and a manual energy balance of the flood flow energy was completed at this location.

ABL abandoned an earlier attempt to place a lateral weir in the model to determine the spill of flood waters to the FDC. This approach appeared to provide unstable and unreliable results (personnel communications, Frew). Instead an approach was used whereby the spill of flow to the Brampton FDC was estimated by conducting a flow split calculation at the Church Street bridge using the multiple opening analysis tool in the Hec Ras program. The Hec Ras multiple opening analysis would determine the appropriate split in flow under the bridge and over the road at Ken Whillans Drive. The portion of flow which would spill at Ken Whillans Drive was assumed to enter the Brampton FDC. This analytical approach was initially suggested by Mr. Greck and discuss with Mr. Frew in an earlier conversation prior to this review. GAL had considered this approach for the Regional Storm event.

This approach is considered reasonable and representative of the likely flow split and spill pathway which may take place at the onset of this event. However, as the flood flows increase and approach those of the regional storm flood the hydraulics become more complex and dynamic. There is a greater potential for the spill and split in flow to occur downstream of Church Street which limits the potential use of the multiple opening analysis flow split approach.

An inspection of the spill area was completed to visually ground truth the data used in the hydraulic model.

Model Setup Review

The points below summarize the key items reviewed in the hydraulic model.

- Plan form geometry was acceptable and consistent with the geometry used to model the regional storm event, see Figure 2.

- Most cross sections upstream of the flow split location and through the Brampton FDC including data points, left and right bank station, manning roughness values, and ineffective flow areas are considered acceptable and found to be similar to those used for the regional storm analyses.

- Cross section data used for the bypass channel differed slightly to those used in the regional storm analyses. This included channel inverts and low flow channel details. Generally a simpler and consistent representation of the channel geometry was used. This was discussed with Mr. Frew. He had developed a typical cross sectional shape and applied it to all cross sections for the bypass channel. The cross sections were not based on a survey of the channel. In comparison the hydraulic model for the regional strum event, prepared by GAL, used automated cut cross sections from digital mapping of the area.

- Compared to the hydraulic model for the regional storm event, additional cross sections were placed between bridge structures along the bypass channel. Particular attention was placed on reviewing the two cross sections added between Church Street and Scott Street, see Figure 4.

- A 350 year return period peak flow of 100.8 m^3/s was used upstream of the flow split. Based on the results of the multiple opening analyses, 97.6 m^3/s was applied to the bypass channel and 3.2 m^3/s was used for the FDC reach. A flow rate of 95.8 m^3/s was used at the downstream confluence. The upstream and downstream flow rates were provided to ABL by TRCA. The TRCA flow rates were based on an interpolation of flow estimates for the regional storm and other return period storm events. They were intended to represent interim future land use conditions.

- The ABL model added a second flow node downstream of the Church Street bridge. This flow node reduces the flow rate in the bypass channel caused by the upstream split in flow. The use of a flow node at this location provides a better representation of the further upstream split in flow by flow events less than the regional storm event.

Model Output Review

Generally, review of the model output tables and graphics showed no significant irregularities with the results. There were minor fluctuations in the water surface profile through the bypass channel reach. For example, in most cases the cross sections between the bridges, excluding sections immediately upstream of a bridge, had a lower computed surface water elevation. This is likely due to the added cross sections. While this is not unusual and in most cases not significant, it may have an influence on the calculated quantity of spill upstream of Church Street.

The estimated spill of 3.2 m^3/s over Church Street was based on a flood elevation of 213.38m or 0.38 m above the minimum assumed road elevation of 213.0 m, see Figure 3.

Comparison with GAL Model Used for Defining the Regional Storm Flood Plain

To further evaluate the findings of the ABL model, a subset of the GAL hydraulic model was prepared for the study area. The same upstream and downstream flow nodes were used to determine the flow split for the 350 year flow event. Initially a greater quantity of spill was identified by the GAL model. The greater quantity of spill was caused by a single cross section downstream of the Church Street bridge (section 26.71). This cross section was found to be inconsistent and not representative of the other sections for the bypass channel. Once corrected the revised GAL model resulted in no spill to the Brampton FDC for the 350 year event, see Figure 3. This is due to a greater calculated flow capacity by the bypass channel and subsequent lower backwater effect.

Summary and Conclusions

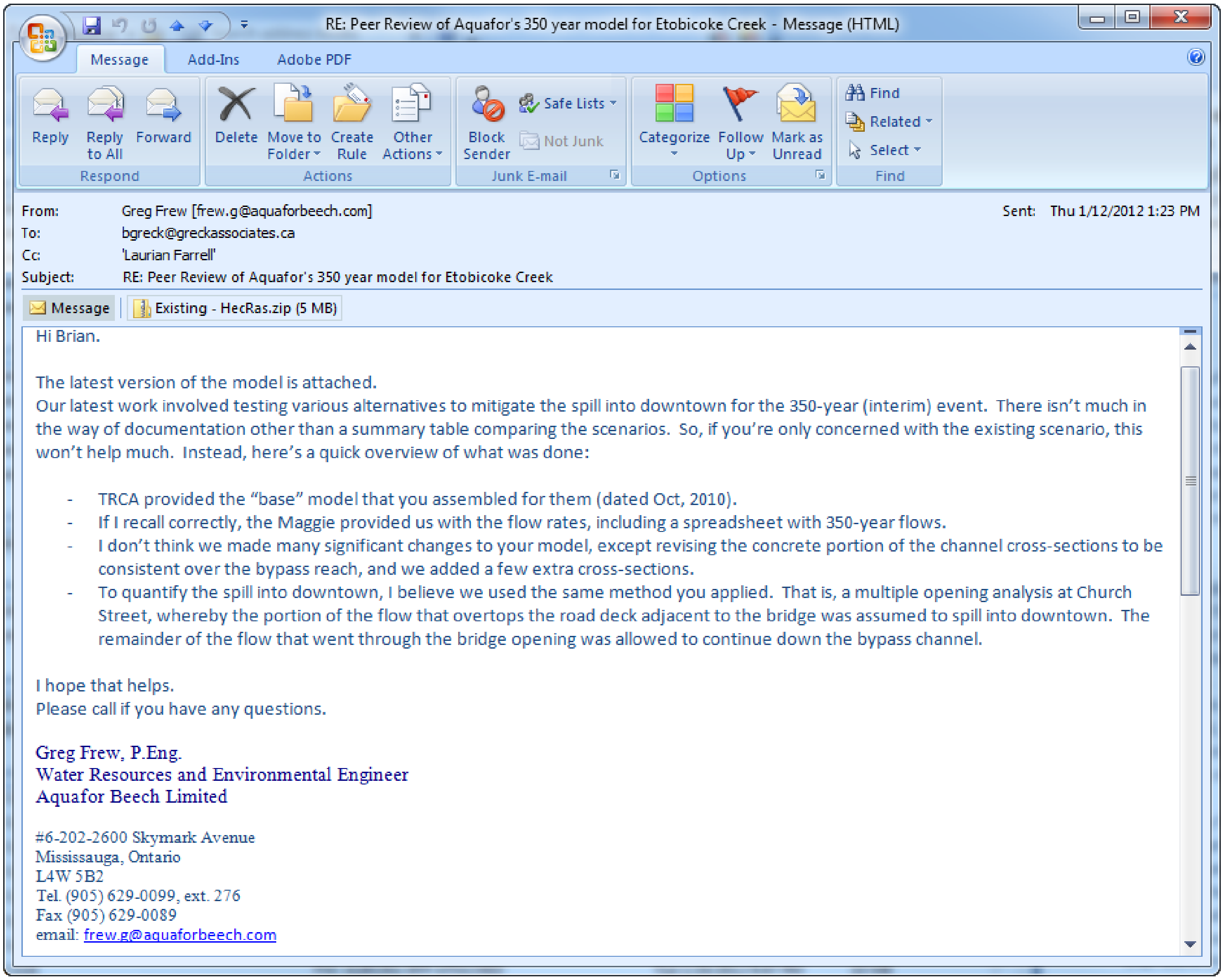
The ABL model presents an accurate representation of the spill for the 350 year flood based on the flow estimate provided by TRCA. The calculate spill to the FDC is sensitive to the hydraulic capacity of the bypass channel. Further assessment of the spill potential should be based on update of the hydraulic model using a topographic survey of the bypass channel, Church Street (including the location of spill at the intersection of Ken Whillans Drive) and adjacent lands. Sensitivity analyses should also be completed for a range of flow rates to further assess the potential for a spill to occur for the 350 year storm event.

If you have any questions or wish to discuss this review further please call me at
(905) 840 -7489, ext. 21.

Yours sincerely,

GRECK AND ASSOCIATES LIMITED

Brian Greck, P. Eng.
President



RE: Peer Review of Aquafor's 350 year model for Etobicoke Creek - Message (HTML)

From: Greg Frew [frew.g@aquaforbeech.com] Sent: Thu 1/12/2012 1:23 PM
To: bgreck@greckassociates.ca
Cc: 'Laurian Farrell'
Subject: RE: Peer Review of Aquafor's 350 year model for Etobicoke Creek

Message | Existing - HecRas.zip (5 MB)

Hi Brian.

The latest version of the model is attached.
Our latest work involved testing various alternatives to mitigate the spill into downtown for the 350-year (interim) event. There isn't much in the way of documentation other than a summary table comparing the scenarios. So, if you're only concerned with the existing scenario, this won't help much. Instead, here's a quick overview of what was done:

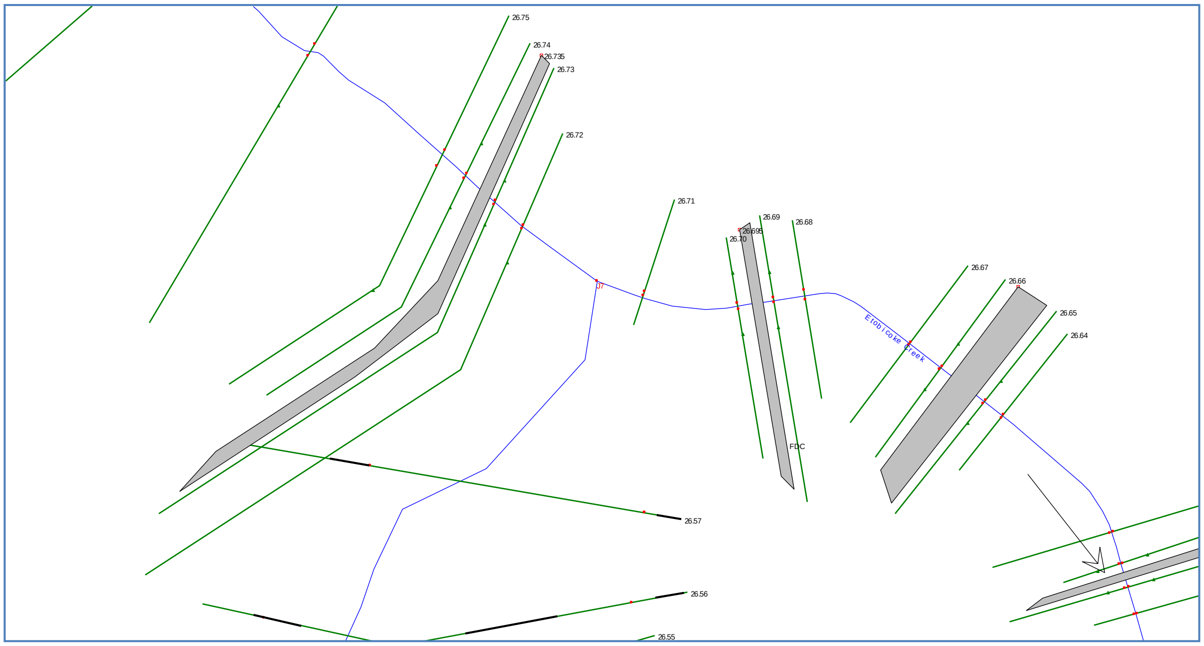
- TRCA provided the "base" model that you assembled for them (dated Oct, 2010).
- If I recall correctly, the Maggie provided us with the flow rates, including a spreadsheet with 350-year flows.
- I don't think we made many significant changes to your model, except revising the concrete portion of the channel cross-sections to be consistent over the bypass reach, and we added a few extra cross-sections.
- To quantify the spill into downtown, I believe we used the same method you applied. That is, a multiple opening analysis at Church Street, whereby the portion of the flow that overtops the road deck adjacent to the bridge was assumed to spill into downtown. The remainder of the flow that went through the bridge opening was allowed to continue down the bypass channel.

I hope that helps.
Please call if you have any questions.

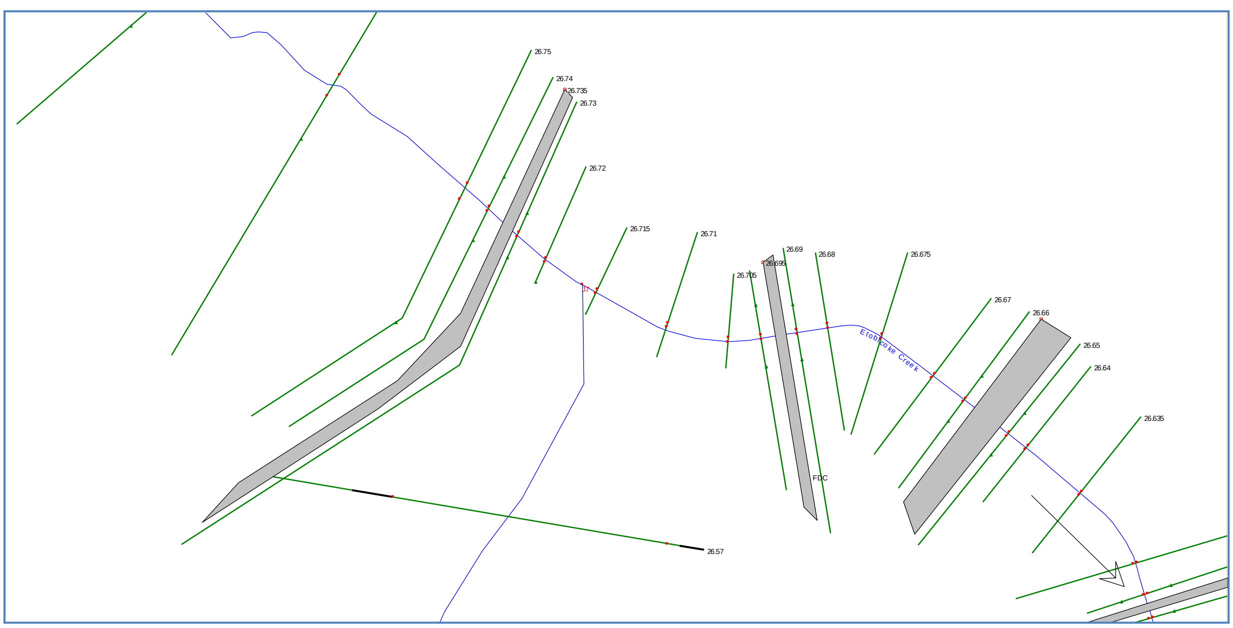
Greg Frew, P.Eng.
Water Resources and Environmental Engineer
Aquafor Beech Limited

#6-202-2600 Skymark Avenue
Mississauga, Ontario
L4W 5B2
Tel. (905) 629-0099, ext. 276
Fax (905) 629-0089
email: frew.g@aquaforbeech.com

Figure 2

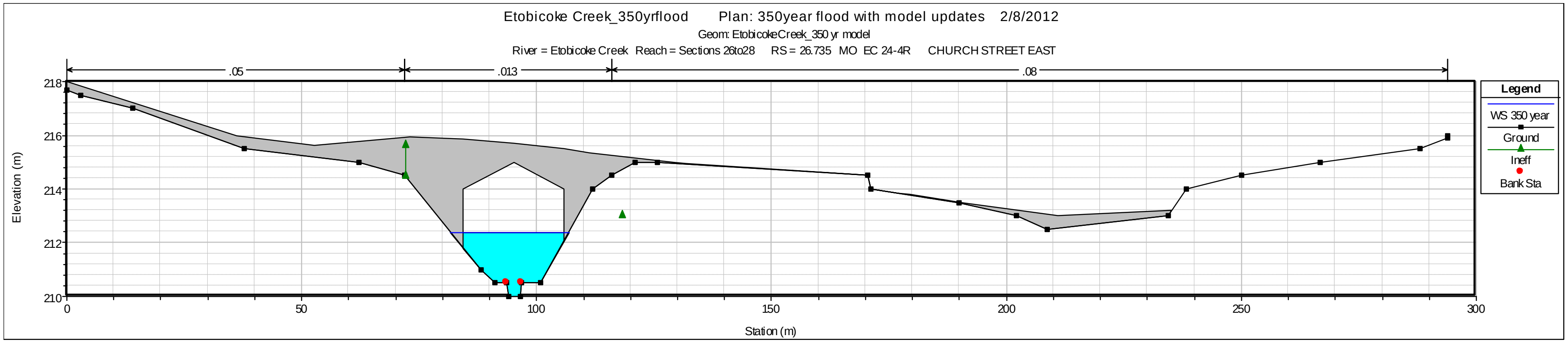


Greck and Asociates Liited Model for the Regional Storm (Interim Flow Conditions)

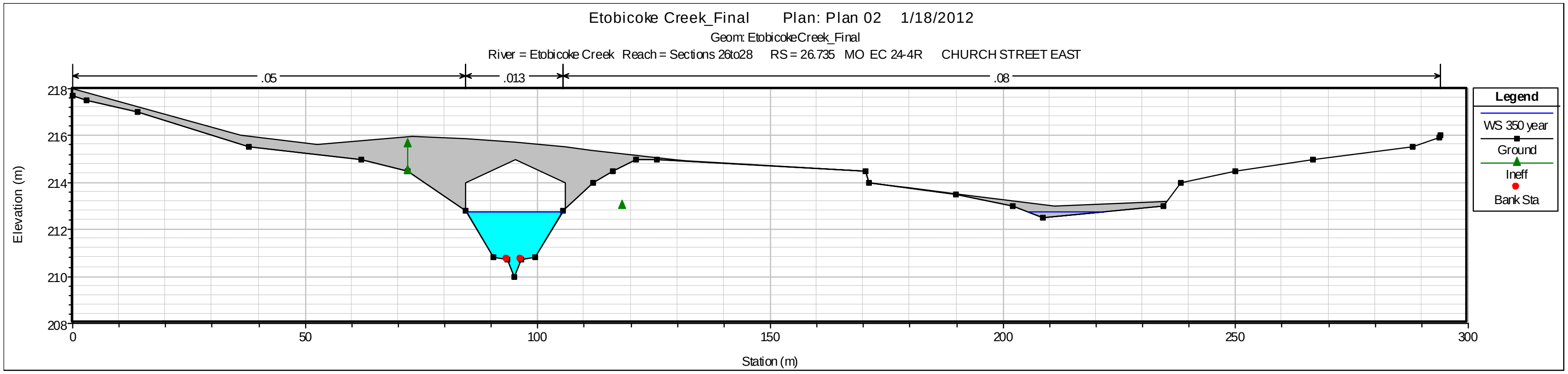


Aquafor Beech Limited Model for the 350 Year Storm (Interim Flow Conditions)

Figure 3

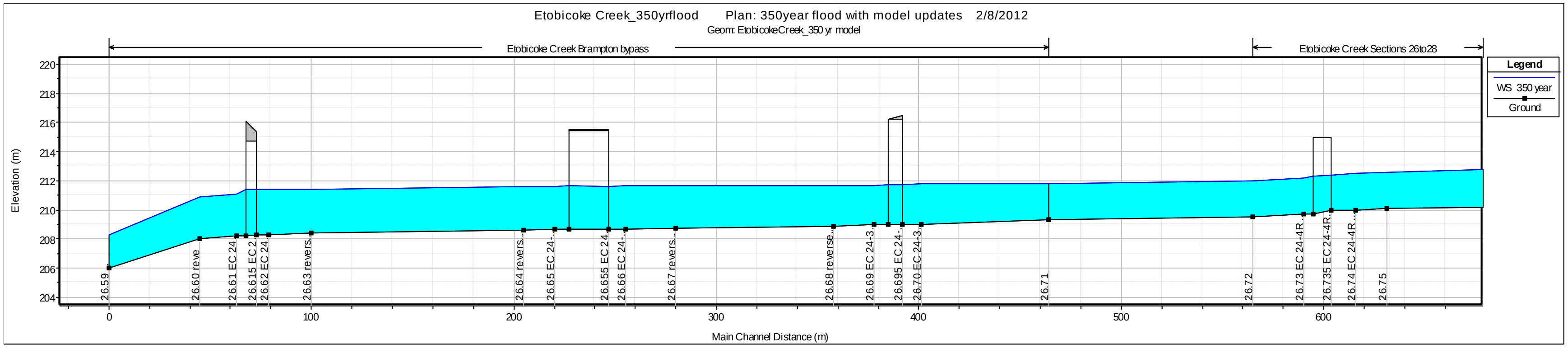


Church Street Bridge Crossing, Greck and Asociates Liited Model for the 350 year Storm

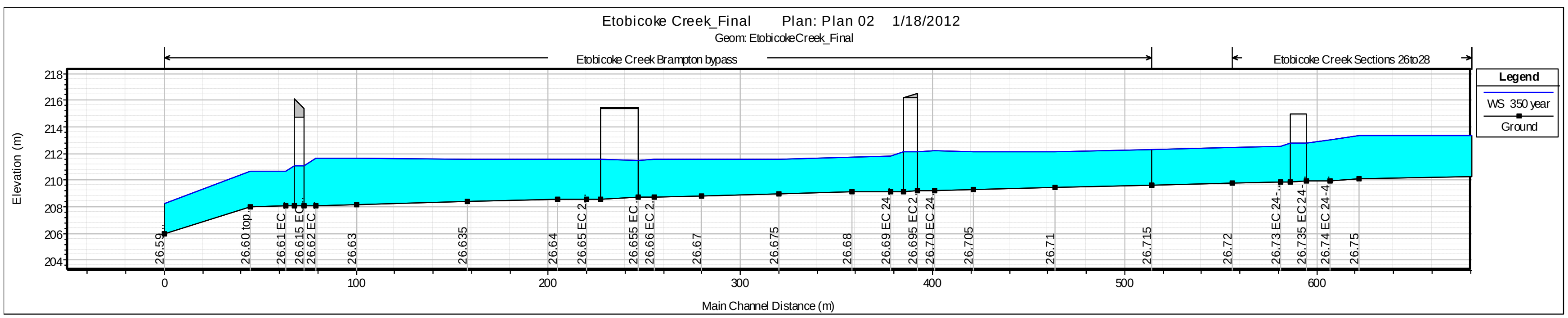


Church Street Bridge Crossing, Aquafor Beech Limited Model for the 350 year Storm

Figure 4



Bypass Channel, Greck and Asociates Liited Model for the 350 year Storm



Bypass Channel, Aquafor Beech Limited Model for the 350 year Storm

Hydraulic Model Update

Memo

To: **Laurian Farrell / Laura Richards** File no: TP112151-26

From: **Vahid Taleban / Aaron Brouwers / Ron Scheckenberger**

Date: November 26, 2013, Revised

Subject: Downtown Brampton Flood Protection Feasibility Study
Etobicoke Creek Hydraulic Model Update

This memorandum has been prepared to document the model updates applied to the Etobicoke Creek hydraulic model. In December 2012, TRCA provided AMEC with the Etobicoke Creek HECRAS model, as part of the Downtown Brampton Flood Protection Feasibility Study, to be used as the tool for assessing various flood mitigation alternatives. A thorough review of the TRCA 2012 HECRAS model has been conducted by AMEC and it has been concluded that elements of the TRCA-2012 model could be improved in order to better reflect the current conditions. The main area of concern has been identified as the representation of the by-pass channel in the model. A comparison of the channel inverts upstream of the bridge structures within the by-pass channel between the model and available design drawings (ref. James E. McLaren Associates, April 1950) has demonstrated significant differences in some cases. For example, while the design drawings indicate that the channel invert upstream of Church Street was proposed to be 209.25 m, the invert is coded as 210.00 m in the TRCA-2012 model (+ 0.75 m). Similarly, upstream of Queen Street the channel invert was proposed to be 209.10 m while the model value is 208.70 m (-0.4 m). Comparison of the Church Street Bridge profile as presented in the provided HECRAS model with the survey results, depicted on Figure 2, also indicates the need to update the bridge profile in the HECRAS model as per the survey results.

The shape of the channel geometry, specifically the low flow portion, presents another area of concern. The AMEC review has indicated that the topographic base used for model development was a 5x5 m^2 resolution DEM which is considered to be too coarse to approximately represent a channel with a bottom width of 2 m (low flow portion). It is also apparent that the available design drawings have not been considered during the current TRCA model development stage.

Geodetic Survey

As a result of the discrepancies identified, AMEC has conducted a detailed geodetic survey (July 2013) of the bypass channel and all of the associated bridge crossings. The channel geometry has subsequently been updated in the TRCA-2012 HECRAS model to better represent existing field conditions. A comparison between one of the cross sections available in the original TRCA-2012 model and the updated cross section based on the survey results has been presented in Figure 1. Cross section 26.69 is located in the by-pass channel upstream of the Scott Street Bridge crossing. As depicted in Figure 1, the low flow channel had not been represented properly in the original model which would have resulted in an over estimation of the flow capacity in the by-pass channel, and hence a lower potential spill flow into the SPA area.

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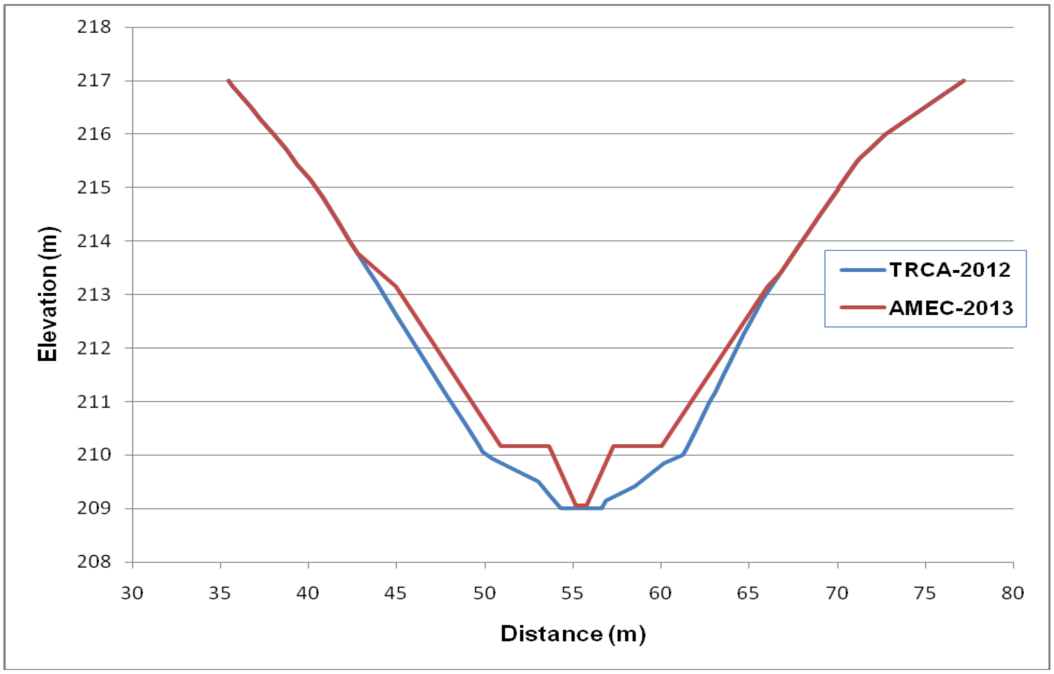

Figure 1- Comparison of Cross section 26.69 between Original HECRAS Model and Updated Model by AMEC

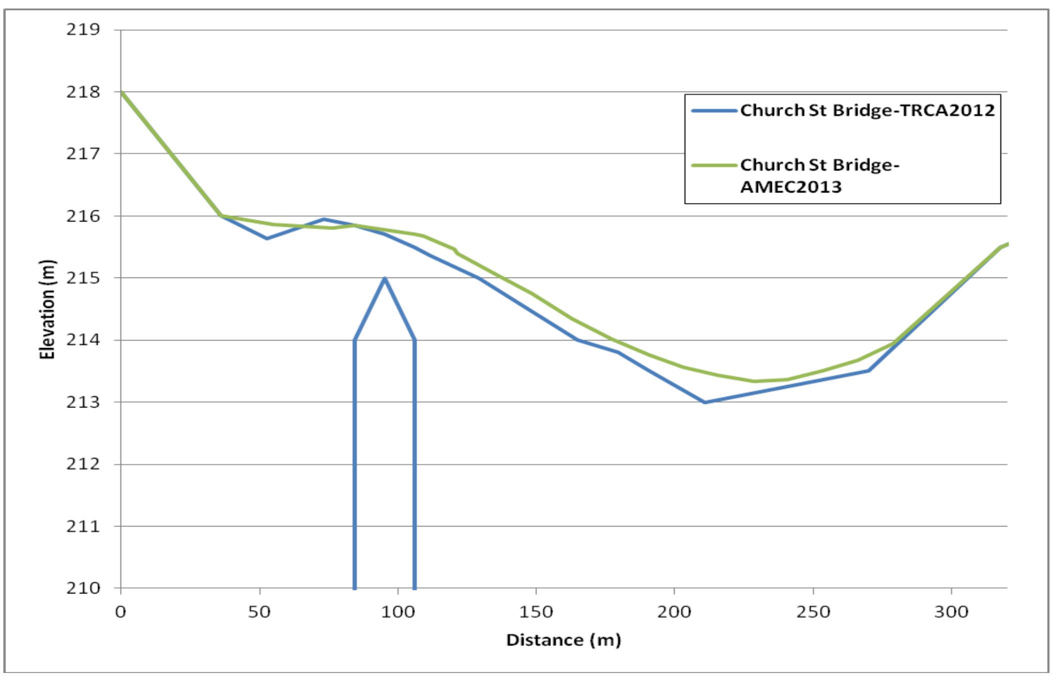

Figure 2- Comparison of Church Street Bridge Profile between Original HECRAS Model and Updated Model by AMEC

Regional Storm

Due to changes to the channel geometry, it has been necessary to update the energy balance approach conducted to determine the proportion of the flow split between the by-pass channel and spill to the SPA area. Table 1 summarizes the results of the updated energy balance and the changes in the flows entering the by-pass channel and the SPA area at the flow split location for the Regional Storm event. The updated model has been executed using the new balanced flows for the Regional Storm event and water surface elevations have been determined accordingly. Table 2 presents the results of the updated AMEC-2013 model and a comparison to the original TRCA-2012 model for water surface elevations during the Regional Storm event.

Table 1- Regional Storm Event Energy Balance Results

	TRCA-2012	AMEC-2013	Difference (%)
Total Regional Storm Flow (m^3/s)	306	306	-
Flow Entering by-pass Channel (m^3/s)	171.3	143.3	-16 %
Flow spilling to SPA Area (m^3/s)	134.7	162.7	+21 %

Table 2- Comparison of the Water Surface Elevations between AMEC-2013 and TRCA-2012 Models

Reach	Station	Q Total	Water Surface Elevation (m)		
		(m^3/s)	AMEC-2013	TRCA-2012	Difference (m)
Sections 26to28	26.82	292	218.12	218.12	0
Sections 26to28	26.81	289	217.74	217.74	0
Sections 26to28	26.8	289	217.72	217.72	0
Sections 26to28	26.795	**Vodden Street**			0
Sections 26to28	26.79	289	216.16	216.16	0
Sections 26to28	26.78	289	215.93	216.03	-0.10
Sections 26to28	26.77	289	214.96	214.48	0.48
Sections 26to28	26.76	306	215.01	214.6	0.41
Sections 26to28	26.75	306	214.89	214.41	0.48
Sections 26to28	26.74	306	214.07	214.14	-0.07
Sections 26to28	26.735	**Church Street**			
Sections 26to28	26.73	306	214.11	213.75	0.36
Sections 26to28	26.72	306	213.79~~213.76~~	213.5~~213.5~~	0.29~~0.26~~
Brampton bypass	26.71	171.3 (143.3)[1]	213.13	212.71	0.42
Brampton bypass	26.7	171.3 (143.3)	213.09	212.6	0.49
Brampton bypass	26.695	**Scott Street**			0
Brampton bypass	26.69	171.3 (143.3)	213.04	212.38	0.66
Brampton bypass	26.68	171.3 (143.3)	212.99	212.42	0.57
Brampton bypass	26.67	171.3 (143.3)	212.92	212.42	0.50
Brampton bypass	26.66	171.3 (143.3)	212.89	212.41	0.48
Brampton bypass	26.655	**Queen Street**			0
Brampton bypass	26.65	171.3 (143.3)	212.86	212.41	0.45
Brampton bypass	26.64	171.3 (143.3)	212.85	212.41	0.44
Brampton bypass	26.63	171.3 (143.3)	212.7	212.16	0.54

Table 2- Comparison of the Water Surface Elevations between AMEC-2013 and TRCA-2012 Models					
Reach	Station	Q Total	Water Surface Elevation (m)		
		(m^3/s)	AMEC-2013	TRCA-2012	Difference (m)
Brampton bypass	26.62	171.3 (143.3)	212.67	212.21	0.46
Brampton bypass	26.615	CNR Tracks			0
Brampton bypass	26.61	171.3 (143.3)	212.27	211.78	0.49
Brampton bypass	26.6	171.3 (143.3)	212.11	211.55	0.56
Brampton bypass	26.59	171.3 (143.3)	210.32	210.28	0.04
SPA	26.57	134.7 (162.7)	213.63	213.4	0.23
SPA	26.56	134.7 (162.7)	213.63	213.4	0.23
SPA	26.55	134.7 (162.7)	213.63	213.4	0.23
SPA	26.54	134.7 (162.7)	213.2	213.01	0.19
SPA	26.535	CNR Tracks			0
SPA	26.53	134.7 (162.7)[2]	213.12	212.9	0.22
SPA	26.52	134.7 (162.7)	213.28	213.07	0.21
SPA	26.51	134.7 (162.7)	213.29	213.07	0.22
SPA	26.5	134.7 (162.7)	213.28	213.06	0.22
SPA	26.49	134.7 (162.7)	213.29	213.07	0.22
SPA	26.48	134.7 (162.7)	213.29	213.07	0.22
SPA	26.47	134.7 (162.7)	213.19	212.98	0.21
SPA	26.46	134.7 (162.7)	212.62	212.46	0.16
SPA	26.45	134.7 (162.7)	212.19	212.04	0.15
SPA	26.44	134.7 (162.7)	212.06	211.93	0.13
SPA	26.43	134.7 (162.7)	212.06	211.92	0.14
SPA	26.42	134.7 (162.7)	212	211.84	0.16
SPA	26.41	134.7 (162.7)	211.96	211.81	0.15
SPA	26.4	134.7 (162.7)	211.86	211.71	0.15
SPA	26.39	134.7 (162.7)	211.39	211.23	0.16
SPA	26.38	134.7 (162.7)	210.51	210.43	0.08
SPA	26.37	134.7 (162.7)	210.3	210.28	0.02
SPA	26.36	134.7 (162.7)	210.26	210.26	0
SPA	26.35	134.7 (162.7)	210.22	210.23	-0.01

[1] 143.3 m^3/s is the proportion of the flow in the by-pass channel during the Regional Storm for the AMEC-2013 model
[2] 162.7 m^3/s is the proportion of the flow in the SPA area during the Regional Storm of the AMEC-2013 model

As presented in both Tables 1 and 2, the updates to the channel geometry have resulted in a lower flow capacity for the by-pass channel during the Regional Storm event. Previously, 171.3 m^3/s had been determined to flow in the by-pass channel during the Regional Storm event and the balance (134.7 m^3/s) would have spilled to the SPA area; however the updated energy balance approach indicates that a larger flow (162.7 m^3/s) would spill into the SPA area, and a lower proportion (143.3 m^3/s) would be conveyed by the by-pass channel. Water surface elevations have also increased as much as 0.66 m within the by-pass channel, and 0.48 m in the reach upstream of Church Street. It is noted however, that there has been no overtopping predicted in the by-pass channel downstream of the original spill location due to the channel geometry refinements.

~~***350 Year Event***~~

The by-pass channel's capacity to convey the 350 year event has also been impacted by the geometry updates. Based on the original TRCA-2012 model, the 350 year storm event was shown to be fully conveyed through the by-pass channel with no spill to the SPA area: The updated model indicates that the by-pass channel would no longer be able to fully convey the 350 year storm. The same energy balance approach has been conducted to determine the portion of the flow spilling to the SPA area during the 350 year storm event; however this approach has not provided reasonable/stable results (i.e. the energy balance has resulted in an unreasonably high spill flow to the SPA). It has been hypothesized that this is due to the fact that the actual spill location for the 350 year event is located immediately upstream of the bridge on Church Street, while the model considers the spill location to be downstream of the bridge (which is accurate for the Regional Storm). Conducting the energy balance approach without modifying the model setup would then result in overestimation of the flows entering the SPA area during the 350 year storm event.

Therefore as an alternative, the spill flow for the 350 year event has been determined as the flow that overtops Church Street, west of the by-pass channel, as calculated by HEC-RAS when the full 350 year flow is routed to the Church Street bridge. Using this approach, the resulting spill flow to the SPA is 4 m^3/s +/-.

Next Steps

Based on the findings presented herein with respect to the updated existing conditions hydraulic modelling, it is recommended that the modelling for the flood mitigation alternatives be updated accordingly; AMEC will advance this task following TRCA's review and approval of the current updated model.

Further, it is noted that this assessment demonstrates the potential need to update Regulatory floodplain mapping for the Etobicoke Creek upstream of the bypass channel and through the SPA. AMEC could provide a scope of work for this additional work should it be required by TRCA.

VT/AB/ll

Natural Heritage Information

MAIN – QUEEN EAST

Region of Peel	NAI Area # 1278	Toronto and Region Conservation Authority
City of Brampton	Size: 9 hectares	Watershed: Etobicoke Creek
Con 1 E, Lots 4, 5	Ownership: 5% private, 95% public (TRCA)	Subwatershed: Upper Etobicoke Creek

General Summary

This urban natural area is small and linear in shape. It is comprised predominantly of deciduous forest with cultural woodland and shallow marsh. While the area is highly disturbed by invasive species, the structural complexity of these communities is maintained, albeit they are predominantly comprised of non-native species. In spite of the disturbance, this area still provides a large area of natural habitat compared with many other locations along Etobicoke Creek and thus, is important for maintaining the health and biodiversity of the Etobicoke Creek corridor and providing wildlife habitat particularly for breeding birds.

TRCA ELC surveyors, botanists and ornithologists have provided complete data coverage for the core NAI inventories (vegetation communities, plant species, breeding birds) plus incidental observations of other fauna over the delineated area (Table 1). However, the available data has been pooled with other similar natural areas nearby (including KENNEDY – STEELES, NAI #1221/1224/2423/2426/2428/2439 and MAIN – BOVAIRD, NAI #1353/1358/1370/1375/1378/2459/2629), and some species listed may be absent at this site, although present nearby. Also, a full plant species list for this area is not currently available, although TRCA-tracked species and plants that dominate the vegetation communities are recorded here.

Table 1: TRCA Field Visits

Visit Date	Inventory Type
01 Aug. 2001	ELC, Flora
unknown	Fauna

Physical Features

This area is in the Peel Plain physiographic region; characterized by flat to undulating topography. Soils of this region tend to be low- permeability clays, deposited when glacial meltwater ponded up over a layer of low permeability deposits.

Etobicoke Creek passes through this natural area and has eroded a shallow valley in the surrounding plain. Between 1834 and 1948 the Etobicoke Creek was known to have flooded its banks through downtown Brampton numerous times which led to an ambitious civil engineering project in 1950 to straighten and reroute the creek (Peel Regional Police, 2010; City of Brampton, Undated). Through this natural site the creek is in a more naturalized bed but just upstream Etobicoke Creek is in an engineered bed from Queen Street to Church Street.

Human History

The Brampton area was settled in the 1820's. In 1834, John Elliott laid out a village plan on the northwest corner of his farm (what is now the southeast corner of Main Street/Hurontario Street and Queen Street; City of Brampton, undated; Bull, 1938). Elliott hailed from Brampton, England (City of Brampton, undated) and renamed the original community known as Buffy's Corners, after William Buffy who ran an early store (tavern) at these crossroads (Groundspeak Inc., 2010).

Early surveyors described the Brampton area as low swampy ground (City of Brampton, undated) and it was also known as “the frog-pond hamlet”. John Elliott’s pasture fields were described before their conversion to farmland as “low-lying beaver meadow, overgrown with bulrushes and loud with batrachian symphonies” (Bull, 1938). This is likely due to the flat topography and poorly-draining soils.

William Perkins Bull in his 1938 book, “From Amphibians to Reptiles” writes of the “frying-pan picnics of Bramptonian youths in these decades (1880’s, 1890’s)…Amid the cat’s-tails and other weeds along Etobicoke flats, young anglers…would fish sometimes with spears provided by the local blacksmith, scoop with their nets, or let down home-made hooks baited with worms or even with bits of old red flannel.” The author goes on to explain that these frogs were likely Green Frogs (*Rana clamitans*) as Bullfrogs (*Rana catesbeiana*) were no longer common in the area by this time.

This natural area lies within the City’s Centennial Park. In addition to the natural area, the park offers a playground, tennis courts, three soccer pitches and a parking lot. The natural area is used for passive recreation, with a network of walking paths. This area is bordered by a railway line at the north end and by Clarence St. at the south end. Surrounding land use is manicured recreational and single-family residential. The residential neighbourhood is older and many yards are treed, providing some urban forest cover for wildlife.

Vegetation Communities

The general community types present here are deciduous forest (52%), shallow marsh (14%), cultural meadow (7%), cultural thicket (3%) and cultural woodland (24%).

Nine plant communities were mapped for this area, comprised of six different vegetation types, none of which are provincially rare (Table 2). One community, the Cattail Mineral Shallow Marsh (MAS2-1), is considered to be a TRCA regional Community of Urban Conservation Concern.

Table 2: ELC Vegetation Communities

Map reference *	**Vegetation type**	**Size in hectares**	**% of natural area**
FOD4-b	Dry-Fresh Manitoba Maple Deciduous Forest (3 communities)	4.19	48.78
FOD4-d	Dry-Fresh Norway Maple Deciduous Forest	0.27	3.18
MAS2-1	Cattail Mineral Shallow Marsh	1.19	13.82
CUM1-1	Dry-Moist Old Field Meadow (2 communities)	0.60	7.01
CUT1-c	Exotic Cultural Thicket	0.24	2.82
CUW1-b	Exotic Cultural Woodland	2.10	24.45
	TOTAL AREA INVENTORIED	**8.59**	

* Note: The map reference code refers to the vegetation type shown on mapping for this area and also to the Appendix list of species typically encountered in this vegetation type.

Species Presence

Vascular Plants

At least 28 vascular plant species are recorded in this natural area, all of which are native. Four of these species are regionally rare (Table 4). Nine of the vascular plant species present here are TRCA regional Species of Conservation Concern and an additional 19 species are TRCA regional Species of Urban Conservation Concern (Table 4).

Breeding Birds

A total of 38 breeding bird species are present in this natural area, of which 34 (89%) are native. One of these, Eastern Meadowlark (*Sturnella magna*), is Threatened nationally (Table 3). One of these species is a TRCA regional Species of Conservation Concern and an additional 14 species are TRCA regional Species of Urban Conservation Concern (Table 4).

Five species of grassland birds, Eastern Kingbird (*Tyrannus tyrannus*), Eastern Meadowlark, Field Sparrow (*Spizella pu*silla), Savannah Sparrow (*Passerculus sandwichensis*) and Willow Flycatcher (*Empidonax traillii*), are supported by the open successional communities present in this area. Two of these grassland bird species (Eastern Meadowlark, Savannah Sparrow) are area-sensitive. One waterfowl species, the Mallard (*Anas platyrhynchos*), also occurs here and a single colonial-nesting bird species, Bank Swallow (*Riparia riparia*), is also present.

Herpetofauna
An incidental record of one frog species, the Green Frog, was the only herpetofaunal species detected at this site. Green Frogs are native and are considered to be TRCA regional Species of Urban Conservation Concern (Table 4).

Mammals
A total of five mammal species were observed incidentally at this site. All are native and common. Three of the mammal species present are TRCA regional Species of Urban Conservation Concern (Table 4).

Table 3: Designated Species At Risk

Scientific name	**Common name**	**COSEWIC**	**COSSARO**	**S rank**	**G rank**
BIRDS					
Sturnella magna	Eastern Meadowlark	THR		S5B	G5

Table 4: Regionally Rare Species (shown in bold), TRCA Regional Species of Conservation Concern (L1-L3), and TRCA Regional Species of Urban Conservation Concern (L4) (Kaiser, 2001; Toronto and Region Conservation Authority, 2007)

Scientific name	**Common name**	**S rank**	**G rank**	**L-rank**
VASCULAR PLANTS				
Amelanchier laevis	Allegheny Serviceberry	S5	G4G5Q	L4
Betula papyrifera	Paper Birch	S5	G5	L4
Carex albursina	White Bear Sedge	S5	G5	L3
Carex arctata	Black Sedge	S5	G5?	L4
Carex crinita	Fringed Sedge	S5	G5	L3
Carex intumescens	Bladder Sedge	S5	G5	L4
Carex lacustris	Lake-bank Sedge	S5	G5	L4
Carex retrorsa	Retrorse Sedge	S5	G5	L4
Carex sprengelii	**Longbeak Sedge**	**S5**	**G5?**	**L4**
Caulophyllum giganteum	**Giant Blue Cohosh**	**S4?**	**G4G5Q**	**L4**
Dryopteris cristata	Crested Shield-fern	S5	G5	L3
Dryopteris marginalis	Marginal Woodfern	S5	G5	L4
Fagus grandifolia	American Beech	S4	G5	L4
Lilium michiganense	Michigan Lily	S5	G5	L3
Monotropa hypopithys	**American Pinesap**	**S4**	**G5**	**L3**
Oryzopsis asperifolia	White-grained Mountain-ricegrass	S5	G5	L3
Pinus resinosa	**Red Pine**	**S5**	**G5**	**L2**
Polygonatum pubescens	Downy Solomon's-seal	S5	G5	L4
Polystichum acrostichoides	Christmas Fern	S5	G5	L3
Populus grandidentata	Large-tooth Aspen	S5	G5	L4
Quercus macrocarpa	Bur Oak	S5	G5	L4
Sagittaria latifolia	Broadleaf Arrowhead	S5	G5	L4

Schoenoplectus tabernaemontani	Soft-stem Bulrush	S5	G5	L4
Sparganium eurycarpum	Large Bur-reed	S5	G5	L3
Thuja occidentalis	Eastern White Cedar	S5	G5	L4
Trillium erectum	Red Trillium	S5	G5	L4
Tsuga canadensis	Eastern Hemlock	S5	G4G5	L4
Typha latifolia	Broad-leaf Cattail	S5	G5	L4
BIRDS				
Riparia riparia	Bank Swallow	L4	S4B	G5
Ceryle alcyon	Belted Kingfisher	L4	S4B	G5
Geothlypis trichas	Common Yellowthroat	L4	S5B	G5
Tyrannus tyrannus	Eastern Kingbird	L4	S5B	G5
Sturnella magna	Eastern Meadowlark	L4	S5B	G5
Contopus virens	Eastern Wood Peewee	L4	S4B	G5
Spizella pusilla	Field Sparrow	L4	S4B	G5
Dumetella carolinensis	Gray Catbird	L4	S5B	G5
Passerina cyanea	Indigo Bunting	L4	S4B	G5
Colaptes auratus	Northern Flicker	L4	S4B	G5
Vireo olivaceus	Red-eyed Vireo	L4	S5B	G5
Passerculus sandwichensis	Savannah Sparrow	L4	S4B	G5
Sitta carolinensis	White-breasted Nuthatch	L4	S5	G5
Empidonax traillii	Willow Flycatcher	L4	S5B	G5
Hylocichla mustelina	Wood Thrush	L3	S4B	G5
HERPETOFAUNA				
Rana clamitans	Green Frog	L4	S5	G5
MAMMALS				
Tamias striatus	Eastern Chipmunk	L4	S5	G5
Sylvilagus floridanus	Eastern Cottontail	L4	S5	G5
Microtus pennsylvanicus	Meadow Vole	L4	S5	G5

Site Condition and Disturbances
This area of Brampton has been occupied by settlers since the 1820's and is just half a kilometre from the crossroads of Main Street and Queen Street where the original village plan was laid out. As such, this general area has been steadily occupied and developed for almost 200 years. Etobicoke Creek, which flows through this natural area, was once lined by cattail marshes and plentiful with frogs. Today, Centennial Park is a city park that provides a natural environment within the city core.

This natural area shows substantial disturbance from causes commonly found in urban areas – exotic species, trash/dumping and fill/earth displacement.

Due to its location, it is not surprising that a large proportion of this natural area is dominated by exotic and invasive species. While exotic disturbance ranges from light to severe, severe is the norm. All five treed communities at this site are dominated by exotic and invasive species. Norway Maple (*Acer platanoides*) is abundantly used as a street and landscaping tree. It reproduces heavily and at this site and has come to dominate a forest community. Manitoba Maple (*Acer negundo*) loves damp soils and does very well in riparian areas. It has spread throughout the valley lowland of this area, flanking the creek.

Being a city park, there are trails in most of the communities, generally causing a moderate disturbance.

MAIN – QUEEN EAST

The communities associated with some of the residences show moderate to severe disturbance from both fill and trash dumping. Natural communities adjacent to other residential areas show only light disturbance from fill and trash. Residential dumping of yard waste can serve to introduce and/or create a point of entry of exotic species into the natural area.

Ecological Features and Functions

With forest communities greater than 2 ha and wetlands over 0.5 ha in size, this natural area has the potential to support and sustain biodiversity, healthy ecosystem functions and to provide long-term resilience for the natural system. The riparian area provides a transitional zone between terrestrial and aquatic habitats, helping to maintain the water quality of the river and providing a movement corridor for plants and wildlife.

As Etobicoke Creek runs through Brampton, a good portion of the valley lands are manicured and developed for recreation or are engineered leaving only a narrow strip of natural vegetation and virtually no wildlife habitat. This site provides a larger area of natural forest and wetland and is key in providing wildlife habitat along Etobicoke Creek. Downstream of this site, across Clarence St. a narrow band of natural vegetation continues along the valley. Upstream of this site the creek bed is encased in concrete from Queen Street to Church Street and not more than a single line of shrubs provides shelter for wildlife alongside the channel. Although this part of the creek does not offer wildlife habitat it does allow for wildlife movement to other natural areas upstream that are one to two kilometers away. At the north end of this natural area the rail line also offers a narrow corridor for wildlife movement, although the rail line itself does not provide wildlife habitat.

Probably the best connectivity between this natural area and others is the urban forest environment of this older neighbourhood. Residential yards have many trees, gardens and landscaping, and combined, they create a large, diffuse area of connectivity between blocks of natural habitat.

Etobicoke Creek runs through this area and thus this natural area supports the connectivity function of Etobicoke Creek and its tributaries that provide a natural habitat corridor that facilitates the cross-regional movement of wildlife between major provincial corridors.

This natural area supports one bird Species At Risk and four regionally rare plant species.

Five area-sensitive grassland bird species breed in this area, two of which are area-sensitive. One waterfowl species and one colonial-nesting bird species are also present.

Based on the above features, this area should be evaluated to determine if significant wildlife habitat is present in accordance with the Provincial Policy Statement, Region of Peel Official Plan, and Brampton Official Plan.

Opportunities

Enhancing the connectivity of this natural area with other areas by improving the quality of movement corridors would benefit the health of the Etobicoke Creek corridor. This natural area serves as a source of biodiversity for other smaller urban natural areas. Connectivity opportunities exist along the valley and rail line but the corridor quality and associated wildlife habitat is poor or non-existent. Whenever possible connecting corridors should be widened by restoration plantings or naturalization of vegetation by minimizing mowing of parklands. Plantings along sparsely vegetated corridors will provide food and shelter for moving wildlife and may provide nesting opportunities for some species if sufficient vegetation structure and complexity is present. The engineered channel upstream of this natural area should be vegetated with restoration plantings and its width increased where possible. Restoration of the channel is key in providing a viable continuous linkage among natural areas along the Etobicoke Creek valley.

Any opportunity to restore the morphology of the watercourse (meandering channel, creek banks, riparian vegetation and wetlands) would also improve the ability of the corridor to provide storage and attenuation of floodwaters and mitigate erosive flows during high water storm events.

As a well-used public recreation area, the park site provides opportunities for public education messaging and activities/events to teach about invasive species issues and local environmental stewardship. Invasive species mapping, monitoring and control should be considered. Landowners should be encouraged to plant only native species adjacent to natural areas and awareness of the ecological danger of dumping of yard waste should be raised.

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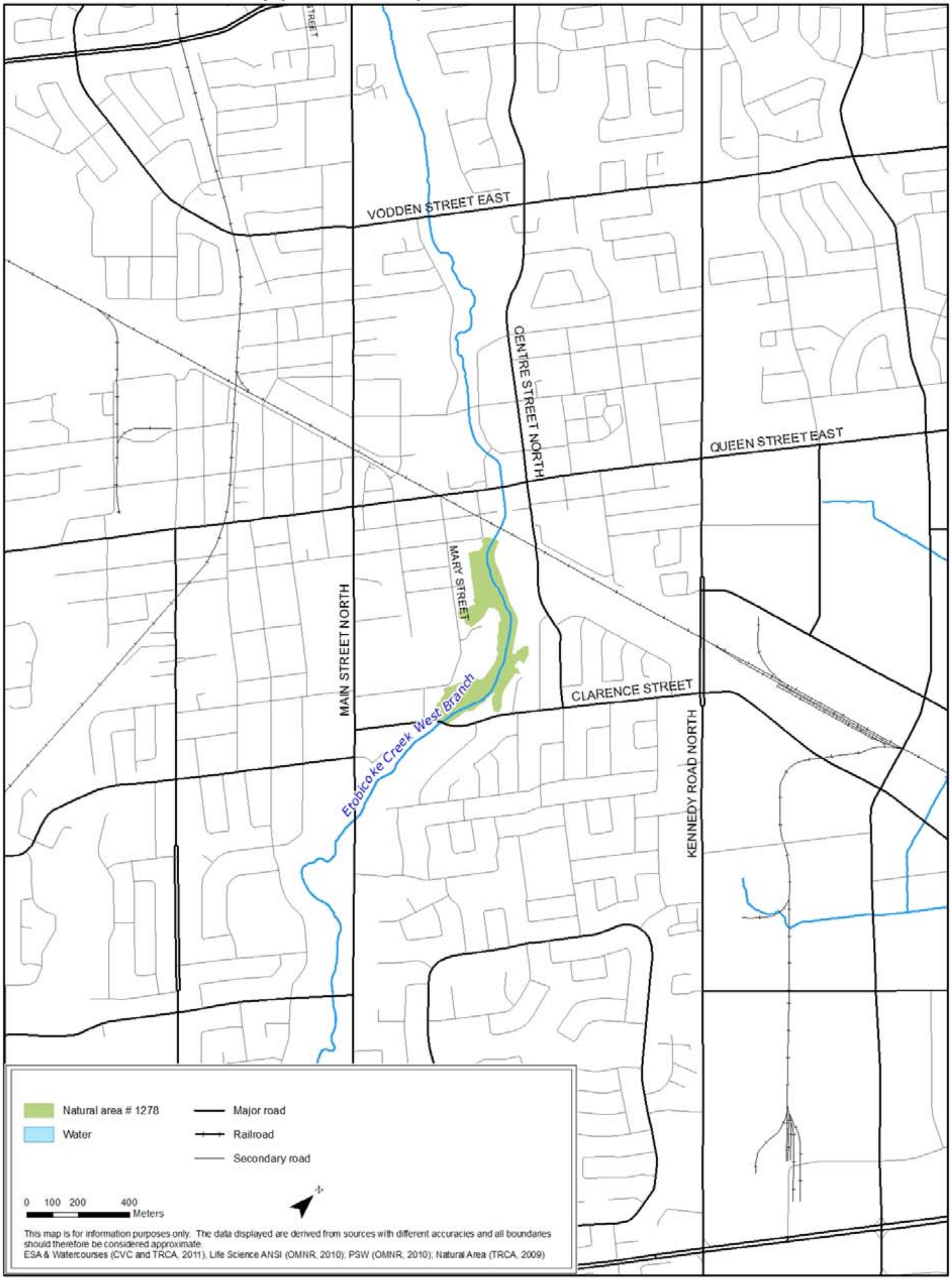
MAIN – QUEEN EAST

Main - Queen East Context Map (NAI Area #1278)



MAIN – QUEEN EAST

Main - Queen East Vegetation Communites Map (NAI Area # 1278)

Summary of Literature Review

Summary of Literature Review – Pedestrian Risk

1. *Flood Risks to People Phase 2 (Department for Environment, Food and Rural Affairs [Defra], Environment Agency, United Kingdom, March 2006)*

The research conducted for this study examined the risk of death or serious harm to people during a flood event and up to one week following the event and developed a predictive methodology for risk to people considering flood mechanics, population, demographics and geographic area vulnerability. The study has tested the risk equations on historical flood events and demonstrated it is both practical in application and effective at estimating the number of people affected by flood events. In application the methodology considers several flood magnitudes to determine an annual average risk. The study also provides guidance on regulating development and flood risk management.

The study developed the following formula to estimate the number of injuries, which becomes the predictor for number of fatalities.

$N_{inj} = N_z$ x Hazard Rating x Area Vulnerability x People Vulnerability

where,

i) N_{inj} = number of injuries within a particular hazard 'zone';
ii) N_z = number of people within the hazard zone (at ground/basement level);
iii) Flood Hazard Rating (HR) = function of flood depth/velocity (within the hazard zone being considered) and debris factor;
iv) Area Vulnerability = function of effectiveness of flood warning, speed of onset of flooding and nature of area (including types of buildings);and,
v) People Vulnerability = function of presence of people who are very old and/or infirm/disabled/long-term sick

Of specific interest is the calculation of the Flood Hazard Rating. The method is similar to the MNR method in that it accounts for depth and velocity, but differs in its consideration of additional risk from debris. The ultimate relationship between an individual's stability and flood depth and velocity is also different in its application of a constant added to velocity.

$HR = d \times (v + 0.5) + DF$

where,

i) HR = (flood) hazard rating;
ii) d = depth of flooding (m);
iii) v = velocity of floodwaters (m/sec); and
iv) DF = debris factor = 0, 0.5, 1 depending on probability that debris will lead to a significantly greater hazard)

The depth-velocity relationship has been developed based on experimental evidence which is graphically depicted by Figure 1.

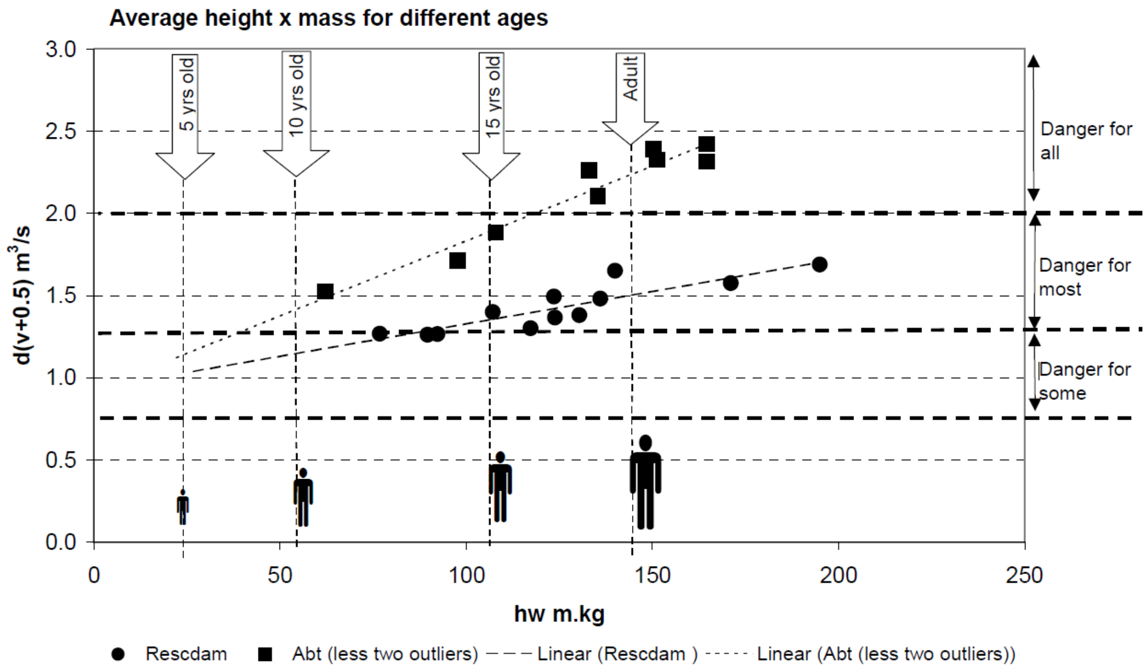


Figure 1 – Flood Risk to People (ref. Defra, Environment Agency, 2006)

The study provides a categorization of the risk to people from flood depth and velocity (ref. Table 2.1)

Table 2.1: Hazard to People as a Function of Velocity and Depth (ref. Defra, Environment Agency, 2006)		
d x (v + 0.5)	**Degree of Flood Hazard**	**Description**
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 - 1.25	Moderate	Dangerous for some (i.e. children) "Danger: Flood zone with deep or fast flowing water"
1.25 - 2.5	Significant	Dangerous for most people "Danger: flood zone with deep fast flowing water"
>2.5	Extreme	Dangerous for all "Extreme danger: flood zone with deep fast flowing water"

Categorization of risk to people could be useful for a range of applications including:

- Planning of safe access and exit for new developments
- Emergency planning advice for people at risk and the emergency services
- Development of household or community flood plans

The study also categorizes a specific geographic areas vulnerability. This method considers the speed of onset of the flood, the nature of the land use and flood warning. The flood warning component is specific to geographic regions in the UK and not applicable for the current study. Nevertheless the method is worth considering. Table 2.3 summarizes the categorization.

Table 2.2: Area Vulnerability (Final Method) (ref. Defra, Environment Agency, 2006)			
Parameter	**1. Low Risk Area**	**2. Medium Risk Area**	**3. High Risk Area**
Speed of onset	Onset of flooding is very gradual (many hours)	Onset of flooding is gradual (an hour or so)	Rapid flooding
Nature of area	Multi-storey apartments	Typical residential area (2 storey homes); commercial and industrial properties	Bungalows, mobile homes, busy roads, parks, single storey, schools, campsites, etc.
Flood Warning	Score for flood warning = 3 – (P1 x (P2 + P3)) where P1 = % of Warning Coverage Target Met P2 = % of Warning Time Target Met P3 = % of Effective Action Target Met		
Area Vulnerability (AV) = sum of scores for 'speed of onset', 'nature of area' and 'flood warning'			

Table 2.3 summarizes the selection of the Debris Factor (DF). It is noted that the majority of areas in the Downtown SPA would be assigned the highest debris factor.

Table 2.3: Guidance on Debris Factors (ref. Defra, Environment Agency, 2006)			
Depths (m)	**Pasture/Arable**	**Woodland**	**Urban**
0 to 0.25	0	0	0
0.25 to 0.75	0	0.5	1
d>0.75 m and/or v>2 m/s	0.5	1	1

The study also recognizes that setting *tolerable* or *acceptable* risk limits would be valuable in making development and flood protection decisions however it does not go so far as to suggest these limits.

Appendix C

Hydrology / Hydraulics

Peak Flow Balance

Alternative			Modelled		Peak Flow (m3/s)						Notes
					350 Year		Regional Storm		Difference (%)		
			HEC-RAS	VO2	Bypass	SPA	Bypass	SPA	Bypass	SPA	
Existing			**Y**		128.9	0	143.3	162.7			
Alternative 'A': Conveyance Improvements	A1	Church Street Flood Berm	Y		128.9	0	143.3	162.7	0.0	0.0	*results reported on the basis of an FPL @ 215.85 at Church. Higher elevations attempted but flow still is not contained
	A2	Rosalea Park Flood Berm	Y		128.9	0	286	20	99.6	-87.7	*results reported on the basis of an FPL @ 215.5 at Rosalea park. Higher elevations attempted but flow still is not contained
	A3	Flood Protection Landform									
		Option i: Church Street	Y		128.9	0	286	20	99.6	-87.7	
		Option ii: Alexander Street	N		NA	NA	NA	NA			
		Option iii: Ellen Street	N		NA	NA	NA	NA			
	A4	Bridge Improvements	Y		128.9	0	143.3	162.7	0.0	0.0	
	A5	Lower By-pass Channel (1.5 m only)	Y		128.9	0	289	17	101.7	-89.6	* The actual spill flow is somewhere between 0 and 17 based on the weir flow
	A6	Widen By-pass Channel	Y		128.9	0	190	116	32.6	-28.7	*Scenario with full Regional flow in bypass channel also tested, minimal reduction in WSELs
	A7	Downstream Channel Improvement	Y		128.9	0	143.3	162.7	0.0	0.0	
	A8	Tailwater Flood Protection Landform	Y		128.9	0	143.3	162.7	0.0	0.0	
	A9	Clarence Street Bridge Improvements	Y		128.9	0	143.3	162.7	0.0	0.0	
Alternative 'B': Flood Control	B1	Online Flood Storage		x							
	B2	Offline Flood Storage	N		NA	NA	NA	NA			
	B3	Stormwater Management	N		NA	NA	NA	NA			
Combinations	C1	A3 + A4 (Church St Only) + A6 (Church St Only)	Y		128.9	0	296	10	106.6	-93.9	*results reported on the basis of an FPL @ 215.5, considered to be highest elevation with management footprint impacts. Higher elevations attempted but flow still is not contained
	C2i	A3 + A5	Y		128.9	0	306	0.1	113.5	-99.9	*max lowering (1.5 m), min FPL (crest 214.6 m)
	C2ii	A3 + A5	Y		128.9	0	306	0.1	113.5	-99.9	*Max FPL (crest 215.2m), min channel lowering (_0.8_m)
	C3	A5 + A6 (@ Bridges Only)	Y		128.9	0	282	24	96.8	-85.2	

2 Year Event

			WSEL (m)													
Reach	**Location**	**Cross Section**	**Existing**	**A1**	**A2**	**A3i**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**C1**	**C2i**	**C2ii**	**C3**
Upstream Church St		26.82	215.95	215.95	215.95	215.95	215.95	215.95	215.95	215.95	215.95	215.95	215.94	215.95	215.95	215.95
Upstream Church St		26.81	214.44	214.44	214.44	214.44	214.44	214.44	214.44	214.44	214.44	214.44	214.45	214.44	214.44	214.44
Upstream Church St		26.8	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48	214.48
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27	214.27
Upstream Church St		26.78	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12	214.12
Upstream Church St		26.77	212.12	212.12	212.12	212.12	212.12	212.12	212.12	212.12	212.12	212.12	212.11	212.12	212.12	212.12
Upstream Church St		26.76	211.78	211.78	211.78	211.78	211.78	211.77	211.77	211.78	211.78	211.78	211.75	211.77	211.77	211.77
Upstream Church St		26.75	211.55	211.55	211.55	211.55	211.55	211.02	211.02	211.55	211.55	211.55	211.47	211.02	211.02	211.02
Upstream Church St		26.74	211.42	211.42	211.42	211.42	211.41	209.92	211.15	211.42	211.42	211.42	211.56	209.92	210.62	209.65
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	211.4	211.4	211.4	211.4	211.39	209.9	211.1	211.4	211.39	211.4	211.56	209.9	210.6	209.6
Upstream Church St		26.72	211.39	211.39	211.39	211.39	211.38	209.89	211.09	211.39	211.38	211.39	211.56	209.89	210.58	209.59
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44
SPA		26.36	206.9	206.9	206.9	206.9	206.9	206.9	206.9	206.88		206.89	206.9	206.9	206.9	206.9
SPA		26.35	206.9	206.9	206.9	206.9	206.9	206.9	206.9	206.88		206.89	206.9	206.9	206.9	206.9
Bypass Channel		26.71	211.34	211.34	211.34	211.34	211.33	209.84	211.06	211.34	211.34	211.34	211.34	209.84	210.54	209.56
Bypass Channel		26.7	211.31	211.31	211.31	211.31	211.29	209.81	211.04	211.31	211.31	211.31	211.31	209.81	210.51	209.54
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	211.28	211.28	211.28	211.28	211.27	209.78	210.98	211.28	211.28	211.28	211.28	209.78	210.46	209.48
Bypass Channel		26.68	211.25	211.25	211.25	211.25	211.24	209.75	210.96	211.25	211.25	211.25	211.25	209.75	210.45	209.46
Bypass Channel		26.67	211.19	211.19	211.19	211.19	211.17	209.69	210.92	211.19	211.19	211.19	211.19	209.69	210.39	209.42
Bypass Channel		26.66	211.16	211.16	211.16	211.16	211.15	209.66	210.9	211.16	211.16	211.16	211.16	209.66	210.36	209.4
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	211.14	211.14	211.14	211.14	211.12	209.64	210.82	211.14	211.14	211.14	211.14	209.64	210.34	209.32
Bypass Channel		26.64	211.12	211.12	211.12	211.12	211.11	209.62	210.81	211.12	211.12	211.12	211.12	209.62	210.32	209.31
Bypass Channel		26.63	211	211	211	211	210.96	209.5	210.7	211	211	211	211	209.5	210.2	209.2
Bypass Channel		26.62	210.97	210.97	210.97	210.97	210.81	209.47	210.68	210.97	210.97	210.97	210.97	209.47	210.17	209.18
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	210.72	210.72	210.72	210.72	210.71	209.22	210.46	210.72	210.72	210.72	210.72	209.22	209.91	208.96
Bypass Channel		26.6	210.58	210.58	210.58	210.58	210.58	209.08	210.32	210.58	210.58	210.58	210.58	209.08	209.78	208.82
Bypass Channel		26.59	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51	207.51
Downstream Bypass		26.34	206.79	206.79	206.79	206.79	206.79	206.79	206.79	206.8	206.79	206.78	206.79	206.79	206.79	206.79
Downstream Bypass		26.33	206.54	206.54	206.54	206.54	206.54	206.54	206.54	206.53	206.54	206.51	206.54	206.54	206.54	206.54
Downstream Bypass		26.32	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.3	206.34	206.34	206.34	206.34
Downstream Bypass		26.31	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.34	206.32	206.32	206.32	206.32
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	206.29	206.29	206.29	206.29	206.29	206.29	206.29	206.29	206.29	206.33	206.29	206.29	206.29	206.29
Downstream Bypass		26.29	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12	206.12
Downstream Bypass		26.28	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92
Downstream Bypass		26.27	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53	205.53
Downstream Bypass		26.26	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13	205.13

			Difference to Existing (m)												
Reach	**Location**	**Cross Section**	**A1**	**A2**	**A3i**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**C1**	**C2i**	**C2ii**	**C3**
Upstream Church St		26.82	0	0	0	0	0	0	0	0	0	-0.01	0	0	0
Upstream Church St		26.81	0	0	0	0	0	0	0	0	0	0.01	0	0	0
Upstream Church St		26.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.78	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.77	0	0	0	0	0	0	0	0	0	-0.01	0	0	0
Upstream Church St		26.76	0	0	0	0	-0.01	-0.01	0	0	0	-0.03	-0.01	-0.01	-0.01
Upstream Church St		26.75	0	0	0	0	-0.53	-0.53	0	0	0	-0.08	-0.53	-0.53	-0.53
Upstream Church St		26.74	0	0	0	-0.01	-1.5	-0.27	0	0	0	0.14	-1.5	-0.8	-1.77
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0	0	0	-0.01	-1.5	-0.3	0	-0.01	0	0.16	-1.5	-0.8	-1.8
Upstream Church St		26.72	0	0	0	-0.01	-1.5	-0.3	0	-0.01	0	0.17	-1.5	-0.81	-1.8
SPA	Church Street	26.57	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	0	0	0	0	0	0	-0.02		-0.01	0	0	0	0
SPA		26.35	0	0	0	0	0	0	-0.02		-0.01	0	0	0	0
Bypass Channel		26.71	0	0	0	-0.01	-1.5	-0.28	0	0	0	0	-1.5	-0.8	-1.78
Bypass Channel		26.7	0	0	0	-0.02	-1.5	-0.27	0	0	0	0	-1.5	-0.8	-1.77
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0	0	0	-0.01	-1.5	-0.3	0	0	0	0	-1.5	-0.82	-1.8
Bypass Channel		26.68	0	0	0	-0.01	-1.5	-0.29	0	0	0	0	-1.5	-0.8	-1.79
Bypass Channel		26.67	0	0	0	-0.02	-1.5	-0.27	0	0	0	0	-1.5	-0.8	-1.77
Bypass Channel		26.66	0	0	0	-0.01	-1.5	-0.26	0	0	0	0	-1.5	-0.8	-1.76
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0	0	0	-0.02	-1.5	-0.32	0	0	0	0	-1.5	-0.8	-1.82
Bypass Channel		26.64	0	0	0	-0.01	-1.5	-0.31	0	0	0	0	-1.5	-0.8	-1.81
Bypass Channel		26.63	0	0	0	-0.04	-1.5	-0.3	0	0	0	0	-1.5	-0.8	-1.8
Bypass Channel		26.62	0	0	0	-0.16	-1.5	-0.29	0	0	0	0	-1.5	-0.8	-1.79
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0	0	0	-0.01	-1.5	-0.26	0	0	0	0	-1.5	-0.81	-1.76
Bypass Channel		26.6	0	0	0	0	-1.5	-0.26	0	0	0	0	-1.5	-0.8	-1.76
Bypass Channel		26.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.34	0	0	0	0	0	0	0.01	0	-0.01	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	-0.01	0	-0.03	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.04	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.04	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

5 Year Event

Reach	Location	Cross Section	WSEL (m) Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23	216.23
Upstream Church St		26.81	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67	214.67
Upstream Church St		26.8	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71	214.71
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42	214.42
Upstream Church St		26.78	214.26	214.26	214.26	214.26	214.26	214.27	214.27	214.26	214.26	214.26	214.27	214.27	214.27	214.27
Upstream Church St		26.77	212.42	212.42	212.42	212.42	212.42	212.41	212.41	212.42	212.42	212.42	212.41	212.41	212.41	212.41
Upstream Church St		26.76	212.1	212.1	212.1	212.1	212.1	212.05	212.05	212.1	212.1	212.1	212.07	212.05	212.05	212.05
Upstream Church St		26.75	211.89	211.89	211.89	211.89	211.89	211.25	211.25	211.89	211.89	211.89	211.82	211.25	211.25	211.25
Upstream Church St		26.74	211.72	211.72	211.72	211.72	211.71	210.22	211.42	211.72	211.72	211.72	211.92	210.22	210.92	209.92
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	211.7	211.7	211.7	211.7	211.69	210.2	211.35	211.7	211.69	211.7	211.92	210.2	210.9	209.85
Upstream Church St		26.72	211.69	211.69	211.69	211.69	211.68	210.19	211.34	211.69	211.68	211.69	211.92	210.19	210.89	209.84
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44
SPA		26.36	207.24	207.24	207.24	207.24	207.24	207.24	207.24	207.17		207.23	207.24	207.24	207.24	207.24
SPA		26.35	207.24	207.24	207.24	207.24	207.24	207.24	207.24	207.17		207.23	207.24	207.24	207.24	207.24
Bypass Channel		26.71	211.64	211.64	211.64	211.64	211.63	210.14	211.32	211.64	211.64	211.64	211.64	210.14	210.84	209.82
Bypass Channel		26.7	211.61	211.61	211.61	211.61	211.59	210.11	211.3	211.61	211.61	211.61	211.61	210.11	210.81	209.8
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	211.58	211.58	211.58	211.58	211.56	210.08	211.22	211.58	211.58	211.58	211.58	210.08	210.76	209.72
Bypass Channel		26.68	211.54	211.54	211.54	211.54	211.53	210.04	211.21	211.54	211.54	211.54	211.54	210.04	210.74	209.71
Bypass Channel		26.67	211.48	211.48	211.48	211.48	211.46	209.98	211.17	211.48	211.48	211.48	211.48	209.98	210.68	209.67
Bypass Channel		26.66	211.45	211.45	211.45	211.45	211.43	209.95	211.15	211.45	211.45	211.45	211.45	209.95	210.65	209.65
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	211.42	211.42	211.42	211.42	211.41	209.92	211.02	211.42	211.42	211.42	211.42	209.92	210.62	209.52
Bypass Channel		26.64	211.41	211.41	211.41	211.41	211.4	209.91	211.01	211.41	211.41	211.41	211.41	209.91	210.61	209.51
Bypass Channel		26.63	211.28	211.28	211.28	211.28	211.24	209.78	210.91	211.28	211.28	211.28	211.28	209.78	210.48	209.41
Bypass Channel		26.62	211.25	211.25	211.25	211.25	211.06	209.75	210.89	211.25	211.25	211.25	211.25	209.75	210.45	209.39
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	210.97	210.97	210.97	210.97	210.96	209.47	210.62	210.97	210.97	210.97	210.97	209.47	210.16	209.12
Bypass Channel		26.6	210.83	210.83	210.83	210.83	210.83	209.33	210.48	210.83	210.83	210.83	210.83	209.33	210.03	208.98
Bypass Channel		26.59	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.68
Downstream Bypass		26.34	207.12	207.12	207.12	207.12	207.12	207.12	207.12	207.11	207.12	207.1	207.12	207.12	207.12	207.12
Downstream Bypass		26.33	206.85	206.85	206.85	206.85	206.85	206.85	206.85	206.85	206.85	206.82	206.85	206.85	206.85	206.85
Downstream Bypass		26.32	206.64	206.64	206.64	206.64	206.64	206.64	206.64	206.64	206.64	206.59	206.64	206.64	206.64	206.64
Downstream Bypass		26.31	206.61	206.61	206.61	206.61	206.61	206.61	206.61	206.61	206.61	206.63	206.61	206.61	206.61	206.61
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	206.56	206.56	206.56	206.56	206.56	206.56	206.56	206.56	206.56	206.63	206.56	206.56	206.56	206.56
Downstream Bypass		26.29	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34	206.34
Downstream Bypass		26.28	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22	206.22
Downstream Bypass		26.27	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8
Downstream Bypass		26.26	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36	205.36

Reach	Location	Cross Section	Difference to Existing (m) A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.81	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.78	0	0	0	0	0.01	0.01	0	0	0	0.01	0.01	0.01	0.01
Upstream Church St		26.77	0	0	0	0	-0.01	-0.01	0	0	0	-0.01	-0.01	-0.01	-0.01
Upstream Church St		26.76	0	0	0	0	-0.05	-0.05	0	0	0	-0.03	-0.05	-0.05	-0.05
Upstream Church St		26.75	0	0	0	0	-0.64	-0.64	0	0	0	-0.07	-0.64	-0.64	-0.64
Upstream Church St		26.74	0	0	0	-0.01	-1.5	-0.3	0	0	0	0.2	-1.5	-0.8	-1.8
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0	0	0	-0.01	-1.5	-0.35	0	-0.01	0	0.22	-1.5	-0.8	-1.85
Upstream Church St		26.72	0	0	0	-0.01	-1.5	-0.35	0	-0.01	0	0.23	-1.5	-0.8	-1.85
SPA	Church Street	26.57	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	0	0	0	0	0	0	-0.07		-0.01	0	0	0	0
SPA		26.35	0	0	0	0	0	0	-0.07		-0.01	0	0	0	0
Bypass Channel		26.71	0	0	0	-0.01	-1.5	-0.32	0	0	0	0	-1.5	-0.8	-1.82
Bypass Channel		26.7	0	0	0	-0.02	-1.5	-0.31	0	0	0	0	-1.5	-0.8	-1.81
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0	0	0	-0.02	-1.5	-0.36	0	0	0	0	-1.5	-0.82	-1.86
Bypass Channel		26.68	0	0	0	-0.01	-1.5	-0.33	0	0	0	0	-1.5	-0.8	-1.83
Bypass Channel		26.67	0	0	0	-0.02	-1.5	-0.31	0	0	0	0	-1.5	-0.8	-1.81
Bypass Channel		26.66	0	0	0	-0.02	-1.5	-0.3	0	0	0	0	-1.5	-0.8	-1.8
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0	0	0	-0.01	-1.5	-0.4	0	0	0	0	-1.5	-0.8	-1.9
Bypass Channel		26.64	0	0	0	-0.01	-1.5	-0.4	0	0	0	0	-1.5	-0.8	-1.9
Bypass Channel		26.63	0	0	0	-0.04	-1.5	-0.37	0	0	0	0	-1.5	-0.8	-1.87
Bypass Channel		26.62	0	0	0	-0.19	-1.5	-0.36	0	0	0	0	-1.5	-0.8	-1.86
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0	0	0	-0.01	-1.5	-0.35	0	0	0	0	-1.5	-0.81	-1.85
Bypass Channel		26.6	0	0	0	0	-1.5	-0.35	0	0	0	0	-1.5	-0.8	-1.85
Bypass Channel		26.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.34	0	0	0	0	0	0	-0.01	0	-0.02	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	0	0	-0.03	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.05	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.07	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

10 Year Event

			WSEL (m)														Difference to Existing (m)												
Reach	Location	Cross Section	Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	216.34	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.81	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	214.84	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.8	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	214.86	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795															0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	214.51	214.52	214.52	214.52	214.52	214.52	214.52	214.51	214.52	214.51	214.52	214.52	214.52	214.52	0.01	0.01	0.01	0.01	0.01	0.01	0	0.01	0	0.01	0.01	0	0.01
Upstream Church St		26.78	214.35	214.36	214.36	214.36	214.36	214.37	214.37	214.35	214.36	214.35	214.36	214.37	214.37	214.37	0.01	0.01	0.01	0.01	0.02	0.02	0	0.01	0	0.01	0.02	0.01	0.02
Upstream Church St		26.77	212.63	212.62	212.62	212.62	212.62	212.59	212.59	212.63	212.62	212.63	212.61	212.59	212.59	212.59	-0.01	-0.01	-0.01	-0.01	-0.04	-0.04	0	-0.01	0	-0.02	-0.04	-0.03	-0.04
Upstream Church St		26.76	212.32	212.31	212.31	212.31	212.31	212.23	212.23	212.32	212.31	212.32	212.28	212.23	212.23	212.23	-0.01	-0.01	-0.01	-0.01	-0.09	-0.09	0	-0.01	0	-0.04	-0.09	-0.08	-0.09
Upstream Church St		26.75	212.11	212.11	212.11	212.11	212.1	211.4	211.4	212.11	212.11	212.11	212.04	211.4	211.4	211.4	0	0	0	-0.01	-0.71	-0.71	0	0	0	-0.07	-0.71	-0.71	-0.71
Upstream Church St		26.74	211.92	211.91	211.91	211.91	211.91	210.42	211.61	211.92	211.91	211.92	212.15	210.41	211.11	210.11	-0.01	-0.01	-0.01	-0.01	-1.5	-0.31	0	-0.01	0	0.23	-1.51	-0.8	-1.81
Upstream Church St	CHURCH STREET EAST	26.735															0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	211.89	211.89	211.89	211.89	211.88	210.39	211.53	211.89	211.89	211.89	212.15	210.39	211.09	210.03	0	0	0	-0.01	-1.5	-0.36	0	0	0	0.26	-1.5	-0.8	-1.86
Upstream Church St		26.72	211.88	211.88	211.88	211.88	211.87	210.38	211.52	211.88	211.88	211.88	212.16	210.38	211.08	210.02	0	0	0	-0.01	-1.5	-0.36	0	0	0	0.28	-1.5	-0.8	-1.86
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535															0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	207.45	207.45	207.45	207.45	207.45	207.45	207.45	207.35		207.43	207.45	207.45	207.45	207.45	0	0	0	0	0	0	-0.1		-0.02	0	0	0	0
SPA		26.35	207.45	207.45	207.45	207.45	207.45	207.45	207.45	207.35		207.43	207.45	207.45	207.45	207.45	0	0	0	0	0	0	-0.1		-0.02	0	0	0	0
Bypass Channel		26.71	211.84	211.84	211.84	211.84	211.82	210.34	211.5	211.84	211.84	211.84	211.84	210.34	211.04	210	0	0	0	-0.02	-1.5	-0.34	0	0	0	0	-1.5	-0.8	-1.84
Bypass Channel		26.7	211.8	211.8	211.8	211.8	211.78	210.3	211.48	211.8	211.8	211.8	211.8	210.3	211	209.98	0	0	0	-0.02	-1.5	-0.32	0	0	0	0	-1.5	-0.8	-1.82
Bypass Channel	SCOTT STREET	26.695															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	211.77	211.77	211.77	211.77	211.75	210.27	211.39	211.77	211.77	211.77	211.77	210.27	210.95	209.89	0	0	0	-0.02	-1.5	-0.38	0	0	0	0	-1.5	-0.82	-1.88
Bypass Channel		26.68	211.73	211.73	211.73	211.73	211.72	210.23	211.38	211.73	211.73	211.73	211.73	210.23	210.93	209.88	0	0	0	-0.01	-1.5	-0.35	0	0	0	0	-1.5	-0.8	-1.85
Bypass Channel		26.67	211.66	211.66	211.66	211.66	211.64	210.16	211.34	211.66	211.66	211.66	211.66	210.16	210.87	209.84	0	0	0	-0.02	-1.5	-0.32	0	0	0	0	-1.5	-0.79	-1.82
Bypass Channel		26.66	211.64	211.64	211.64	211.64	211.62	210.14	211.32	211.64	211.64	211.64	211.64	210.14	210.84	209.82	0	0	0	-0.02	-1.5	-0.32	0	0	0	0	-1.5	-0.8	-1.82
Bypass Channel	QUEEN STREET EAST	26.655															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	211.61	211.61	211.61	211.61	211.59	210.11	211.17	211.61	211.61	211.61	211.61	210.11	210.81	209.67	0	0	0	-0.02	-1.5	-0.44	0	0	0	0	-1.5	-0.8	-1.94
Bypass Channel		26.64	211.6	211.6	211.6	211.6	211.58	210.1	211.16	211.6	211.6	211.6	211.6	210.1	210.8	209.66	0	0	0	-0.02	-1.5	-0.44	0	0	0	0	-1.5	-0.8	-1.94
Bypass Channel		26.63	211.46	211.46	211.46	211.46	211.41	209.96	211.06	211.46	211.46	211.46	211.46	209.96	210.66	209.56	0	0	0	-0.05	-1.5	-0.4	0	0	0	0	-1.5	-0.8	-1.9
Bypass Channel		26.62	211.43	211.43	211.43	211.43	211.23	209.93	211.04	211.43	211.43	211.43	211.43	209.93	210.63	209.54	0	0	0	-0.2	-1.5	-0.39	0	0	0	0	-1.5	-0.8	-1.89
Bypass Channel	CNR TRACKS	26.615															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	211.13	211.13	211.13	211.13	211.13	209.63	210.72	211.13	211.13	211.13	211.13	209.63	210.33	209.23	0	0	0	0	-1.5	-0.41	0	0	0	0	-1.5	-0.8	-1.9
Bypass Channel		26.6	211	211	211	211	211	209.5	210.59	211	211	211	211	209.5	210.2	209.09	0	0	0	0	-1.5	-0.41	0	0	0	0	-1.5	-0.8	-1.91
Bypass Channel		26.59	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	207.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.34	207.32	207.32	207.32	207.32	207.32	207.32	207.32	207.3	207.32	207.29	207.32	207.32	207.32	207.32	0	0	0	0	0	0	-0.02	0	-0.03	0	0	0	0
Downstream Bypass		26.33	207.03	207.03	207.03	207.03	207.03	207.03	207.03	207.03	207.03	207	207.03	207.03	207.03	207.03	0	0	0	0	0	0	0	0	-0.03	0	0	0	0
Downstream Bypass		26.32	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.75	206.82	206.82	206.82	206.82	0	0	0	0	0	0	0	0	-0.07	0	0	0	0
Downstream Bypass		26.31	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.8	206.77	206.77	206.77	206.77	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305															0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	206.71	206.71	206.71	206.71	206.71	206.71	206.71	206.71	206.71	206.8	206.71	206.71	206.71	206.71	0	0	0	0	0	0	0	0	0.09	0	0	0	0
Downstream Bypass		26.29	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	206.37	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	205.97	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	205.51	0	0	0	0	0	0	0	0	0	0	0	0	0

25 Year Event

			WSEL (m)														Difference to Existing (m)												
Reach	Location	Cross Section	Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	216.47	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.81	215.02	215.02	215.02	215.02	215.02	215.03	215.03	215.02	215.02	215.02	215.02	215.03	215.03	215.03	0	0	0	0	0.01	0.01	0	0	0	0	0.01	0.01	0.01
Upstream Church St		26.8	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	215.03	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795															0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	214.62	214.62	214.62	214.62	214.62	214.63	214.63	214.62	214.62	214.62	214.62	214.63	214.63	214.63	0	0	0	0	0.01	0.01	0	0	0	0	0.01	0.01	0.01
Upstream Church St		26.78	214.46	214.46	214.46	214.46	214.46	214.49	214.49	214.46	214.46	214.46	214.47	214.49	214.49	214.49	0	0	0	0	0.03	0.03	0	0	0	0.01	0.03	0.03	0.03
Upstream Church St		26.77	212.85	212.85	212.85	212.85	212.85	212.8	212.79	212.85	212.85	212.85	212.83	212.8	212.8	212.8	0	0	0	0	-0.05	-0.06	0	0	0	-0.02	-0.05	-0.05	-0.05
Upstream Church St		26.76	212.55	212.55	212.55	212.55	212.55	212.42	212.38	212.55	212.55	212.55	212.51	212.42	212.42	212.42	0	0	0	0	-0.13	-0.17	0	0	0	-0.04	-0.13	-0.13	-0.13
Upstream Church St		26.75	212.35	212.35	212.35	212.35	212.35	211.56	211.68	212.35	212.35	212.35	212.29	211.56	211.56	211.56	0	0	0	0	-0.79	-0.67	0	0	0	-0.06	-0.79	-0.79	-0.79
Upstream Church St		26.74	212.13	212.13	212.13	212.13	212.12	210.64	211.86	212.13	212.13	212.13	212.41	210.63	211.33	210.36	0	0	0	-0.01	-1.49	-0.27	0	0	0	0.28	-1.5	-0.8	-1.77
Upstream Church St	CHURCH STREET EAST	26.735															0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	212.11	212.11	212.11	212.11	212.09	210.61	211.77	212.11	212.1	212.11	212.41	210.61	211.31	210.27	0	0	0	-0.02	-1.5	-0.34	0	-0.01	0	0.3	-1.5	-0.8	-1.84
Upstream Church St		26.72	212.1	212.1	212.1	212.1	212.08	210.6	211.77	212.1	212.09	212.1	212.41	210.6	211.3	210.27	0	0	0	-0.02	-1.5	-0.33	0	-0.01	0	0.31	-1.5	-0.8	-1.83
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535															0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.55		207.66	207.68	207.68	207.68	207.68	0	0	0	0	0	0	-0.13		-0.02	0	0	0	0
SPA		26.35	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.55		207.66	207.68	207.68	207.68	207.68	0	0	0	0	0	0	-0.13		-0.02	0	0	0	0
Bypass Channel		26.71	212.05	212.05	212.05	212.05	212.03	210.55	211.75	212.05	212.05	212.05	212.05	210.55	211.25	210.25	0	0	0	-0.02	-1.5	-0.3	0	0	0	0	-1.5	-0.8	-1.8
Bypass Channel		26.7	212.01	212.01	212.01	212.01	211.99	210.52	211.74	212.01	212.01	212.01	212.01	210.52	211.21	210.24	0	0	0	-0.02	-1.49	-0.27	0	0	0	0	-1.49	-0.8	-1.77
Bypass Channel	SCOTT STREET	26.695															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	211.98	211.98	211.98	211.98	211.96	210.48	211.64	211.98	211.98	211.98	211.98	210.48	211.16	210.14	0	0	0	-0.02	-1.5	-0.34	0	0	0	0	-1.5	-0.82	-1.84
Bypass Channel		26.68	211.94	211.94	211.94	211.94	211.92	210.44	211.63	211.94	211.94	211.94	211.94	210.44	211.14	210.13	0	0	0	-0.02	-1.5	-0.31	0	0	0	0	-1.5	-0.8	-1.81
Bypass Channel		26.67	211.87	211.87	211.87	211.87	211.85	210.38	211.6	211.87	211.87	211.87	211.87	210.38	211.08	210.1	0	0	0	-0.02	-1.49	-0.27	0	0	0	0	-1.49	-0.79	-1.77
Bypass Channel		26.66	211.84	211.84	211.84	211.84	211.82	210.35	211.59	211.84	211.84	211.84	211.84	210.35	211.05	210.09	0	0	0	-0.02	-1.49	-0.25	0	0	0	0	-1.49	-0.79	-1.75
Bypass Channel	QUEEN STREET EAST	26.655															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	211.81	211.81	211.81	211.81	211.79	210.32	211.45	211.81	211.81	211.81	211.81	210.32	211.02	209.95	0	0	0	-0.02	-1.49	-0.36	0	0	0	0	-1.49	-0.79	-1.86
Bypass Channel		26.64	211.8	211.8	211.8	211.8	211.78	210.31	211.45	211.8	211.8	211.8	211.8	210.31	211.01	209.95	0	0	0	-0.02	-1.49	-0.35	0	0	0	0	-1.49	-0.79	-1.85
Bypass Channel		26.63	211.65	211.65	211.65	211.65	211.61	210.17	211.4	211.65	211.65	211.65	211.65	210.17	210.87	209.9	0	0	0	-0.04	-1.48	-0.25	0	0	0	0	-1.48	-0.78	-1.75
Bypass Channel		26.62	211.61	211.61	211.61	211.61	211.41	210.14	211.39	211.61	211.61	211.61	211.61	210.14	210.84	209.89	0	0	0	-0.2	-1.47	-0.22	0	0	0	0	-1.47	-0.77	-1.72
Bypass Channel	CNR TRACKS	26.615															0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	211.31	211.31	211.31	211.31	211.31	209.82	210.85	211.31	211.31	211.31	211.31	209.82	210.52	209.35	0	0	0	0	-1.49	-0.46	0	0	0	0	-1.49	-0.79	-1.96
Bypass Channel		26.6	211.18	211.18	211.18	211.18	211.18	209.68	210.71	211.18	211.18	211.18	211.18	209.68	210.38	209.21	0	0	0	0	-1.5	-0.47	0	0	0	0	-1.5	-0.8	-1.97
Bypass Channel		26.59	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	207.93	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.34	207.53	207.53	207.53	207.53	207.53	207.53	207.53	207.51	207.53	207.51	207.53	207.53	207.53	207.53	0	0	0	0	0	0	-0.02	0	-0.02	0	0	0	0
Downstream Bypass		26.33	207.24	207.24	207.24	207.24	207.24	207.24	207.24	207.24	207.24	207.19	207.24	207.24	207.24	207.24	0	0	0	0	0	0	0	0	-0.05	0	0	0	0
Downstream Bypass		26.32	207.02	207.02	207.02	207.02	207.02	207.02	207.02	207.02	207.02	206.94	207.02	207.02	207.02	207.02	0	0	0	0	0	0	0	0	-0.08	0	0	0	0
Downstream Bypass		26.31	206.96	206.96	206.96	206.96	206.96	206.96	206.96	206.96	206.96	207	206.96	206.96	206.96	206.96	0	0	0	0	0	0	0	0	0.04	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305															0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	206.88	206.88	206.88	206.88	206.88	206.88	206.88	206.88	206.88	207	206.88	206.88	206.88	206.88	0	0	0	0	0	0	0	0	0.12	0	0	0	0
Downstream Bypass		26.29	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	206.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	206.53	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	206.17	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	205.67	0	0	0	0	0	0	0	0	0	0	0	0	0

50 Year Event

Reach	Location	Cross Section	WSEL (m) Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	216.44	216.44	216.44	216.44	216.44	216.43	216.44	216.44	216.44	216.44	216.44	216.43	216.43	216.43
Upstream Church St		26.81	215.18	215.18	215.18	215.18	215.18	215.19	215.18	215.18	215.18	215.18	215.18	215.19	215.19	215.19
Upstream Church St		26.8	215.16	215.16	215.16	215.16	215.16	215.17	215.16	215.16	215.16	215.16	215.16	215.17	215.17	215.17
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	214.69	214.69	214.69	214.69	214.69	214.7	214.71	214.69	214.69	214.69	214.69	214.7	214.7	214.7
Upstream Church St		26.78	214.54	214.54	214.54	214.54	214.54	214.58	214.59	214.54	214.54	214.54	214.55	214.58	214.58	214.58
Upstream Church St		26.77	213.02	213.02	213.02	213.02	213.02	212.95	212.93	213.02	213.02	213.02	213	212.95	212.95	212.95
Upstream Church St		26.76	212.72	212.72	212.72	212.72	212.71	212.56	212.51	212.72	212.72	212.72	212.68	212.56	212.56	212.56
Upstream Church St		26.75	212.53	212.52	212.52	212.52	212.52	211.68	211.87	212.53	212.52	212.53	212.46	211.68	211.68	211.68
Upstream Church St		26.74	212.29	212.29	212.29	212.29	212.28	210.79	212.04	212.29	212.28	212.29	212.59	210.78	211.48	210.54
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	212.26	212.26	212.26	212.26	212.24	210.76	211.94	212.26	212.25	212.26	212.59	210.76	211.46	210.44
Upstream Church St		26.72	212.25	212.25	212.25	212.25	212.23	210.75	211.93	212.25	212.24	212.25	212.59	210.75	211.45	210.43
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44
SPA		26.36	207.84	207.84	207.84	207.84	207.84	207.84	207.84	207.7		207.82	207.84	207.84	207.84	207.84
SPA		26.35	207.84	207.84	207.84	207.84	207.84	207.84	207.84	207.7		207.82	207.84	207.84	207.84	207.84
Bypass Channel		26.71	212.2	212.2	212.2	212.2	212.18	210.7	211.92	212.2	212.2	212.2	212.2	210.7	211.4	210.42
Bypass Channel		26.7	212.16	212.16	212.16	212.16	212.14	210.66	211.9	212.16	212.16	212.16	212.16	210.66	211.36	210.4
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	212.13	212.13	212.13	212.13	212.1	210.63	211.8	212.13	212.13	212.13	212.13	210.63	211.3	210.3
Bypass Channel		26.68	212.09	212.09	212.09	212.09	212.07	210.59	211.79	212.09	212.09	212.09	212.09	210.59	211.29	210.29
Bypass Channel		26.67	212.02	212.02	212.02	212.02	211.99	210.52	211.76	212.02	212.02	212.02	212.02	210.52	211.22	210.26
Bypass Channel		26.66	211.99	211.99	211.99	211.99	211.96	210.49	211.75	211.99	211.99	211.99	211.99	210.49	211.19	210.25
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	211.96	211.96	211.96	211.96	211.94	210.46	211.6	211.96	211.96	211.96	211.96	210.46	211.16	210.1
Bypass Channel		26.64	211.94	211.94	211.94	211.94	211.93	210.44	211.59	211.94	211.94	211.94	211.94	210.44	211.15	210.09
Bypass Channel		26.63	211.8	211.8	211.8	211.8	211.74	210.29	211.54	211.8	211.8	211.8	211.8	210.29	211	210.04
Bypass Channel		26.62	211.76	211.76	211.76	211.76	211.54	210.26	211.53	211.76	211.76	211.76	211.76	210.26	210.96	210.03
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	211.45	211.45	211.45	211.45	211.44	209.95	210.94	211.45	211.45	211.45	211.45	209.95	210.65	209.44
Bypass Channel		26.6	211.31	211.31	211.31	211.31	211.31	209.81	210.8	211.31	211.31	211.31	211.31	209.81	210.51	209.3
Bypass Channel		26.59	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02	208.02
Downstream Bypass		26.34	207.68	207.68	207.68	207.68	207.68	207.68	207.68	207.65	207.68	207.65	207.68	207.68	207.68	207.68
Downstream Bypass		26.33	207.37	207.37	207.37	207.37	207.37	207.37	207.37	207.37	207.37	207.32	207.37	207.37	207.37	207.37
Downstream Bypass		26.32	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.06	207.14	207.14	207.14	207.14
Downstream Bypass		26.31	207.07	207.07	207.07	207.07	207.07	207.07	207.07	207.07	207.07	207.12	207.07	207.07	207.07	207.07
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	206.97	206.97	206.97	206.97	206.97	206.97	206.97	206.97	206.97	207.11	206.97	206.97	206.97	206.97
Downstream Bypass		26.29	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7	206.7
Downstream Bypass		26.28	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65	206.65
Downstream Bypass		26.27	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32	206.32
Downstream Bypass		26.26	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8	205.8

Reach	Location	Cross Section	Difference to Existing (m) A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	0	0	0	0	-0.01	0	0	0	0	0	-0.01	-0.01	-0.01
Upstream Church St		26.81	0	0	0	0	0.01	0	0	0	0	0	0.01	0.01	0.01
Upstream Church St		26.8	0	0	0	0	0.01	0	0	0	0	0	0.01	0.01	0.01
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	0	0	0.01	0.02	0	0	0	0	0.01	0.01	0.01
Upstream Church St		26.78	0	0	0	0	0.04	0.05	0	0	0	0.01	0.04	0.04	0.04
Upstream Church St		26.77	0	0	0	0	-0.07	-0.09	0	0	0	-0.02	-0.07	-0.07	-0.07
Upstream Church St		26.76	0	0	0	-0.01	-0.16	-0.21	0	0	0	-0.04	-0.16	-0.16	-0.16
Upstream Church St		26.75	-0.01	-0.01	-0.01	-0.01	-0.85	-0.66	0	-0.01	0	-0.07	-0.85	-0.84	-0.85
Upstream Church St		26.74	0	0	0	-0.01	-1.5	-0.25	0	-0.01	0	0.3	-1.51	-0.81	-1.75
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0	0	0	-0.02	-1.5	-0.32	0	-0.01	0	0.33	-1.5	-0.8	-1.82
Upstream Church St		26.72	0	0	0	-0.02	-1.5	-0.32	0	-0.01	0	0.34	-1.5	-0.8	-1.82
SPA	Church Street	26.57	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	0	0	0	0	0	0	-0.14		-0.02	0	0	0	0
SPA		26.35	0	0	0	0	0	0	-0.14		-0.02	0	0	0	0
Bypass Channel		26.71	0	0	0	-0.02	-1.5	-0.28	0	0	0	0	-1.5	-0.8	-1.78
Bypass Channel		26.7	0	0	0	-0.02	-1.5	-0.26	0	0	0	0	-1.5	-0.8	-1.76
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0	0	0	-0.03	-1.5	-0.33	0	0	0	0	-1.5	-0.83	-1.83
Bypass Channel		26.68	0	0	0	-0.02	-1.5	-0.3	0	0	0	0	-1.5	-0.8	-1.8
Bypass Channel		26.67	0	0	0	-0.03	-1.5	-0.26	0	0	0	0	-1.5	-0.8	-1.76
Bypass Channel		26.66	0	0	0	-0.03	-1.5	-0.24	0	0	0	0	-1.5	-0.8	-1.74
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0	0	0	-0.02	-1.5	-0.36	0	0	0	0	-1.5	-0.8	-1.86
Bypass Channel		26.64	0	0	0	-0.01	-1.5	-0.35	0	0	0	0	-1.5	-0.79	-1.85
Bypass Channel		26.63	0	0	0	-0.06	-1.51	-0.26	0	0	0	0	-1.51	-0.8	-1.76
Bypass Channel		26.62	0	0	0	-0.22	-1.5	-0.23	0	0	0	0	-1.5	-0.8	-1.73
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0	0	0	-0.01	-1.5	-0.51	0	0	0	0	-1.5	-0.8	-2.01
Bypass Channel		26.6	0	0	0	0	-1.5	-0.51	0	0	0	0	-1.5	-0.8	-2.01
Bypass Channel		26.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.34	0	0	0	0	0	0	-0.03	0	-0.03	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	0	0	-0.05	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.08	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	0.05	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.14	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

100 Year Event

Reach	Location	Cross Section	WSEL (m) Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	216.38	216.38	216.38	216.38	216.38	216.37	216.37	216.38	216.38	216.38	216.38	216.37	216.37	216.37
Upstream Church St		26.81	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33	215.33
Upstream Church St		26.8	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29	215.29
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	214.75	214.75	214.75	214.75	214.76	214.77	214.78	214.75	214.75	214.75	214.76	214.77	214.77	214.77
Upstream Church St		26.78	214.61	214.62	214.62	214.62	214.62	214.65	214.67	214.61	214.62	214.61	214.62	214.65	214.65	214.65
Upstream Church St		26.77	213.19	213.19	213.19	213.19	213.18	213.1	213.08	213.19	213.18	213.19	213.17	213.1	213.1	213.1
Upstream Church St		26.76	212.89	212.89	212.89	212.89	212.88	212.7	212.64	212.89	212.89	212.89	212.85	212.7	212.7	212.7
Upstream Church St		26.75	212.69	212.69	212.69	212.69	212.68	211.79	212.06	212.69	212.69	212.69	212.64	211.79	211.79	211.79
Upstream Church St		26.74	212.44	212.44	212.44	212.44	212.43	210.94	212.22	212.44	212.44	212.44	212.78	210.94	211.64	210.72
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	212.41	212.41	212.41	212.41	212.39	210.91	212.11	212.41	212.41	212.41	212.78	210.91	211.61	210.61
Upstream Church St		26.72	212.4	212.4	212.4	212.4	212.38	210.9	212.1	212.4	212.39	212.4	212.78	210.9	211.6	210.6
SPA	Church Street	26.57	212.04	212.04	212.04	212.04	212.04	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04
SPA	Union Street - Nelson Street	26.56	211.4	211.4	211.4	211.4	211.4	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4
SPA	Union Street - Nelson Street	26.55	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Union Street - Main Street	26.54	211.25	211.25	211.25	211.25	211.25	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	211.22	211.22	211.22	211.22	211.22	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22
SPA	Main Street - Nelson Street North of Queen	26.52	211.02	211.02	211.02	211.02	211.02	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02
SPA	Main Street - Nelson Street North of Queen	26.51	210.87	210.87	210.87	210.87	210.87	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87
SPA	Main Street - Nelson Street North of Queen	26.5	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.49	210.82	210.82	210.82	210.82	210.82	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.48	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - Nelson Street North of Queen	26.47	210.81	210.81	210.81	210.81	210.81	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - George Street North of Wellington	26.46	210.76	210.76	210.76	210.76	210.76	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76
SPA	Main Street - George Street North of Wellington	26.45	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.44	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.43	210.58	210.58	210.58	210.58	210.58	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Wellington Street	26.42	210.56	210.56	210.56	210.56	210.56	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56
SPA	Main Street	26.41	210.18	210.18	210.18	210.18	210.18	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18
SPA	Main Street	26.4	210.17	210.17	210.17	210.17	210.17	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17
SPA	WoodBrook Drive	26.39	210.04	210.04	210.04	210.04	210.04	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04
SPA	WoodBrook Drive - Chappel Street	26.38	208.79	208.79	208.79	208.79	208.79	208.79	208.79	208.79		208.79	208.79	208.79	208.79	208.79
SPA	Mary Street	26.37	208.44	208.44	208.44	208.44	208.44	208.44	208.44	208.44		208.44	208.44	208.44	208.44	208.44
SPA		26.36	207.99	207.99	207.99	207.99	207.99	207.99	207.99	207.84		207.97	207.99	207.99	207.99	207.99
SPA		26.35	207.99	207.99	207.99	207.99	207.99	207.99	207.99	207.84		207.97	207.99	207.99	207.99	207.99
Bypass Channel		26.71	212.36	212.36	212.36	212.36	212.33	210.85	212.09	212.36	212.36	212.36	212.36	210.85	211.55	210.59
Bypass Channel		26.7	212.32	212.32	212.32	212.32	212.29	210.81	212.08	212.32	212.32	212.32	212.32	210.81	211.51	210.58
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	212.28	212.28	212.28	212.28	212.25	210.78	211.96	212.28	212.28	212.28	212.28	210.78	211.45	210.46
Bypass Channel		26.68	212.24	212.24	212.24	212.24	212.22	210.74	211.95	212.24	212.24	212.24	212.24	210.74	211.44	210.45
Bypass Channel		26.67	212.17	212.17	212.17	212.17	212.14	210.67	211.93	212.17	212.17	212.17	212.17	210.67	211.37	210.43
Bypass Channel		26.66	212.14	212.14	212.14	212.14	212.11	210.64	211.92	212.14	212.14	212.14	212.14	210.64	211.34	210.42
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	212.11	212.11	212.11	212.11	212.09	210.61	211.75	212.11	212.11	212.11	212.11	210.61	211.31	210.25
Bypass Channel		26.64	212.09	212.09	212.09	212.09	212.08	210.59	211.74	212.09	212.09	212.09	212.09	210.59	211.29	210.24
Bypass Channel		26.63	211.94	211.94	211.94	211.94	211.9	210.44	211.7	211.94	211.94	211.94	211.94	210.44	211.14	210.2
Bypass Channel		26.62	211.91	211.91	211.91	211.91	211.68	210.41	211.69	211.91	211.91	211.91	211.91	210.41	211.11	210.19
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	211.59	211.59	211.59	211.59	211.58	210.09	211.03	211.59	211.59	211.59	211.59	210.09	210.79	209.53
Bypass Channel		26.6	211.45	211.45	211.45	211.45	211.45	209.95	210.89	211.45	211.45	211.45	211.45	209.95	210.65	209.39
Bypass Channel		26.59	208.15	208.15	208.15	208.15	208.15	208.15	208.15	208.12	208.15	208.14	208.15	208.15	208.15	208.15
Downstream Bypass		26.34	207.82	207.82	207.82	207.82	207.82	207.82	207.82	207.79	207.82	207.79	207.82	207.82	207.82	207.82
Downstream Bypass		26.33	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.5	207.49	207.44	207.49	207.49	207.49	207.49
Downstream Bypass		26.32	207.26	207.26	207.26	207.26	207.26	207.26	207.26	207.26	207.26	207.17	207.26	207.26	207.26	207.26
Downstream Bypass		26.31	207.18	207.18	207.18	207.18	207.18	207.18	207.18	207.18	207.18	207.23	207.18	207.18	207.18	207.18
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	207.05	207.05	207.05	207.05	207.05	207.05	207.05	207.05	207.05	207.22	207.05	207.05	207.05	207.05
Downstream Bypass		26.29	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82	206.82
Downstream Bypass		26.28	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77	206.77
Downstream Bypass		26.27	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46	206.46
Downstream Bypass		26.26	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92	205.92

Reach	Location	Cross Section	Difference to Existing (m) A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	0	0	0	0	-0.01	-0.01	0	0	0	0	-0.01	-0.01	-0.01
Upstream Church St		26.81	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	0	0.01	0.02	0.03	0	0	0	0.01	0.02	0.02	0.02
Upstream Church St		26.78	0.01	0.01	0.01	0.01	0.04	0.06	0	0.01	0	0.01	0.04	0.03	0.04
Upstream Church St		26.77	0	0	0	-0.01	-0.09	-0.11	0	-0.01	0	-0.02	-0.09	-0.09	-0.09
Upstream Church St		26.76	0	0	0	-0.01	-0.19	-0.25	0	0	0	-0.04	-0.19	-0.19	-0.19
Upstream Church St		26.75	0	0	0	-0.01	-0.9	-0.63	0	0	0	-0.05	-0.9	-0.9	-0.9
Upstream Church St		26.74	0	0	0	-0.01	-1.5	-0.22	0	0	0	0.34	-1.5	-0.8	-1.72
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0	0	0	-0.02	-1.5	-0.3	0	0	0	0.37	-1.5	-0.8	-1.8
Upstream Church St		26.72	0	0	0	-0.02	-1.5	-0.3	0	-0.01	0	0.38	-1.5	-0.8	-1.8
SPA	Church Street	26.57	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.56	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Nelson Street	26.55	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.54	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.52	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.51	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.5	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.49	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.48	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - Nelson Street North of Queen	26.47	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.46	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.45	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.44	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street - George Street North of Wellington	26.43	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Wellington Street	26.42	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.41	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Main Street	26.4	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive	26.39	0	0	0	0	0	0	0		0	0	0	0	0
SPA	WoodBrook Drive - Chappel Street	26.38	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Mary Street	26.37	0	0	0	0	0	0	0		0	0	0	0	0
SPA		26.36	0	0	0	0	0	0	-0.15		-0.02	0	0	0	0
SPA		26.35	0	0	0	0	0	0	-0.15		-0.02	0	0	0	0
Bypass Channel		26.71	0	0	0	-0.03	-1.51	-0.27	0	0	0	0	-1.51	-0.81	-1.77
Bypass Channel		26.7	0	0	0	-0.03	-1.51	-0.24	0	0	0	0	-1.51	-0.81	-1.74
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0	0	0	-0.03	-1.5	-0.32	0	0	0	0	-1.5	-0.83	-1.82
Bypass Channel		26.68	0	0	0	-0.02	-1.5	-0.29	0	0	0	0	-1.5	-0.8	-1.79
Bypass Channel		26.67	0	0	0	-0.03	-1.5	-0.24	0	0	0	0	-1.5	-0.8	-1.74
Bypass Channel		26.66	0	0	0	-0.03	-1.5	-0.22	0	0	0	0	-1.5	-0.8	-1.72
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0	0	0	-0.02	-1.5	-0.36	0	0	0	0	-1.5	-0.8	-1.86
Bypass Channel		26.64	0	0	0	-0.01	-1.5	-0.35	0	0	0	0	-1.5	-0.8	-1.85
Bypass Channel		26.63	0	0	0	-0.04	-1.5	-0.24	0	0	0	0	-1.5	-0.8	-1.74
Bypass Channel		26.62	0	0	0	-0.23	-1.5	-0.22	0	0	0	0	-1.5	-0.8	-1.72
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0	0	0	-0.01	-1.5	-0.56	0	0	0	0	-1.5	-0.8	-2.06
Bypass Channel		26.6	0	0	0	0	-1.5	-0.56	0	0	0	0	-1.5	-0.8	-2.06
Bypass Channel		26.59	0	0	0	0	0	0	-0.03	0	-0.01	0	0	0	0
Downstream Bypass		26.34	0	0	0	0	0	0	-0.03	0	-0.03	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	0.01	0	-0.05	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.09	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	0.05	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.17	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

350 Year Event

Reach	Location	Cross Section	WSEL (m) Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11	217.11
Upstream Church St		26.81	216	216	216	216	216	216	216	216	216	216	216	216	216	216
Upstream Church St		26.8	215.89	215.89	215.89	215.9	215.89	215.89	215.89	215.89	215.89	215.89	215.89	215.89	215.89	215.89
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	215.01	215.01	215.01	214.99	215.01	215.08	215.05	215.01	215.01	215.01	215.02	215.08	215.08	215.08
Upstream Church St		26.78	215.04	215.03	215.03	214.99	215.03	215.14	215.1	215.03	215.03	215.03	215.04	215.14	215.14	215.14
Upstream Church St		26.77	213.57	213.6	213.62	213.77	213.58	213.22	213.35	213.61	213.61	213.61	213.55	213.22	213.22	213.22
Upstream Church St		26.76	213.61	213.64	213.66	213.65	213.63	213.24	213.39	213.66	213.65	213.66	213.6	213.24	213.24	213.24
Upstream Church St		26.75	213.44	213.49	213.52	213.4	213.47	212.26	212.89	213.51	213.51	213.51	213.42	212.26	212.26	212.26
Upstream Church St		26.74	213.14	213.22	213.05	213.05	212.96	211.55	213.02	213.04	213.03	213.04	213.5	211.55	212.25	211.52
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	212.99	213.02	213.02	213.02	212.97	211.52	212.86	213.02	213.01	213.02	213.5	211.52	212.22	211.36
Upstream Church St		26.72	212.98	213.01	213.01	213.01	212.96	211.51	212.85	213.01	213	213.01	213.5	211.51	212.21	211.35
SPA	Church Street	26.57	212.16	212.04	212.04	212.04	212.13	212.04	212.04	212.04		212.04	212.04	212.04	212.04	212.04
SPA	Union Street - Nelson Street	26.56	211.49	211.4	211.4	211.4	211.47	211.4	211.4	211.4		211.4	211.4	211.4	211.4	211.4
SPA	Union Street - Nelson Street	26.55	211.47	211.25	211.25	211.25	211.41	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Union Street - Main Street	26.54	211.45	211.25	211.25	211.25	211.39	211.25	211.25	211.25		211.25	211.25	211.25	211.25	211.25
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	211.35	211.22	211.22	211.22	211.32	211.22	211.22	211.22		211.22	211.22	211.22	211.22	211.22
SPA	Main Street - Nelson Street North of Queen	26.52	211.16	211.02	211.02	211.02	211.12	211.02	211.02	211.02		211.02	211.02	211.02	211.02	211.02
SPA	Main Street - Nelson Street North of Queen	26.51	211.04	210.87	210.87	210.87	210.99	210.87	210.87	210.87		210.87	210.87	210.87	210.87	210.87
SPA	Main Street - Nelson Street North of Queen	26.5	211.07	210.82	210.82	210.82	211.01	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.49	211.07	210.82	210.82	210.82	211	210.82	210.82	210.82		210.82	210.82	210.82	210.82	210.82
SPA	Main Street - Nelson Street North of Queen	26.48	211.05	210.81	210.81	210.81	210.99	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - Nelson Street North of Queen	26.47	211.02	210.81	210.81	210.81	210.97	210.81	210.81	210.81		210.81	210.81	210.81	210.81	210.81
SPA	Main Street - George Street North of Wellington	26.46	210.91	210.76	210.76	210.76	210.87	210.76	210.76	210.76		210.76	210.76	210.76	210.76	210.76
SPA	Main Street - George Street North of Wellington	26.45	210.79	210.58	210.58	210.58	210.74	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.44	210.78	210.58	210.58	210.58	210.73	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Main Street - George Street North of Wellington	26.43	210.78	210.58	210.58	210.58	210.73	210.58	210.58	210.58		210.58	210.58	210.58	210.58	210.58
SPA	Wellington Street	26.42	210.64	210.56	210.56	210.56	210.62	210.56	210.56	210.56		210.56	210.56	210.56	210.56	210.56
SPA	Main Street	26.41	210.52	210.18	210.18	210.18	210.46	210.18	210.18	210.18		210.18	210.18	210.18	210.18	210.18
SPA	Main Street	26.4	210.5	210.17	210.17	210.17	210.44	210.17	210.17	210.17		210.17	210.17	210.17	210.17	210.17
SPA	WoodBrook Drive	26.39	210.17	210.04	210.04	210.04	210.14	210.04	210.04	210.04		210.04	210.04	210.04	210.04	210.04
SPA	WoodBrook Drive - Chappel Street	26.38	209.08	208.71	208.71	208.71	209	208.71	208.71	208.79		208.71	208.71	208.71	208.71	208.71
SPA	Mary Street	26.37	208.6	208.61	208.61	208.61	208.61	208.61	208.61	208.44		208.56	208.61	208.61	208.61	208.61
SPA		26.36	208.61	208.61	208.61	208.61	208.61	208.61	208.61	208.36		208.56	208.61	208.61	208.61	208.61
SPA		26.35	208.61	208.61	208.61	208.61	208.61	208.61	208.61	208.36		208.56	208.61	208.61	208.61	208.61
Bypass Channel		26.71	212.93	212.96	212.96	212.96	212.91	211.47	212.85	212.96	212.96	212.96	212.96	211.47	212.17	211.35
Bypass Channel		26.7	212.89	212.92	212.92	212.92	212.86	211.43	212.84	212.92	212.92	212.92	212.92	211.43	212.12	211.34
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	212.85	212.88	212.88	212.88	212.82	211.38	212.68	212.88	212.88	212.88	212.88	211.38	212.05	211.18
Bypass Channel		26.68	212.8	212.83	212.83	212.83	212.78	211.34	212.67	212.83	212.83	212.83	212.83	211.34	212.03	211.17
Bypass Channel		26.67	212.73	212.76	212.76	212.76	212.7	211.27	212.65	212.76	212.76	212.76	212.76	211.27	211.96	211.15
Bypass Channel		26.66	212.71	212.74	212.74	212.74	212.67	211.24	212.64	212.74	212.74	212.74	212.74	211.24	211.94	211.14
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	212.67	212.7	212.7	212.7	212.64	211.21	212.39	212.7	212.7	212.7	212.7	211.21	211.9	210.89
Bypass Channel		26.64	212.66	212.69	212.69	212.69	212.63	211.2	212.39	212.69	212.69	212.69	212.69	211.2	211.89	210.89
Bypass Channel		26.63	212.51	212.54	212.54	212.54	212.44	211.06	212.35	212.54	212.54	212.54	212.54	211.06	211.74	210.85
Bypass Channel		26.62	212.48	212.51	212.51	212.51	212.19	211.03	212.35	212.51	212.51	212.51	212.51	211.03	211.71	210.84
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	212.09	212.13	212.13	212.13	212.09	210.62	211.42	212.13	212.13	212.13	212.13	210.62	211.32	209.91
Bypass Channel		26.6	211.94	211.98	211.98	211.98	211.96	210.48	211.26	211.98	211.98	211.98	211.98	210.48	211.18	209.76
Bypass Channel		26.59	208.69	208.68	208.68	208.68	208.69	208.68	208.68	208.53	208.68	208.65	208.68	208.68	208.68	208.68
Downstream Bypass		26.34	208.38	208.38	208.38	208.38	208.38	208.38	208.38	208.31	208.38	208.31	208.38	208.38	208.38	208.38
Downstream Bypass		26.33	207.99	207.99	207.99	207.99	207.99	207.99	207.99	208.01	207.99	207.86	207.99	207.99	207.99	207.99
Downstream Bypass		26.32	207.79	207.79	207.79	207.79	207.79	207.79	207.79	207.79	207.79	207.55	207.79	207.79	207.79	207.79
Downstream Bypass		26.31	207.67	207.67	207.67	207.67	207.67	207.67	207.67	207.67	207.67	207.62	207.67	207.67	207.67	207.67
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	207.39	207.39	207.39	207.39	207.39	207.39	207.39	207.39	207.39	207.61	207.39	207.39	207.39	207.39
Downstream Bypass		26.29	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36	207.36
Downstream Bypass		26.28	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3	207.3
Downstream Bypass		26.27	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04	207.04
Downstream Bypass		26.26	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4	206.4

Reach	Location	Cross Section	Difference to Existing (m) A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.81	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.8	0	0	0.01	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	-0.02	0	0.07	0.04	0	0	0	0.01	0.07	0.07	0.07
Upstream Church St		26.78	-0.01	-0.01	-0.05	-0.01	0.1	0.06	-0.01	-0.01	-0.01	0	0.1	0.11	0.1
Upstream Church St		26.77	0.03	0.05	0.2	0.01	-0.35	-0.22	0.04	0.04	0.04	-0.02	-0.35	-0.38	-0.35
Upstream Church St		26.76	0.03	0.05	0.04	0.02	-0.37	-0.22	0.05	0.04	0.05	-0.01	-0.37	-0.4	-0.37
Upstream Church St		26.75	0.05	0.08	-0.04	0.03	-1.18	-0.55	0.07	0.07	0.07	-0.02	-1.18	-1.23	-1.18
Upstream Church St		26.74	0.08	-0.09	-0.09	-0.18	-1.59	-0.12	-0.1	-0.11	-0.1	0.36	-1.59	-0.97	-1.62
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0.03	0.03	0.03	-0.02	-1.47	-0.13	0.03	0.02	0.03	0.51	-1.47	-0.8	-1.63
Upstream Church St		26.72	0.03	0.03	0.03	-0.02	-1.47	-0.13	0.03	0.02	0.03	0.52	-1.47	-0.8	-1.63
SPA	Church Street	26.57	-0.12	-0.12	-0.12	-0.03	-0.12	-0.12	-0.12		-0.12	-0.12	-0.12	0	-0.12
SPA	Union Street - Nelson Street	26.56	-0.09	-0.09	-0.09	-0.02	-0.09	-0.09	-0.09		-0.09	-0.09	-0.09	0	-0.09
SPA	Union Street - Nelson Street	26.55	-0.22	-0.22	-0.22	-0.06	-0.22	-0.22	-0.22		-0.22	-0.22	-0.22	0	-0.22
SPA	Union Street - Main Street	26.54	-0.2	-0.2	-0.2	-0.06	-0.2	-0.2	-0.2		-0.2	-0.2	-0.2	0	-0.2
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	-0.13	-0.13	-0.13	-0.03	-0.13	-0.13	-0.13		-0.13	-0.13	-0.13	0	-0.13
SPA	Main Street - Nelson Street North of Queen	26.52	-0.14	-0.14	-0.14	-0.04	-0.14	-0.14	-0.14		-0.14	-0.14	-0.14	0	-0.14
SPA	Main Street - Nelson Street North of Queen	26.51	-0.17	-0.17	-0.17	-0.05	-0.17	-0.17	-0.17		-0.17	-0.17	-0.17	0	-0.17
SPA	Main Street - Nelson Street North of Queen	26.5	-0.25	-0.25	-0.25	-0.06	-0.25	-0.25	-0.25		-0.25	-0.25	-0.25	0	-0.25
SPA	Main Street - Nelson Street North of Queen	26.49	-0.25	-0.25	-0.25	-0.07	-0.25	-0.25	-0.25		-0.25	-0.25	-0.25	0	-0.25
SPA	Main Street - Nelson Street North of Queen	26.48	-0.24	-0.24	-0.24	-0.06	-0.24	-0.24	-0.24		-0.24	-0.24	-0.24	0	-0.24
SPA	Main Street - Nelson Street North of Queen	26.47	-0.21	-0.21	-0.21	-0.05	-0.21	-0.21	-0.21		-0.21	-0.21	-0.21	0	-0.21
SPA	Main Street - George Street North of Wellington	26.46	-0.15	-0.15	-0.15	-0.04	-0.15	-0.15	-0.15		-0.15	-0.15	-0.15	0	-0.15
SPA	Main Street - George Street North of Wellington	26.45	-0.21	-0.21	-0.21	-0.05	-0.21	-0.21	-0.21		-0.21	-0.21	-0.21	0	-0.21
SPA	Main Street - George Street North of Wellington	26.44	-0.2	-0.2	-0.2	-0.05	-0.2	-0.2	-0.2		-0.2	-0.2	-0.2	0	-0.2
SPA	Main Street - George Street North of Wellington	26.43	-0.2	-0.2	-0.2	-0.05	-0.2	-0.2	-0.2		-0.2	-0.2	-0.2	0	-0.2
SPA	Wellington Street	26.42	-0.08	-0.08	-0.08	-0.02	-0.08	-0.08	-0.08		-0.08	-0.08	-0.08	0	-0.08
SPA	Main Street	26.41	-0.34	-0.34	-0.34	-0.06	-0.34	-0.34	-0.34		-0.34	-0.34	-0.34	0	-0.34
SPA	Main Street	26.4	-0.33	-0.33	-0.33	-0.06	-0.33	-0.33	-0.33		-0.33	-0.33	-0.33	0	-0.33
SPA	WoodBrook Drive	26.39	-0.13	-0.13	-0.13	-0.03	-0.13	-0.13	-0.13		-0.13	-0.13	-0.13	0	-0.13
SPA	WoodBrook Drive - Chappel Street	26.38	-0.37	-0.37	-0.37	-0.08	-0.37	-0.37	-0.29		-0.37	-0.37	-0.37	0	-0.37
SPA	Mary Street	26.37	0.01	0.01	0.01	0.01	0.01	0.01	-0.16		-0.04	0.01	0.01	0	0.01
SPA		26.36	0	0	0	0	0	0	-0.25		-0.05	0	0	0	0
SPA		26.35	0	0	0	0	0	0	-0.25		-0.05	0	0	0	0
Bypass Channel		26.71	0.03	0.03	0.03	-0.02	-1.46	-0.08	0.03	0.03	0.03	0.03	-1.46	-0.79	-1.58
Bypass Channel		26.7	0.03	0.03	0.03	-0.03	-1.46	-0.05	0.03	0.03	0.03	0.03	-1.46	-0.8	-1.55
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0.03	0.03	0.03	-0.03	-1.47	-0.17	0.03	0.03	0.03	0.03	-1.47	-0.83	-1.67
Bypass Channel		26.68	0.03	0.03	0.03	-0.02	-1.46	-0.13	0.03	0.03	0.03	0.03	-1.46	-0.8	-1.63
Bypass Channel		26.67	0.03	0.03	0.03	-0.03	-1.46	-0.08	0.03	0.03	0.03	0.03	-1.46	-0.8	-1.58
Bypass Channel		26.66	0.03	0.03	0.03	-0.04	-1.47	-0.07	0.03	0.03	0.03	0.03	-1.47	-0.8	-1.57
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0.03	0.03	0.03	-0.03	-1.46	-0.28	0.03	0.03	0.03	0.03	-1.46	-0.8	-1.78
Bypass Channel		26.64	0.03	0.03	0.03	-0.03	-1.46	-0.27	0.03	0.03	0.03	0.03	-1.46	-0.8	-1.77
Bypass Channel		26.63	0.03	0.03	0.03	-0.07	-1.45	-0.16	0.03	0.03	0.03	0.03	-1.45	-0.8	-1.66
Bypass Channel		26.62	0.03	0.03	0.03	-0.29	-1.45	-0.13	0.03	0.03	0.03	0.03	-1.45	-0.8	-1.64
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0.04	0.04	0.04	0	-1.47	-0.67	0.04	0.04	0.04	0.04	-1.47	-0.81	-2.18
Bypass Channel		26.6	0.04	0.04	0.04	0.02	-1.46	-0.68	0.04	0.04	0.04	0.04	-1.46	-0.8	-2.18
Bypass Channel		26.59	-0.01	-0.01	-0.01	0	-0.01	-0.01	-0.16	-0.01	-0.04	-0.01	-0.01	0	-0.01
Downstream Bypass		26.34	0	0	0	0	0	0	-0.07	0	-0.07	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	0.02	0	-0.13	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.24	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	-0.05	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.22	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

REGIONAL Event

Reach	Location	Cross Section	WSEL (m) Existing	A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12	218.12
Upstream Church St		26.81	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74	217.74
Upstream Church St		26.8	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72	217.72
Upstream Church St	VODDEN STREET	26.795														
Upstream Church St		26.79	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16	216.16
Upstream Church St		26.78	215.93	216.41	216.4	216.4	215.93	216.23	216.09	215.93	215.93	215.93	216.16	216.24	215.93	216.23
Upstream Church St		26.77	214.96	216.14	216.12	216.12	214.96	213.9	214.32	214.96	214.96	214.96	215.72	214.01	215	213.9
Upstream Church St		26.76	215.01	216.15	216.13	216.13	215.01	214.25	214.49	215.01	215.01	215.01	215.74	214.31	215.04	214.25
Upstream Church St		26.75	214.89	216.12	216.09	216.09	214.89	213.56	214.26	214.89	214.89	214.89	215.69	213.93	214.93	213.73
Upstream Church St		26.74	214.07	216.08	216.06	216.06	214.07	213.49	214.15	214.07	214.07	214.07	215.71	213.6	214.51	213.89
Upstream Church St	CHURCH STREET EAST	26.735														
Upstream Church St		26.73	214.11	214.17	215.08	215.08	214.11	213.19	213.9	214.11	214.11	214.11	215.68	213.38	214.14	213.6
Upstream Church St		26.72	213.79	213.79	215.1	215.1	213.79	213.18	213.92	213.79	213.79	213.79	215.68	213.37	214.15	213.63
SPA	Church Street	26.57	213.63	213.63	212.25	212.25	213.63	212.23	213.25	213.63		213.63	212.19	212.04	212.04	212.27
SPA	Union Street - Nelson Street	26.56	213.63	213.63	212.07	212.07	213.63	211.99	213.24	213.63		213.63	211.76	211.4	211.4	212.18
SPA	Union Street - Nelson Street	26.55	213.63	213.63	212.08	212.08	213.63	211.99	213.25	213.63		213.63	211.77	211.25	211.25	212.18
SPA	Union Street - Main Street	26.54	213.2	213.2	211.94	211.94	213.2	211.87	212.87	213.2		213.2	211.69	211.25	211.25	212.02
SPA	Railway	26.535														
SPA	Union Street - Main Street	26.53	213.12	213.12	211.72	211.72	213.12	211.67	212.74	213.12		213.12	211.53	211.22	211.22	211.79
SPA	Main Street - Nelson Street North of Queen	26.52	213.28	213.28	211.62	211.62	213.28	211.57	212.91	213.28		213.28	211.41	211.02	211.02	211.7
SPA	Main Street - Nelson Street North of Queen	26.51	213.29	213.29	211.56	211.56	213.29	211.46	212.91	213.29		213.29	211.25	210.87	210.87	211.66
SPA	Main Street - Nelson Street North of Queen	26.5	213.28	213.28	211.6	211.6	213.28	211.52	212.9	213.28		213.28	211.32	210.82	210.82	211.69
SPA	Main Street - Nelson Street North of Queen	26.49	213.29	213.29	211.6	211.6	213.29	211.53	212.91	213.29		213.29	211.32	210.82	210.82	211.7
SPA	Main Street - Nelson Street North of Queen	26.48	213.29	213.29	211.6	211.6	213.29	211.52	212.91	213.29		213.29	211.31	210.81	210.81	211.69
SPA	Main Street - Nelson Street North of Queen	26.47	213.19	213.19	211.56	211.56	213.19	211.48	212.83	213.19		213.19	211.28	210.81	210.81	211.65
SPA	Main Street - George Street North of Wellington	26.46	212.62	212.62	211.33	211.33	212.62	211.25	212.35	212.62		212.62	211.11	210.76	210.76	211.39
SPA	Main Street - George Street North of Wellington	26.45	212.19	212.19	211.13	211.13	212.19	211.09	211.95	212.19		212.19	210.99	210.58	210.58	211.17
SPA	Main Street - George Street North of Wellington	26.44	212.06	212.06	211.12	211.12	212.06	211.09	211.82	212.06		212.06	210.98	210.58	210.58	211.17
SPA	Main Street - George Street North of Wellington	26.43	212.06	212.06	211.12	211.12	212.06	211.08	211.83	212.06		212.06	210.97	210.58	210.58	211.17
SPA	Wellington Street	26.42	212	212	210.91	210.91	212	210.86	211.73	212		212	210.73	210.56	210.56	210.97
SPA	Main Street	26.41	211.96	211.96	210.9	210.9	211.96	210.85	211.7	211.97		211.97	210.73	210.24	210.24	210.95
SPA	Main Street	26.4	211.86	211.86	210.84	210.84	211.86	210.8	211.61	211.87		211.87	210.69	210.24	210.24	210.89
SPA	WoodBrook Drive	26.39	211.39	211.39	210.36	210.36	211.39	210.33	211.11	211.42		211.41	210.27	210.24	210.24	210.39
SPA	WoodBrook Drive - Chappel Street	26.38	210.51	210.51	210.25	210.25	210.51	210.24	210.39	210.41		210.45	210.24	210.24	210.24	210.25
SPA	Mary Street	26.37	210.3	210.3	210.24	210.24	210.3	210.24	210.27	209.89		210.15	210.24	210.24	210.24	210.24
SPA		26.36	210.26	210.26	210.24	210.24	210.26	210.24	210.25	209.82		210.11	210.24	210.24	210.24	210.24
SPA		26.35	210.22	210.22	210.24	210.24	210.22	210.24	210.23	209.7		210.05	210.24	210.24	210.24	210.24
Bypass Channel		26.71	213.13	213.13	215.08	215.08	213.09	213.16	213.77	213.13	213.13	213.13	215.27	213.36	214.13	213.51
Bypass Channel		26.7	213.09	213.09	214.93	214.93	213.05	213.04	213.76	213.09	213.09	213.09	215.13	213.21	213.95	213.5
Bypass Channel	SCOTT STREET	26.695														
Bypass Channel		26.69	213.04	213.04	214.83	214.83	213	212.95	213.54	213.04	213.04	213.04	215.01	213.11	213.86	213.21
Bypass Channel		26.68	212.99	212.99	214.82	214.82	212.96	212.94	213.54	212.99	212.99	212.99	215	213.11	213.86	213.2
Bypass Channel		26.67	212.92	212.92	214.8	214.8	212.88	212.89	213.52	212.92	212.92	212.92	214.99	213.07	213.83	213.19
Bypass Channel		26.66	212.89	212.89	214.8	214.8	212.85	212.88	213.52	212.89	212.89	212.89	214.99	213.05	213.81	213.19
Bypass Channel	QUEEN STREET EAST	26.655														
Bypass Channel		26.65	212.86	212.86	214.51	214.51	212.82	212.63	213.17	212.86	212.86	212.86	214.61	212.77	213.5	212.73
Bypass Channel		26.64	212.85	212.85	214.5	214.5	212.81	212.62	213.17	212.85	212.85	212.85	214.61	212.76	213.49	212.72
Bypass Channel		26.63	212.7	212.7	214.47	214.47	212.62	212.47	213.14	212.7	212.7	212.7	214.6	212.63	213.39	212.71
Bypass Channel		26.62	212.67	212.67	214.53	214.53	212.36	212.45	213.13	212.67	212.67	212.67	214.64	212.62	213.45	212.71
Bypass Channel	CNR TRACKS	26.615														
Bypass Channel		26.61	212.27	212.27	213.56	213.56	212.26	211.94	211.85	212.27	212.27	212.27	213.63	212.06	212.77	210.89
Bypass Channel		26.6	212.11	212.11	213.23	213.23	212.11	211.8	211.67	212.11	212.11	212.11	213.25	211.91	212.86	210.72
Bypass Channel		26.59	210.32	210.32	210.13	210.13	210.32	210.13	210.27	209.72	210.32	210.18	210.12	210.1	210.1	210.14
Downstream Bypass		26.34	209.85	209.85	209.85	209.85	209.85	209.85	209.85	209.72	209.85	209.64	209.85	209.85	209.85	209.85
Downstream Bypass		26.33	209.41	209.41	209.41	209.41	209.41	209.41	209.41	209.48	209.41	208.98	209.41	209.41	209.41	209.41
Downstream Bypass		26.32	209.33	209.33	209.33	209.33	209.33	209.33	209.33	209.33	209.33	208.79	209.33	209.33	209.33	209.33
Downstream Bypass		26.31	209.24	209.24	209.24	209.24	209.24	209.24	209.24	209.24	209.24	208.83	209.24	209.24	209.24	209.24
Downstream Bypass	CLARENCE STREET	26.305														
Downstream Bypass		26.3	208.37	208.37	208.37	208.37	208.37	208.37	208.37	208.37	208.37	208.65	208.37	208.37	208.37	208.37
Downstream Bypass		26.29	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58	208.58
Downstream Bypass		26.28	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51	208.51
Downstream Bypass		26.27	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28	208.28
Downstream Bypass		26.26	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49	207.49

Reach	Location	Cross Section	Difference to Existing (m) A1	A2	A3i	A4	A5	A6	A7	A8	A9	C1	C2i	C2ii	C3
Upstream Church St		26.82	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.81	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St	VODDEN STREET	26.795	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.79	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.78	0.48	0.47	0.47	0	0.3	0.16	0	0	0	0.23	0.31	-0.48	0.3
Upstream Church St		26.77	1.18	1.16	1.16	0	-1.06	-0.64	0	0	0	0.76	-0.95	-1.14	-1.06
Upstream Church St		26.76	1.14	1.12	1.12	0	-0.76	-0.52	0	0	0	0.73	-0.7	-1.11	-0.76
Upstream Church St		26.75	1.23	1.2	1.2	0	-1.33	-0.63	0	0	0	0.8	-0.96	-1.19	-1.16
Upstream Church St		26.74	2.01	1.99	1.99	0	-0.58	0.08	0	0	0	1.64	-0.47	-1.57	-0.18
Upstream Church St	CHURCH STREET EAST	26.735	0	0	0	0	0	0	0	0	0	0	0	0	0
Upstream Church St		26.73	0.06	0.97	0.97	0	-0.92	-0.21	0	0	0	1.57	-0.73	-0.03	-0.51
Upstream Church St		26.72	0	1.31	1.31	0	-0.61	0.13	0	0	0	1.89	-0.42	0.36	-0.16
SPA	Church Street	26.57	0	-1.38	-1.38	0	-1.4	-0.38	0		0	-1.44	-1.59	-1.59	-1.36
SPA	Union Street - Nelson Street	26.56	0	-1.56	-1.56	0	-1.64	-0.39	0		0	-1.87	-2.23	-2.23	-1.45
SPA	Union Street - Nelson Street	26.55	0	-1.55	-1.55	0	-1.64	-0.38	0		0	-1.86	-2.38	-2.38	-1.45
SPA	Union Street - Main Street	26.54	0	-1.26	-1.26	0	-1.33	-0.33	0		0	-1.51	-1.95	-1.95	-1.18
SPA	Railway	26.535	0	0	0	0	0	0	0		0	0	0	0	0
SPA	Union Street - Main Street	26.53	0	-1.4	-1.4	0	-1.45	-0.38	0		0	-1.59	-1.9	-1.9	-1.33
SPA	Main Street - Nelson Street North of Queen	26.52	0	-1.66	-1.66	0	-1.71	-0.37	0		0	-1.87	-2.26	-2.26	-1.58
SPA	Main Street - Nelson Street North of Queen	26.51	0	-1.73	-1.73	0	-1.83	-0.38	0		0	-2.04	-2.42	-2.42	-1.63
SPA	Main Street - Nelson Street North of Queen	26.5	0	-1.68	-1.68	0	-1.76	-0.38	0		0	-1.96	-2.46	-2.46	-1.59
SPA	Main Street - Nelson Street North of Queen	26.49	0	-1.69	-1.69	0	-1.76	-0.38	0		0	-1.97	-2.47	-2.47	-1.59
SPA	Main Street - Nelson Street North of Queen	26.48	0	-1.69	-1.69	0	-1.77	-0.38	0		0	-1.98	-2.48	-2.48	-1.6
SPA	Main Street - Nelson Street North of Queen	26.47	0	-1.63	-1.63	0	-1.71	-0.36	0		0	-1.91	-2.38	-2.38	-1.54
SPA	Main Street - George Street North of Wellington	26.46	0	-1.29	-1.29	0	-1.37	-0.27	0		0	-1.51	-1.86	-1.86	-1.23
SPA	Main Street - George Street North of Wellington	26.45	0	-1.06	-1.06	0	-1.1	-0.24	0		0	-1.2	-1.61	-1.61	-1.02
SPA	Main Street - George Street North of Wellington	26.44	0	-0.94	-0.94	0	-0.97	-0.24	0		0	-1.08	-1.48	-1.48	-0.89
SPA	Main Street - George Street North of Wellington	26.43	0	-0.94	-0.94	0	-0.98	-0.23	0		0	-1.09	-1.48	-1.48	-0.89
SPA	Wellington Street	26.42	0	-1.09	-1.09	0	-1.14	-0.27	0		0	-1.27	-1.44	-1.44	-1.03
SPA	Main Street	26.41	0	-1.06	-1.06	0	-1.11	-0.26	0.01		0.01	-1.23	-1.72	-1.72	-1.01
SPA	Main Street	26.4	0	-1.02	-1.02	0	-1.06	-0.25	0.01		0.01	-1.17	-1.62	-1.62	-0.97
SPA	WoodBrook Drive	26.39	0	-1.03	-1.03	0	-1.06	-0.28	0.03		0.02	-1.12	-1.15	-1.15	-1
SPA	WoodBrook Drive - Chappel Street	26.38	0	-0.26	-0.26	0	-0.27	-0.12	-0.1		-0.06	-0.27	-0.27	-0.27	-0.26
SPA	Mary Street	26.37	0	-0.06	-0.06	0	-0.06	-0.03	-0.41		-0.15	-0.06	-0.06	-0.06	-0.06
SPA		26.36	0	-0.02	-0.02	0	-0.02	-0.01	-0.44		-0.15	-0.02	-0.02	-0.02	-0.02
SPA		26.35	0	0.02	0.02	0	0.02	0.01	-0.52		-0.17	0.02	0.02	0.02	0.02
Bypass Channel		26.71	0	1.95	1.95	-0.04	0.03	0.64	0	0	0	2.14	0.23	1	0.38
Bypass Channel		26.7	0	1.84	1.84	-0.04	-0.05	0.67	0	0	0	2.04	0.12	0.86	0.41
Bypass Channel	SCOTT STREET	26.695	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.69	0	1.79	1.79	-0.04	-0.09	0.5	0	0	0	1.97	0.07	0.82	0.17
Bypass Channel		26.68	0	1.83	1.83	-0.03	-0.05	0.55	0	0	0	2.01	0.12	0.87	0.21
Bypass Channel		26.67	0	1.88	1.88	-0.04	-0.03	0.6	0	0	0	2.07	0.15	0.91	0.27
Bypass Channel		26.66	0	1.91	1.91	-0.04	-0.01	0.63	0	0	0	2.1	0.16	0.92	0.3
Bypass Channel	QUEEN STREET EAST	26.655	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.65	0	1.65	1.65	-0.04	-0.23	0.31	0	0	0	1.75	-0.09	0.64	-0.13
Bypass Channel		26.64	0	1.65	1.65	-0.04	-0.23	0.32	0	0	0	1.76	-0.09	0.64	-0.13
Bypass Channel		26.63	0	1.77	1.77	-0.08	-0.23	0.44	0	0	0	1.9	-0.07	0.69	0.01
Bypass Channel		26.62	0	1.86	1.86	-0.31	-0.22	0.46	0	0	0	1.97	-0.05	0.78	0.04
Bypass Channel	CNR TRACKS	26.615	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass Channel		26.61	0	1.29	1.29	-0.01	-0.33	-0.42	0	0	0	1.36	-0.21	0.5	-1.38
Bypass Channel		26.6	0	1.12	1.12	0	-0.31	-0.44	0	0	0	1.14	-0.2	0.75	-1.39
Bypass Channel		26.59	0	-0.19	-0.19	0	-0.19	-0.05	-0.6	0	-0.14	-0.2	-0.22	-0.22	-0.18
Downstream Bypass		26.34	0	0	0	0	0	0	-0.13	0	-0.21	0	0	0	0
Downstream Bypass		26.33	0	0	0	0	0	0	0.07	0	-0.43	0	0	0	0
Downstream Bypass		26.32	0	0	0	0	0	0	0	0	-0.54	0	0	0	0
Downstream Bypass		26.31	0	0	0	0	0	0	0	0	-0.41	0	0	0	0
Downstream Bypass	CLARENCE STREET	26.305	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.3	0	0	0	0	0	0	0	0	0.28	0	0	0	0
Downstream Bypass		26.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.28	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream Bypass		26.26	0	0	0	0	0	0	0	0	0	0	0	0	0

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Appendix D

Capital Cost Estimates

Downtown Brampton Flood Mitigation Feasibility Study - Preliminary Cost Estimates *Estimates include 15% Engineering, 25% Contingency*		
ALTERNATIVE	**Option** (if any)	**Capital Cost**
Upstream - Alternatives to Mitigate Flood Spill into SPA at Church Street		
Combination 1 A3: Flood Protection Landform + A4: Church St Bridge Widening + A6: Widen Bypass Channel (Church St Only)	Option 1 - Church Street FPL	**$64,870,050**
	Option 2 - Alexander Street FPL	**$30,340,100 + Condo Acquisition**
	Option 3 - Ellen Street FPL	**$38,732,050**
Combination 2 A3: Flood Protection Landform + A5: Lower Bypass Channel + A6: Widen Bypass Channel	Option 1 - Church Street FPL	**$69,228,250**
	Option 2 - Alexander Street FPL	**$35,795,200 + Condo Acquisition**
	Option 3 - Ellen Street FPL	**$43,613,850**
Combination 3 A5: Lower Bypass Channel + A6: Widen Bypass Channel		**$15,624,000**
Downstream - Alternatives to Mitigate Backwater into SPA		
A7: Downstream Channel Improvements		**$13,832,000**
A8: Tailwater Flood Protection Landform		**$10,941,595**
A9: Clarence Street Bridge Improvements		**$4,900,000**

Downtown Brampton Flood Mitigation Feasibility Study - Preliminary Cost Estimates *Estimates include 15% Engineering, 25% Contingency*			
ALTERNATIVE	**Option** (if any)	**Capital Cost**	**Notes**
Upstream - Alternatives to Mitigate Flood Spill into SPA at Church Street			
Combination 1 A3: Flood Protection Landform + A4: Church St Bridge Widening + A6: Widen Bypass Channel (Church St Only)	Option 1 - Church Street FPL	**$64,870,050**	- Full mitigation of Regulatory spill from Etobicoke Creek - Upstream flood impacts: potential need to acquire 2 residential properties; floodproofing of 8 additional properties - Option 3 preferred - further consultation with TRCA to confirm permittability of local storm sewers within FPL footprint - *Option 2 does not include acquisition & demolition of 58 Church St (13 Story Condo Building) - **assumed unfeasible** - Acquisition of private property required under all alternatives (commercial, residential - single & multi tennant)
	Option 2 - Alexander Street FPL	~~**$30,340,100**~~	
	Option 3 - Ellen Street FPL	**$38,732,050**	
Combination 2 A3: Flood Protection Landform + A5: Lower Bypass Channel + A6: Widen Bypass Channel	Option 1 - Church Street FPL	**$69,228,250**	- Full mitigation of Regulatory spill from Etobicoke Creek - Channel lowering presents high risk for constraints/conflicts ($2M allowance) - Trunk sanitary sewer crossing @ railway limits lowering to maximum 1.5 m +/- *(Church St. bridge expansion may be required, model update required to confirm)* - Potential for property conflicts related to widening - Upstream flood impacts: potential need to acquire 2 residential properties; floodproofing of 8 additional properties - Option 3 preferred - further consultation with TRCA to confirm permittability of local storm sewers within FPL footprint - *Option 2 does not include acquisition & demolition of 58 Church St (13 Story Condo Building) - **assumed unfeasible**
	Option 2 - Alexander Street FPL	~~**$35,795,200**~~	
	Option 3 - Ellen Street FPL	**$43,613,850**	
Combination 3 A5: Lower Bypass Channel + A6: Widen Bypass Channel		**$15,624,000**	- Partial spill mitigation - Channel lowering presents high risk for constraints/conflicts ($2M allowance) - Trunk sanitary sewer crossing @ railway limits lowering to maximum 1.5 m +/- (Church St. bridge expansion may be required, model update required to confirm) - Potential for property conflicts related to widening
Downstream - Alternatives to Mitigate Backwater Flooding in SPA			
A7: Downstream Channel Improvements		**$13,832,000**	- Flood frequency remains the same - Moderate relief of flooding in SPA, primarily downstream of Wellington Street (Regulatory flood elevation reduced up to 0.5 m +/-) - Limits of landfill are unknown, remediation costs unknown ($5 M allowance provided) - Impacts to City park / recreation centre lands (no cost assigned)
A8: Tailwater Flood Protection Landform		**$10,941,595**	- Eliminates flooding in SPA associated with backwater from Etobicoke Creek (*issues with minor system*) - Blocks surface conveyance outlet of SPA spill to Etobicoke Creek - must be implemented with Combination 1 or 2 - Blocks surface conveyance outlet for local drainage - minor or major storm sewer through FPL required - **not in keeping with FPL design guidelines and may be a feasibility issue, further consultation with TRCA staff required** - Backwater in Etobicoke Creek will require backflow prevention - no outflow from local area during Regulatory event (consistent with existing condition) - Requires acquisition of 3 residential properties - Alternative 'berm' would reduce footprint & eliminate impact to private property at the expense of 'permanent' flood protection
A9: Clarence Street Bridge Improvements		**$4,900,000**	- Flood frequency remains the same - Minor relief of flooding in SPA downstream of Chapel Street (Regulatory flood elevation reduced up to 0.2 m +/-)

Combination 1 Alternative A3: Flood Protection Landform + A4: Church St Bridge Widening + A6: Widen Bypass Channel (Church St Only)									
			EST. QTY.				TOTAL		
ITEM NO.	ITEM	UNIT	Option 1	Option 2	Option 3	UNIT PRICE	Option 1	Option 2	Option 3
Alt A3: Flood Protection Landform									
1	Land Acquisition (Including legal & demolision)	LS					$24,950,000	$1,050,000	$1,050,000
	53 Church St (6 Story Apartment Building)	LS	1			$18,000,000	$18,000,000	$0	$0
	58 Church St (13 Story Condo Building)	LS		1			$0	$0	$0
	Residential lots	EA	2			$1,000,000	$2,000,000	$0	$0
	Commercial	m2	9900	2100	2100	$500	$4,950,000	$1,050,000	$1,050,000
2	Infrastructure/utilities: new, relocate or protect in place	LS					$4,385,000	$4,325,000	$4,325,000
	Protect in-place 200 mm dia watermain		120	0	0	$500	$60,000	$0	$0
	Relocate 1200 mm dia sanitary sewer	m	275	275	275	$3,000	$825,000	$825,000	$825,000
	Relocate 1200 mm dia sanitary sewer (tunnel under watercourse)	m	100	100	100	$15,000	$1,500,000	$1,500,000	$1,500,000
	Relocate Utilities (Allowance)	LS	1	1	1	$2,000,000	$2,000,000	$2,000,000	$2,000,000
3	FPL (Engineered fill, grade to specifications, erosion protection, topsoil)						$7,799,250	$7,338,500	$12,518,750
	Earth excavation & disposal offsite	m3	43800	38600	62400	$35	$1,533,000	$1,351,000	$2,184,000
	Borrow, compact, clay fill	m3	99800	86500	155300	$60	$5,988,000	$5,190,000	$9,318,000
	Erosion protection, wet side toe	t	1855	2650	3445	$150	$278,250	$397,500	$516,750
	Dry Side Toe Minor Storm Sewer System (900 mm diameter)	m			400	$1,250	$0	$0	$500,000
	Dry Side Toe Minor Storm Sewer System (675 mm diameter)	m		400		$1,000	$0	$400,000	$0
4	Landscaping (Topsoil, Seeding & Planting)	m^2	43800	38600	62400	$30	$1,314,000	$1,158,000	$1,872,000
5	Church Street / Ken Whillans Drive Reconstruction	m					$1,087,500	$1,000,000	$1,100,000
	Church Street	m	350	260	260	$2,500	$875,000	$650,000	$650,000
	Ken Whillans Drive	m	85	140	180	$2,500	$212,500	$350,000	$450,000
6	Upstream flood impact mitigation (Allowance)	LS					$2,400,000	$2,400,000	$2,400,000
	Acquire residential lots, including legal and demolision fees	EA	2	2	2	$800,000	$1,600,000	$1,600,000	$1,600,000
	Floodproof impact lots	EA	8	8	8	$100,000	$800,000	$800,000	$800,000
Alt A4: Church Street Bridge									
7	Bridge including foundations and appurtenances (52 m span +/-)	EA	1	1	1	$4,000,000	$4,000,000	$4,000,000	$4,000,000
Alt A4: Church Street Bridge									
8	Channel Widening/Rehabilitation (through Church St bridge)	m	200	200	200	$2,000	$400,000	$400,000	$400,000
SUBTOTAL							$46,335,750	$21,671,500	$27,665,750
	Engineering (15%)						$6,950,363	$3,250,725	$4,149,863
	Contingency (25%)						$11,583,938	$5,417,875	$6,916,438
TOTAL							**$64,870,050**	**$30,340,100**	**$38,732,050**

Combination 2 Alternative A3: Flood Protection Landform + A5: Lower Bypass Channel + A6: Widen Bypass Channel									
ITEM NO.	ITEM	UNIT	EST. QTY.			UNIT PRICE	EST. QTY.		
			Option 1	Option 2	Option 3		Option 1	Option 2	Option 3
Alt A3: Flood Protection Landform									
1	**Land Acquisition (Including legal & demolision)**						**$24,550,000**	**$1,050,000**	**$1,050,000**
	53 Church St (6 Story Apartment Building)	LS	1			$18,000,000	$18,000,000	$0	$0
	58 Church St (13 Story Condo Building)	LS		1			$0	$0	$0
	Residential lots	EA	2			$800,000	$1,600,000	$0	$0
	Commercial	m2	9900	2100	2100	$500	$4,950,000	$1,050,000	$1,050,000
2	**Infrastructure/utilities: new, relocate or protect in place**						**$5,885,000**	**$5,825,000**	**$5,825,000**
	Protect in-place 200 mm dia watermain		120	0	0	$500	$60,000	$0	$0
	Relocate 1200 mm dia sanitary sewer	m	275	275	275	$3,000	$825,000	$825,000	$825,000
	Relocate 1200 mm dia sanitary sewer (tunnel under watercourse)	m	100	100	100	$30,000	$3,000,000	$3,000,000	$3,000,000
	Relocate Utilities	LS	1	1	1	$2,000,000	$2,000,000	$2,000,000	$2,000,000
3	**FPL (Engineered fill, grade to specifications, erosion protection, topsoil)**						**$6,402,250**	**$6,328,000**	**$11,107,750**
	Earth excavation & disposal offsite	m3	38800	33500	57000	$35	$1,358,000	$1,172,500	$1,995,000
	Borrow, compact, clay fill	m3	76100	69300	131600	$60	$4,566,000	$4,158,000	$7,896,000
	Erosion protection, wet side toe	t	1855	2650	3445	$150	$278,250	$397,500	$516,750
	Dry Side Toe Minor Storm Sewer System (900 mm diameter)	m			400	$1,250	$0	$0	$500,000
	Dry Side Toe Minor Storm Sewer System (675 mm diameter)	m		400		$1,000	$0	$400,000	$0
	Creek Rehabilitation (through Church St bridge)	m	200	200	200	$1,000	$200,000	$200,000	$200,000
4	**Landscaping (Topsoil, Seeding & Planting)**	**m^2**	**38800**	**33500**	**57000**	**$30**	**$1,164,000**	**$1,005,000**	**$1,710,000**
5	**Church Street / Ken Whillans Drive Reconstruction**						**$1,087,500**	**$1,000,000**	**$1,100,000**
	Church Street	m	350	260	260	$2,500	$875,000	$650,000	$650,000
	Ken Whillans Drive	m	85	140	180	$2,500	$212,500	$350,000	$450,000
6	**Upstream flood impact mitigation (Allowance)**						**$1,200,000**	**$1,200,000**	**$1,200,000**
	Acquire residential lots, including legal and demolision fees	EA				$800,000	$0	$0	$0
	Floodproof lot	EA	8	8	8	$150,000	$1,200,000	$1,200,000	$1,200,000
Alt A5/A6: Lower/Widen Bypass Channel									
8	**Lower Bypass Channel**						**$9,160,000**	**$9,160,000**	**$9,160,000**
	Dewatering	LS	1	1	1	$500,000	$500,000	$500,000	$500,000
	Demolition & disposal of existing bypass channel	m^3	3000	3000	3000	$300	$900,000	$900,000	$900,000
	Existing infrastructure/utilities: relocate or protect in place (Allowance)	LS	1	1	1	$2,000,000	$2,000,000	$2,000,000	$2,000,000
	Earth excavation & disposal offsite	m^3	25200	25200	25200	$50	$1,260,000	$1,260,000	$1,260,000
	Reconstruction of by-pass channel *(cost may be covered by Riverwalk Project)*	m^3	3000	3000	3000	$1,500	$4,500,000	$4,500,000	$4,500,000
	Property Impacts (Allowance)	LS	1	1	1	$2,000,000	$2,000,000	$2,000,000	$2,000,000
SUBTOTAL							$49,448,750	$25,568,000	$31,152,750
	Engineering (15%)						$7,417,313	$3,835,200	$4,672,913
	Contingency (25%)						$12,362,188	$6,392,000	$7,788,188
TOTAL							**$69,228,250**	**$35,795,200**	**$43,613,850**

Combination 3 A5: Lower Bypass Channel + A6: Widen Bypass Channel					
			EST. QTY.		**EST. QTY.**
ITEM NO.	**ITEM**	**UNIT**	**Option 1**	**UNIT PRICE**	**Option 1**
Alt A5/A6: Lower/Widen Bypass Channel					
	Dewatering	LS	1	$500,000	$500,000
	Demolition & disposal of existing bypass channel	m^3	3000	$300	$900,000
	Existing infrastructure/utilities: relocate or protect in place (Allowance)	LS	1	$2,000,000	$2,000,000
	Earth excavation & disposal offsite	m^3	25200	$50	$1,260,000
	Reconstruction of by-pass channel *(cost may be covered by Riverwalk Project)*	m^3	3000	$1,500	$4,500,000
	Property Impacts (Allowance)	LS	1	$2,000,000	$2,000,000
SUBTOTAL					$11,160,000
	Engineering (15%)				$1,674,000
	Contingency (25%)				$2,790,000
TOTAL					**$15,624,000**

Alternative A7: Downstream Floodplain Improvements					
ITEM NO.	**ITEM**	**UNIT**	**EST. QTY.**	**UNIT PRICE**	**TOTAL**
2	Existing infrastructure/utilities: relocate or protect in place	LS	1	$200,000	$200,000
3	Earth excavation & disposal offsite	m^3	60000	$35	$2,100,000
4	Landfill impact mitigation (Allowance)	LS	1	$5,000,000	$5,000,000
5	Watercourse rehabilitation / natural heritage compensation	m	860	$3,000	$2,580,000
SUBTOTAL					*$9,880,000*
	Engineering (15%)				$1,482,000
	Contingency (25%)				$2,470,000
TOTAL					**$13,832,000**

Alternative A8: Tailwater Flood Protection Landform					
ITEM NO.	**ITEM**	**UNIT**	**EST. QTY.**	**UNIT PRICE**	**TOTAL**
	Land Acquisition (Residential lots)	EA	3	$800,000	$2,400,000
	Earth excavation & disposal offsite	m^3	22000	$35	$770,000
	Borrow, compact, clay fill	m^3	57000	$60	$3,420,000
	Erosion protection, wet side toe	t	1669.5	$150	$250,425
	Minor Storm Sewer System w/ Backflow Prevention (1200 mm diameter assumed)	m	210	$1,500	$315,000
	Landscaping (Topsoil, Seeding & Planting)	m^2	22000	$30	$660,000
SUBTOTAL					$7,815,425
	Engineering (15%)				$1,172,314
	Contingency (25%)				$1,953,856
TOTAL					**$10,941,595**

Alternative A9: Clarence Street Bridge Improvements					
ITEM NO.	**ITEM**	**UNIT**	**EST. QTY.**	**UNIT PRICE**	**TOTAL**
1	Bridge including foundations and appurtenances (48 m span +/-)	LS	1	$3,500,000	$3,500,000
SUBTOTAL					*$3,500,000*
	Engineering (15%)				$525,000
	Contingency (25%)				$875,000
TOTAL					**$4,900,000**