Submitted to:

Toronto and Region Conservation Authority,

5 Shoreham Drive
Downsview, Ontario
M3N 1S4
Attention: Mr. Nick Lorrain
Senior Project Manager, Engineering Services

ETOBICOKE CREEK FLOODPLAIN MAPPING UPDATE

FINAL REPORT

Prepared by:

Aquafor Beech Limited

December, 2016

Aquafor Beech Reference: 65655

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Aquafor Beech Limited

16 December, 2016

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

Attention: **Mr. Nick Lorrain**
Senior Project Manager, Engineering Services

Dear Mr. Lorrain:

Aquafor Beech Limited is pleased to submit the Final Report for the Etobicoke Creek Floodplain Mapping Update Study. The study included:

- Review and update of TRCA's existing HEC-RAS hydraulic model for Etobicoke Creek;
- Extension of the hydraulic model over additional tributary reaches;
- Application of TRCA's updated flood flow estimates for Etobicoke Creek; and
- Regulatory Floodplain Mapping through the Cities of Toronto, Mississauga, Brampton and Town of Caledon.

It has been our pleasure working with the TRCA on the study. Should you have any questions, please contact myself at (905) 790-3885, ext. 276.

Sincerely,
AQUAFOR BEECH LIMITED

LICENSED PROFESSIONAL ENGINEER
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16Dec'16
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1 INTRODUCTION

In 2013, the Toronto and Region Conservation Authority (TRCA) completed a hydrology update study which defined flood flow estimates throughout the Etobicoke Creek watershed. In 2014, TRCA retained Aquafor Beech Limited to complete a watershed-wide floodplain mapping update using the updated flood flows. The process included a comprehensive update to the existing HEC-RAS hydraulic model for Etobicoke Creek, extending the model to cover additional tributary reaches, and development of Regulatory Floodplain Mapping for all reaches.

1.1 Study Area

The study area is illustrated in Figure 1.1 and includes the main branch and tributaries of the Etobicoke Creek watershed as it flows south from the Town of Caledon, through the Cities of Brampton, Mississauga and Toronto to the outlet at Lake Ontario. Portions of the watershed which are subject to separate detailed studies are excluded from this study. The excluded areas include:

- Little Etobicoke Creek near Dixie Road and Dundas Street in Mississauga. Floodplain mapping for this area is being completed as part of a separate 2-D modelling study;
- Spring Creek from upstream of Highway 407 to roughly Williams Parkway in Brampton. Floodplain mapping for this area is being completed as part of a separate 2-D modelling study;
- The Main Branch of Etobicoke Creek through the downtown core of the City of Brampton from upstream of Clarence Street to north of Church Street. Mapping for this area is being updated as part of a Special Policy Area (SPA) study.

1.2 Study Objectives

The key objectives of the study are as follows:

- a review and update to the existing HEC-RAS hydraulic model in order to identify and correct model deficiencies;
- updating the model to include new flood flows from the 2013 Hydrology Update Study;
- plotting updated Regulatory Floodplain Map sheets;
- extension of the HEC-RAS model and floodplain mapping coverage beyond the current limits.

Based on the above, a 2-phased approach was applied to complete the study:

- Phase 1 includes the first three objectives noted above, namely a review and update to the existing HEC-RAS model and floodplain mapping;

- Phase 2 includes extension of the modelling and mapping over a number of tributary reaches which were previously not covered.

The stream reaches covered in each of the two study phases are illustrated in Figure 1.2. As shown, Phase 1 covers most of the existing 28 floodplain map sheets. The remaining map sheets are the subject of separate studies. Phase 2 covers an additional 10 floodplain map sheets.

Figure 1.1: Study Area

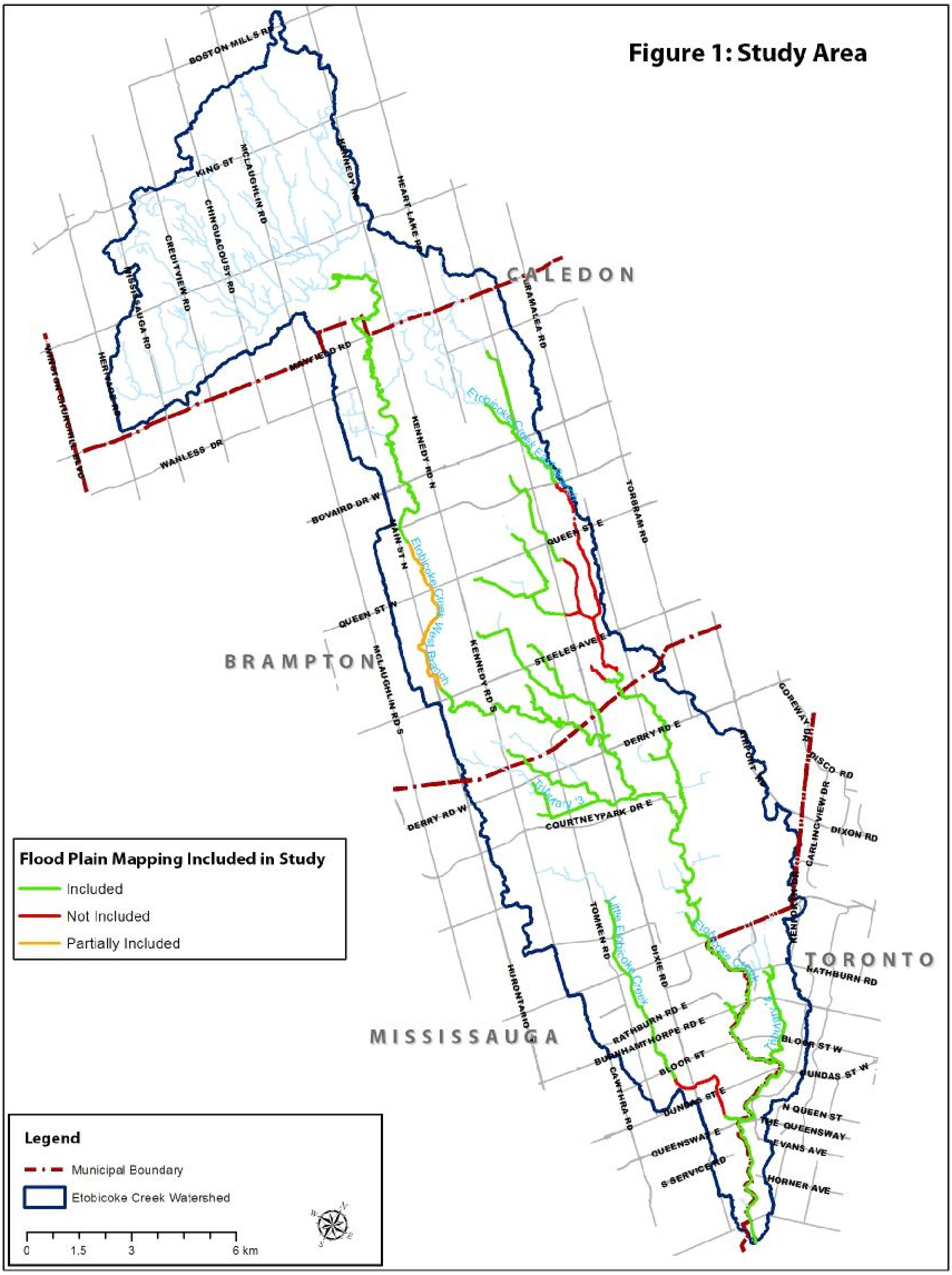
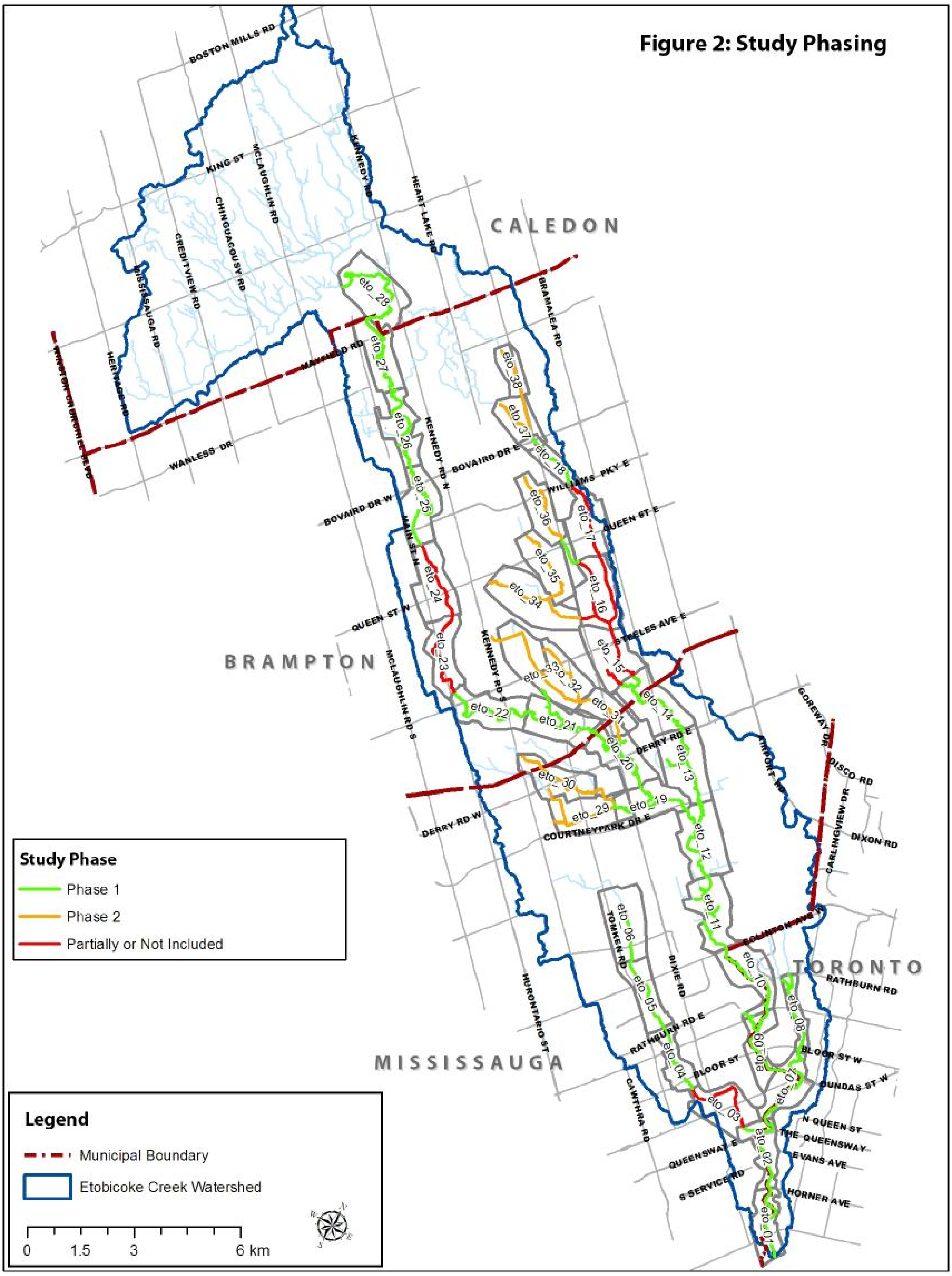


Figure 1.2: Study Phasing



2 PHASE 1 – EXISTING HYDRAULIC MODEL AND FLOODPLAIN MAPPING UPDATE

Key tasks involved in the first phase of the study included incorporation of updated flood flow rates from the 2013 hydrology update study, as well as completing a comprehensive review of the model parameters, bridge modelling approaches, cross-section spacing and orientation in order to improve model performance, stability and minimize model warnings. The “base” HEC-RAS hydraulic model used in this update study was originally assembled by Greck and Associates in 2012, which was, in turn, an update to an earlier version of the model. The Greck and Associates update included an inventory of bridge and culvert crossing structures as well as updates to the coding of these structures using available design information and topographic mapping.

2.1 Flood Flow Rates

Flood flow rates from the 2013 Etobicoke Creek Hydrology Update Study (MMM) were supplied by TRCA for use in the hydraulic model update. Flows for design storm events ranging from the 2-year through 100-year storm, as well as the 350-year storm and Regional Storm were included. The 2-year through 100-year flood flow rates are based on the Existing Conditions landuse scenario which includes stormwater management controls. The 350-year and Regional Storm flood flow rates are based on the Future Conditions landuse scenario excluding stormwater management facilities, as per TRCA standard practices. The flood flow rates applied in the hydraulic model update are summarized in Appendix A.

Boundary conditions for the model, in the form of starting water surface elevations, were also provided by TRCA at the outlet to Lake Ontario, as well as upstream of the creek reaches being modelled under separate 2-D model studies. Starting water surface elevations are summarized in Table 2.1.

Table 2.1: Phase 1 Model Boundary Conditions

Locations	Starting Water Surface Elevation (m)								Notes
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	350 Year	Regional	
Reach 1 – Lake Ontario Cross-section No. 1.01	75.8	75.8	75.8	75.8	75.8	75.8	75.8	75.8	Mean Lake Ontario Water level
Little Etobicoke Creek Cross-section No. 8.23	125.18	125.39	125.52	125.66	125.76	125.85	126.24	126.59	Flood level set per separate 2D model of downstream reach
Etobicoke Creek (Downtown Brampton) Cross-section No. 26.81	214.44	214.67	214.84	215.03	215.19	215.33	216.00	217.74	Flood level set per separate Downtown Brampton model
Spring Creek Cross-section No. 23.41	212.84	213.22	213.58	213.79	213.87	213.94	214.63	214.90	Flood level set per separate 2D model of downstream reach

2.2 Cross-Section Adjustments

The model update included a comprehensive review of the existing hydraulic model cross-section locations, orientation and spacing. Several adjustments were completed in an effort to improve general model performance, stability and minimize model warnings. This included:

- Adding new cross-sections to the model to reduce the spacing between sections and/or reduce the changes in water surface elevations;
- Extension of cross-sections in an effort to contain the flood elevation and avoid vertical extensions within the model;
- Re-orientation of cross-sections to better follow a path perpendicular to the direction of flow as well as to avoid intersecting other cross-sections;
- Moving / adding / and/or re-orienting cross-sections to better represent the estimated flow contraction and expansion zones upstream and downstream of bridge/culvert crossings. This is discussed further in Section 2.3.

In most cases, the cross-sections were defined using a digital topographic surface supplied by TRCA. At select locations, portions of the cross-sections were defined instead using survey data or direct measurement from contour mapping. Appendix B summarizes the cross-section adjustments, together with the rational for each change. In total, approximately 135 cross-sections were added and/or modified throughout the model.

One of the key objectives of TRCA's model update was to reduce the instances where the model is unable to balance the conveyance calculations, resulting in critical depth solutions, and to reduce the instances where the computed water surface elevation between cross-sections is greater than 0.5m. Further model refinements were tested through TRCA's review of the model, including the use of the cross-section interpolation command in HEC-RAS, however, in most instances these attempts were unsuccessful, or resulted in further critical depth solutions. Through this review, it was concluded that the critical depth solutions are generally a reflection of the geometry of the Etobicoke Creek valley system, including the longitudinal profile, abrupt changes in the valley configuration, and cross-sectional areas that can vary considerably from a narrow confined system to a wide shallow system. For these reasons, TRCA and Aquafor study team members were satisfied that the cross-section model adjustments result in reasonable model performance and that critical depth solutions and changes in water surface elevations are generally a reflection of the valley geometry and/or impacts associated with bridge/culvert crossing structures. Correspondence between TRCA and Aquafor Beech regarding the review of the model setup and results is provided in Appendix G.

2.3 Bridge / Culvert Structure Adjustments

The coding of bridge and culvert crossing structures within the model was reviewed and adjusted, where necessary, to improve general model performance and in an effort to improve consistency in the structure modelling approach throughout the model.

It should be noted that, in most cases, the bridge/culvert opening dimensions and weir profiles above the structure (generally represented by the roadway profile) were coded as part of the preceding 2012 Greck and Associates study using available design information and mapping. The scope of the current 2014 update study included visual cross-checks of the model coding for these structures versus the Stream Crossing Field Inventory Sheets and associated photos from the 2012 study. Detailed surveys, measurements and re-coding of the structure openings and weir profiles were generally not required. Rather, the current study focused on review and adjustment of the structure modelling approaches to conform with recommended modelling standards and to improve the general consistency in applying these approaches throughout the model.

A summary of the model adjustments to the coding of bridge and culvert crossing structures is provided in Appendix C. In general, the model adjustments included the following:

- Set the stationing of the ineffective flow area to correspond to the structure opening widths;
- Checked and revised the ineffective flow elevations, where necessary, according to the weir profile for the structure;
- Cross-section spacing adjustments upstream and downstream of the crossing structures:
  - downstream cross-section spacing was checked and revised, where necessary, to meet a recommended expansion ratio of 2:1 (Figure 2.1);
  - upstream cross-section spacing was checked and revised, where necessary, to meet a recommended contraction ratio of 1:1 (Figure 2.1).

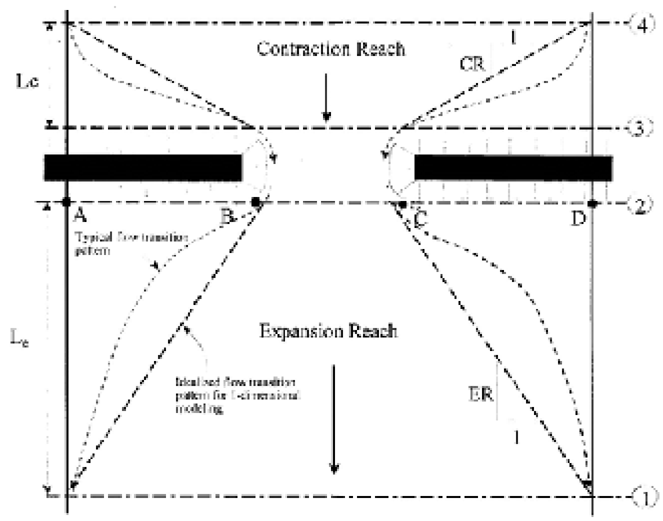


Figure 2.1: Cross-Section Locations at Bridge/Culvert Crossings

(source: HEC-RAS Model User's Manual)

- checked and revised the bridge modelling approach, where necessary:
  - for low flows, the model was set to select the highest energy answer using appropriate coefficients for peirs (where present);
  - for high flows, the model was set to use pressure and/or weir flow calculations
- checked and revised entrance loss coefficients for culverts, where necessary, according to the headwall/wingwall configuration;
- set the Manning's "n" values through the bridge opening to match the roughness from the surrounding cross-sections.

Additional adjustments were also completed at select structure locations to account for some site-specific conditions. This included adjustments to the standard Manning's "n" values to reflect concrete surfaces through select bridges (see Section 2.4). Other site-specific modifications to the model include:

- the Brampton SPA at Main Street. Here, a topographic survey of the weir profile, bridge opening, and the bounding low flow channel was completed and used to supplement the cross-section coding from the topographic mapping. In addition, spot elevations on the top of the berm on the east side of the creek upstream of Main Street were also used to adjust the corresponding berm heights in the model cross-sections. Further, a multiple opening approach, using both a bridge opening and conveyance segment (for the potential overland spill "around" the bridge) was found to produce a less abrupt flood profile than the traditional bridge modelling approach at this location.

- the Highway 407 bridge at Spring Creek. Here, the bounding cross-sections were re-oriented and coded from contour mapping, as the digital surface produced inconsistencies at the bridge opening. Further, the weir profile was re-oriented to reflect the fact that flood waters would spill westward via the north ditch, before the road is overtopped. Also, it was noted that photos of this bridge which accompany the 2012 structure inventory may have been switched with the Highway 407 bridge over the Main Branch of Etobicoke Creek.

Within the Pearson Airport lands there are two other crossing structures on Spring Creek which may require further future adjustment if additional information becomes available:

- the Courtney Park Drive crossing of Spring Creek is coded as a bridge with 19 peirs. However, this crossing actually consists of 20 box culverts. This structure was discussed with TRCA and it was recommended that the coding be updated if design information becomes available from federal Airport staff.

- the Pearson Airport runway crossing of Spring Creek is a long (>500m) triple barrel box structure. Available design information indicates that one of the barrels includes low-flow baffle structures. This structure was discussed with TRCA and it was recommended that the coding be updated if further design information becomes available from federal Airport staff. Given the non-standard configuration of this structure, alternative modelling methods may also be investigated.

Correspondence between TRCA and Aquafor Beech regarding the review of the model setup, including the bridge structures, is provided in Appendix G.

2.4 Manning's Roughness Adjustments

For consistency, Manning's "n" roughness values were set to TRCA standards throughout most of the HEC-RAS model:

- main channel – 0.035
- overbanks – 0.080
- concrete culverts – 0.013

As noted in Section 2.3 above, the Manning's "n" values through bridge openings were also set to match the 0.035 and 0.080 roughness values for the main channel and overbank areas, respectively.

There were, however, select locations where the Manning's roughness values varied from the general values outlined above in order to account for site-specific conditions. These areas included:

- The Etobicoke Creek SPA at Dundas Street. Here, a value of 0.050 was used to represent the urban overbank conditions at the overland spill zone through the industrial/commercial lots on the west side of the creek.
- The Brampton East SPA at Main Street. Here, a value of 0.050 was used to represent the urban overbank conditions at the overland spill zone through the commercial parking area on the southeast side of the creek.
- Spring Creek north of Chingcousy Park in Brampton. Here, values of 0.013 and 0.050 were used to represent the concrete channel and manicured overbank park area, respectively.
- Bridges at Eglinton Avenue, Williams Parkway, and Sandalwood Parkway. A value of 0.013 was used to represent the concrete surfaces through each of these bridges.

A summary of the Manning's "n" roughness values applied throughout the model is provided in Appendix D.

2.5 Model Results and Floodplain Mapping

The updated HEC-RAS hydraulic model was applied to establish water surface profiles for each of the 2-year through 100-year design storm flows for the Existing Conditions landuse scenario. In addition, the model was also applied to determine the 350-year and Regional Storm flood profiles associated with the future uncontrolled landuse scenario. The model was executed using the subcritical flow regime. Model results, including profile plots and output tables are presented in Appendix E.

The Regulatory Flood profile for the subject reaches of Etobicoke Creek is based on the Regional Storm results. Results from the HEC-RAS model were exported and the HEC-GeoRAS model extension was applied to plot the resulting floodplain extents onto the supplied topographic basemapping. The preliminary floodplain mapping results were reviewed in conjunction with the model output to verify and refine the floodplain extents. Correspondence between TRCA and Aquafor Beech regarding the review of the floodplain mapping is provided in Appendix H.

The resulting Regulatory Floodplain Mapping is included in digital format, on compact disc, in Appendix I of the report. Full-scale plots of the resulting Regulatory Floodplain Maps were also supplied to TRCA.

As was illustrated in Figure 1.2, the Phase 1 study includes floodplain mapping for all or part of 25 of 28 map sheets which cover the study area. An additional 3 map sheets are the subject of separate 2-D modelling and/or SPA studies by TRCA and are excluded from the modelling and mapping for this current study, namely:

- Map 3: 2-D modelling for Little Etobicoke Creek near Dixie Road and Dundas Street in Mississauga;
- Map 16: 2-D modelling for Spring Creek through Brampton. This reach actually extends from just north of Highway 407 on Map 15 to Central Park Drive on Map 17;
- Map 24: Mapping for the Main Branch of Etobicoke Creek through downtown Brampton is being updated as part of a Special Policy Area (SPA) study.

Regarding the second item above, HEC-RAS model results indicate that flood elevations exceed cross-section extents on Spring Creek near Central Park Drive and Hilldale Crescent immediately upstream of the 2-D modelling area on Map 17. The topography of this area was reviewed with TRCA in an effort to extend the model cross-sections and contain the flood levels. However, model results continue to indicate a potential spill of floodwaters from the watercourse at these locations. Due to these spills, it is recommended that modelling and floodplain mapping for this reach of Spring Creek from Central Park Drive to Williams Parkway on Map 17 would be better addressed as part of the downstream 2-D modelling study.

In addition to the Regulatory Floodplain Mapping, 350-year floodlines were also mapped over Map Sheets 7 and 23, covering the Etobicoke Creek SPA at Dundas Street, and the Brampton East SPA, respectively.

3 PHASE 2 – HYDRAULIC MODEL AND FLOODPLAIN MAPPING EXTENSION

The second phase of the study includes extension of the hydraulic modelling and floodplain mapping over a number of tributary reaches which were previously not covered. The Phase 2 stream reaches are illustrated in Figure 1.2.

3.1 Structure Inventory

Bridge and culvert crossing structures along the Phase 2 stream reaches were identified and indexed from a preliminary review of GIS mapping and air photos. A total of 58 hydraulic structures were identified. **Figure 3.1** illustrates the location of these structures.

Available design drawings were used to document key hydraulic information for the structures, including:

- Structure type (culvert/bridge);
- Material (concrete/steel);
- Opening shape and dimensions;
- Upstream and downstream invert elevations.

Field investigations were completed to visually cross-check the information from the design drawings and to create a photographic inventory for the structures. For several structures, either no background design drawings were available, or the invert elevations were not identified on the drawings. Further topographic surveys were completed for these structures in order to define the invert elevations to be used in the model. In total, surveys were completed at 19 structures with missing information.

Structure inventory forms summarizing the key hydraulic information gathered through the topographic surveys and available design drawings are included in Appendix F.

A number of indexed structures were found to be small pedestrian bridges. These locations were reviewed with TRCA staff, and where they do not represent a significant obstruction to flood flows, they were not included in the model. These include:

- Structures 6, 8, 16, 17 and 22 – small footbridges;
- Structures 23 and 26 – footbridges or access roads which have been recently removed.

Figure 3.1: Phase 2 Bridge and Culvert Structure Locations

3.2 Hydraulic Model Setup

3.2.1 Flood Flow Rates and Boundary Conditions

Flood flow rates from the 2013 Etobicoke Creek Hydrology Update Study (MMM) were supplied by TRCA for use in extending the hydraulic model over the subject Phase 2 stream reaches. As with the Phase 1 study, the 2-year through 100-year flood flow rates are based on the Existing Conditions landuse scenario which includes stormwater management controls, whereas the 350-year and Regional Storm flood flow rates are based on the Future Conditions landuse scenario excluding stormwater management facilities, as per TRCA standard practices. The flood flow rates applied in the hydraulic model update are summarized in Appendix A.

Boundary conditions for the model, in the form of starting water surface elevations, were set as follows:

- Where the modelled Phase 2 stream reach represents an extension to an existing Phase 1 model reach, the starting water surface was set to the values calculated at the upstream end of the Phase 1 reach;

- Where the modelled Phase 2 stream reach was not contiguous with an existing Phase 1 model reach, or was upstream of a separate 2D model reach, the starting water surface was set to normal depth with an assumed slope set according to the slope of the channel.

Starting water surface elevations for the Phase 2 model reaches are summarized in Table 3.1. As shown, boundary conditions for Reaches 1a, 2e1 and 3a1 were set according to the Phase 1 model results. Normal depth assumptions were applied at the downstream end of Reaches 2a and 2b1. Both of these starting channel reaches are quite steep, therefore, the upstream model results are not expected to be impacted significantly by any backwater at these starting locations.

Table 3.1: Phase 2 Model Boundary Conditions

Locations	Starting Water Surface Elevation (m)								Notes
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	350 Year	Regional	
Reach 1a1 – Cross-section No. 23.67	229.75	230.16	230.42	230.70	230.88	231.04	231.52	232.50	starting water levels set equal to calculated WSEL's from Phase 1 results at X-section 23.67
Reach 2a – Cross-section 22.61	Normal depth assumed. Starting slope set at 1% based on approximate slope between x-sections 22.62 to 22.67								
Reach 2b1 – Cross-section 21.0	Normal depth assumed. Starting slope set at 2.8% based on approximate slope between x-sections 21.00 to 21.05								
Reach 2e1 – Cross-section 29.00	171.79	171.97	172.04	172.08	172.14	172.60	173.05	173.66	starting water levels set equal to calculated WSEL's from Phase 1 results at X-section 25.06
Reach 3a1 – Cross-section 19.10	162.99	163.25	163.42	163.62	163.77	163.92	195.49	165.86	starting water levels set equal to calculated WSEL's from Phase 1 results at X-section 19.05

3.2.2 Cross-Sections

A base model was assembled using topographical information from the TRCA digital elevation model (DEM), together with ArcGIS software and the HEC-GeoRAS. This spatial data was used to define channel cross-sections, stream centrelines, and overbank locations for the Phase 2 stream reaches. Cross sections were spaced to account for changes in channel geometry, meanders, bridge/culvert structures, and to account for the narrowest sections of the creeks.

Manning's roughness coefficients were assigned to each cross-section based on conditions observed in available areal photography. Unlike the Phase 1 stream reaches, many of the Phase 2 stream reaches are engineered urban channels that do not have a typical valley/floodplain shape. Instead, flows that exceed the channel capacity are conveyed over the surrounding urban lands. Manning's "n" values were set according to TRCA standards:

- main channel – 0.035
- vegetated banks – 0.080
- concrete culverts – 0.013
- urban lawns and/or roadways – 0.050

The "low-flow" channel inverts were then refined throughout the base model to match defined invert elevations at the bridge/culvert crossing structures. The inverts between structures were also refined to provide a smoother and more consistent stream profile than was defined initially through the DEM. The base model was further refined through the addition of obstructions within the cross-sections to represent buildings which may be within the flow path.

Care was taken to extend cross-sections to an elevation sufficient to contain the flow, wherever feasible, in an effort to prevent the model from assuming artificial vertical extensions. In many locations, this required extension of the cross-sections to a topographic high point that represents the location where spill out of the channel would begin, possibly into an adjacent tributary system. In some locations, buildings may also be located on the topographic high point that represents the spill location between tributaries. In these situations, vertical walls were included in the coding, where appropriate, to represent the edge of a building located on a high point.

It was later confirmed that the modelled flood elevations exceeded the cross-section extents at several locations. These locations were reviewed to confirm that the resulting artificial vertical model extensions were indeed associated with locations where the flood flows may potentially spill from the creek. These spill locations are reviewed later in Section 3.3.1.

3.2.3 Culvert/Bridge Structures

Four cross sections were coded at each bridge/culvert structure to account for expansion and contraction of the flow at these structures (i.e. two upstream and two downstream of each structure). The spacing of these cross-sections was estimated using flow expansion and contraction ratios recommended in the model manual. In general, the locations for the upstream cross-sections were selected by assuming a typical flow contraction ratio of 1:1, while the downstream cross-section locations were selected based on expansion ratios that were typically in the range of 2:1 (see Figure 2.1). Expansion and contraction coefficients used in the model were setup using the following recommended values:

	Contraction Coefficient	Expansion Coefficient
Natural Sections	0.1	0.3
Abrupt Changes (culverts)	0.3	0.5

Data from the structure survey (Section 3.1), including the structure material, opening dimensions and invert elevations, were applied to code the bridge/culvert structures into the model. Manning’s roughness coefficients for the structures were selected from standard values recommended for use with concrete and corrugated steel pipes. The ineffective flow area option was applied in the model to restrict the flow area to the width of the structure opening until the structure is overtopped and weir flow begins over the road structure.

Overflow/weir profiles were defined using topographic information from the TRCA digital elevation model (DEM). Weir profiles were located along what was judged to be the spill “horizon”. Review of the topographic mapping indicates that, in some locations, the overflow weir profile is not necessarily represented by the road surface alone. For example, the weir profiles for Highway 410 culvert structures were often located to account for spill that would occur down a roadside ditch before the floodwaters ever reached the road. In other situations, the upstream boulevard may be higher than the road, meaning that the floodwaters would have to pond to a greater level than the centre of road elevation before overflow begins. The estimated height and length of observed parapet headwalls were also included in the weir profiles, where appropriate, to represent obstructions to the flow.

It is noted that Structure #55 on Tributary 3a required special consideration when setting up the HEC-RAS model. This structure consists of a storm sewer with varying pipe sizes and some bends along a total length of 826m. Since HEC-RAS does not allow varying pipe sizes over the length of a structure, external calculations were completed to estimate an equivalent manning's "n" that accounts for the losses through all of the pipe segments and bends. Calculations are included in the structure inventory in Appendix F. As shown, pipe sizes vary from 1.8m (entrance) to 2.25m (exit). Using the actual total length (826m), the losses through the system can be represented by a single 1.8m pipe (first pipe segment) with a Manning's "n" of 0.013. Documentation was added to the description in the HEC-RAS culvert editor to outline the assumptions.

3.3 Model Results and Floodplain Mapping

The HEC-RAS hydraulic model for the Phase 2 stream reaches was applied to establish water surface profiles for each of the 2-year through 100-year design storm flows for the Existing Conditions landuse scenario. In addition, the model was also applied to determine the 350-year and Regional Storm flood profiles associated with the future uncontrolled landuse scenario. The model was executed using the subcritical flow regime. Model results for the Phase 2 stream reaches, including profile plots and output tables are presented in Appendix G.

The Regulatory Flood profile for the Phase 2 stream reaches is based on the Regional Storm results. Results from the HEC-RAS model were exported and the HEC-GeoRAS model extension was applied to plot the resulting floodplain extents onto the supplied topographic basemapping. The preliminary floodplain mapping results were reviewed in conjunction with the model output to verify and refine the floodplain extents. Correspondence between TRCA and Aquafor Beech regarding the review of the hydraulic model setup and draft floodplain mapping is provided in Appendix H.

The resulting Regulatory Floodplain Mapping is included in digital format, on compact disc, in Appendix I of the report. Full-scale plots of the resulting Regulatory Floodplain Maps were also supplied to TRCA.

3.3.1 Spills

As noted in Section 3.2.2, several locations were found where flood flows may spill out of the subject creek reaches and into adjacent tributaries. These locations are illustrated in Figure 3.2 and discussed further below.

- **Spill Area 1** – The Regional Storm flow exceeds the channel capacity of Tributary 1a at this location. The depth of the floodwaters may be up to approximately 0.7m at the spill location. The topography of the area suggests that the spilled floodwaters would be conveyed westward towards Tributary 1b through the subdivision on the north side of Peter Robertson Blvd. Additional spill from Tributary 1a to Tributary 1b may also occur immediately south of Peter Robertson Blvd. Given the number of buildings that are potentially impacted, further detailed 2D modelling and floodplain mapping is recommended to better define the flood hazards at this location.

- **Spill Area 2** – Flood flows exceed the channel capacity of Tributary 2b at this location, resulting in a significant spill of floodwaters southward between West Drive and Dixie Road, as well as southwestward in the vicinity of Floribunda Crescent. Modelling results suggest that floodwaters may begin to spill for flood events as frequent as the 2-year storm, and could be over 2m in depth for the Regional Storm at the spill location. The topography of the area suggests that the spilled floodwaters would be conveyed south through the employment lands and Dixie Road to Tributary 2b1 just south of Orenda Road. Given the number of buildings that are potentially impacted, as well as the depth and frequency of the predicted spills, further detailed 2D modelling and floodplain mapping is recommended to better define the flood hazards at this location.

- **Spill Area 3 -** Flood flows exceed the channel capacity on the north side of Tributary 2b1 at this location. Modelling results suggest that floodwaters may begin to spill onto Orenda Road for flood events that exceed the 25-year storm, and may be approximately 0.5m to 1.0m deep for the Regional Storm at the spill location. The topography of the area suggests that the spilled floodwaters would be conveyed southwest along Orenda Road to the outfall of a piped segment of Tributary 2b1 near the intersection of Orenda Road and Dixie Road. It is recommended that further detailed 2D modelling and floodplain mapping be undertaken for this area in conjunction with Spill Area 2.

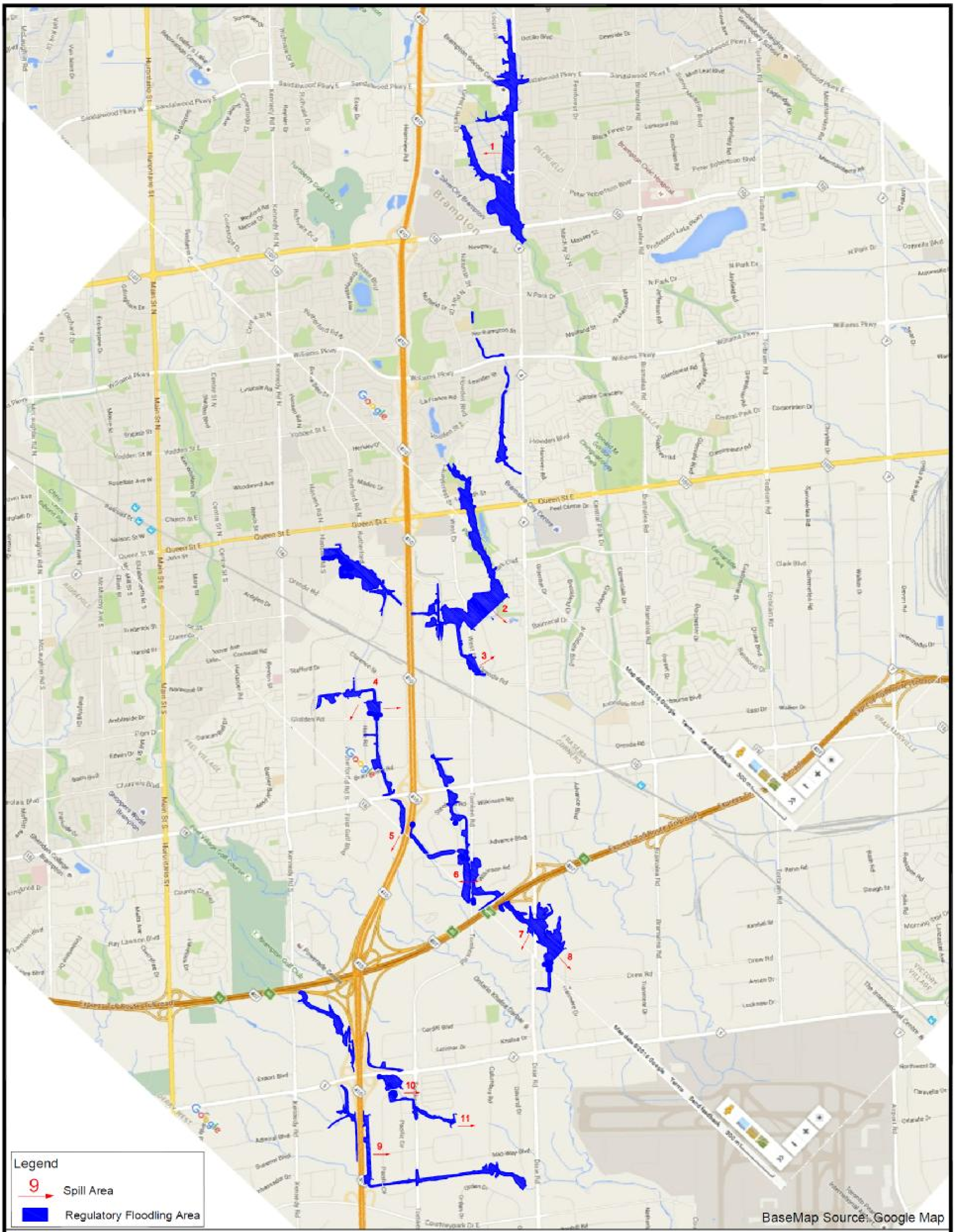


Figure 3.2 - Regulatory Floodplain and Potential Spill Areas

- **Spill Area 4 -** Flood flows exceed the channel capacity on Tributary 2d at this location. Modelling results suggest that floodwaters may begin to spill into the surrounding employment lands for flood events that exceed the 100-year storm, and could be up to approximately 0.5m in depth for the Regional Storm at the spill location. Floodwaters will spill to the south and west side of the channel just upstream of Glidden Road, and the topography of the area suggests that the spill would re-enter the channel southeast of the intersection of Glidden Road and Hale Road. Additional spill may also occur from the east side of the channel just upstream of Glidden Road. Topography suggests that these spilled floodwaters would be collected near Glidden Road and Heart Lake Road, and possibly be directed under Highway 410 to Tributary 2e.

- **Spill Area 5** – Floodwaters that pond on Tributary 2d behind Highway 410 will spill southward along the west ditch of the highway. Modelling results suggest that floodwaters may begin to spill for flood events that exceed the 10-year storm. The topography of the area suggests that the spilled floodwaters would be conveyed south along the Highway 410 ditch before being directed southeast via a highway culvert to a small tributary of the Main Branch of Etobicoke Creek.

- **Spill Area 6** – At this location, Tributaries 2d and 2e flow south, parallel to each other on either side of Tomken Road. Floodwaters from both tributaries are expected to exceed their channel capacities and spill into each other, resulting in a single, wide floodplain at this location. Floodwaters will spill to the east near Wilkinson Road and to the south on the upstream side of Tomken Road. The topography of the area suggests that floodwaters from both of these spills will be collected on the north side of Highway 407 and return to the main channel, just downstream of Junction 12 at Reach 2e1.

  Alternative methods to better define the flood elevations for these two channels were investigated by the Study Team and TRCA. Attempts were made to adjust the flow rates in order to balance the water levels between the two channels, however, the hydraulics were found to be too complex for a one-dimensional steady state model. Given that a number of buildings and roads are potentially affected by the spills, and given the complexity of the interacting channel flows, further 2D modelling is recommended to better define the flood hazards at this location. For the purposes of the current floodplain mapping study, the highest of the two modelled flood elevations was plotted over both channels.

- **Spill Area 7** – This spill occurs as floodwaters backup and exceed an elevation of approximately 180m behind Dixie Road on Tributary 2e1. The spill occurs in a southerly direction on the upstream side of the road. Modelling results indicate that floodwaters may begin to spill for flood events that exceed the 10-year storm. The topography of the area suggests that the spilled floodwaters would be collected northwest of the intersection of Dixie Road and Drew Road, before being conveyed via a storm pipe back to the Tributary 2e1 channel.

- **Spill Area 8 -** Flood flows exceed the channel capacity on the east side of Tributary 2e1 at this location. Modelling results suggest that floodwaters may begin to spill into the surrounding employment lands upstream of Drew Road for Regional Storm, and may exceed 1m in depth at the topographic low points on the east side of the channel. The topography of the area suggests that the floodwaters will be conveyed through the development via Tranmere Drive, potentially re-entering the 2e1 channel south of Drew Road.

- **Spill Area 9 -** Flood flows exceed the channel capacity on the east side of Tributary 3b at this location. Modelling results suggest that floodwaters may begin to spill eastward into the surrounding employment lands for flood events that exceed the 100-year storm, and may exceed 1m in depth at the topographic low points on the east side of the channel. The topography of the area suggests that the spill may be conveyed through the Pacific Circle development area, likely re-joining Tributary 3b downstream at the Pacific Circle cul-de-sac or Tomken Road. Given the number of buildings that are potentially impacted, as well as the depth of the predicted spills, further detailed 2D modelling and floodplain mapping is recommended to better define the flood hazards at this location.

- **Spill Area 10 -** This spill occurs as floodwaters backup on the north side of Pacific Circle on Tributary 3a. The spill is expected to be relatively shallow, at approximately 0.5m or less, and would occur in a southeasterly direction via the road itself. The topography of the area suggests that the spilled floodwaters would be directed southeast, re-joining the Tributary 3a channel just downstream of a second Pacific Circle crossing.

- **Spill Area 11** – This spill occurs as floodwaters backup behind the entrance to a 826m long storm sewer section (Structure #55), and begin to spill into the employment lands to the southeast. Model results suggest that spill may begin for flood events that exceed the 5-year storm, and the depth of the floodwaters may be up to approximately 0.7m for the Regional Storm at the spill location. The topography of the area suggests that the spilled floodwaters would be directed southeast through the employment lands, via Invader Crescent and Columbus Road, before joining the Tributary 3a1 channel just downstream of the storm sewer outfall south of Midway

Blvd. Given the number of buildings that are potentially impacted, as well as the frequency of the predicted spills, further detailed 2D modelling and floodplain mapping is recommended to better define the flood hazards at this location.

In summary, based on the review and preliminary assessment of the spill areas noted above, including the number of buildings affected, as well as the frequency and depth of flooding, it is recommended that TRCA consider further detailed 2D modelling and floodplain mapping to better define the flood hazards at sites 1, 2 & 3 (combined), 6, 9, and 11.

4 CONCLUSIONS AND RECOMMENDATIONS

TRCA retained Aquafor Beech Limited to complete a watershed-wide floodplain mapping update for the Etobicoke Creek watershed. The study included:

- Review and update of TRCA's existing HEC-RAS hydraulic model for Etobicoke Creek;
- Extension of the hydraulic model over additional tributary reaches;
- Application of TRCA's updated flood flow estimates for Etobicoke Creek; and
- Regulatory Floodplain Mapping through the Cities of Toronto, Mississauga, Brampton and Town of Caledon.

The study was completed in two phases corresponding to the updates to the existing model/mapping, followed by model/mapping extensions. Figure 1.2 illustrates the areas covered by each of the two phases of the study, as well as a number of reaches that are subject to separate 2D modelling studies.

4.1 Conclusions

In Phase 1 of the study, the existing hydraulic model was updated to improve general model performance, stability and minimize model warnings. This included:

- Cross-section adjustments, including re-orientation and extensions to existing cross-sections, as well as adding new cross-sections to the model. In total, approximately 135 cross-sections were added and/or modified throughout the model;
- Review and adjustment to the coding of bridge/culvert crossing structures within the model to improve general model performance and provide consistency in the structure modelling approach throughout the watershed;
- Application of TRCA's standard Manning's "n" roughness values;

As part of Phase 2 of the study, the model was then extended over a number of additional tributary reaches which were previously not covered. This included:

- Use of topographic information from TRCA's digital elevation model to define channel cross-sections, stream centerlines, and overbank locations;

- Coding of bridge/culvert structures into the model based on information from as-constructed drawings; and

- Topographic surveys to gather hydraulic information for other bridge/culvert structures for which no background drawings were available.

Updated TRCA flood flow estimates for Etobicoke Creek were then applied in the model. The study concluded with the development of updated Regulatory Floodplain Mapping over the subject reaches of Etobicoke Creek. In addition, 350-year floodlines were also mapped over map sheets covering the Etobicoke Creek SPA at Dundas Street, and the Brampton East SPA.

4.2 Recommendations

Through the course of the study, a number of recommendations were made to further improve the accuracy of TRCA's modelling and floodplain mapping:

- The coding of two crossing structures on the Pearson Airport property should be updated in the model if additional design information becomes available from federal airport staff. The Courtney Park Drive and airport runway crossing of the Spring Creek tributary include multiple non-standard culverts, however, the model coding for these structures could not be updated as topographic surveys on the airport property were not possible.

- Hydraulic model results indicate that flood elevations exceed the cross-section extents on Spring Creek near Central Park Drive and Hilldale Crescent, representing a potential spill of floodwaters from the watercourse at these locations. Due to these spills, it is recommended that modelling and floodplain mapping for this reach of Spring Creek would be better addressed as part of the separate downstream 2D modelling study which TRCA is undertaking;

- The Phase 2 hydraulic model extension and floodplain mapping identified eleven (11) potential new spill locations, as illustrated in Figure 3.2. These spill areas were reviewed in terms of the number of buildings affected, as well as the frequency and depth of flooding. On this basis it is recommended that TRCA consider further detailed 2D modelling and floodplain mapping to better define the flood hazards at spill sites 1, 2 & 3 (combined), 6, 9, and 11.

- Upon completion of any separate future 2D modelling studies within the watershed, it is recommended that the boundary conditions in the HEC-RAS model be updated for the adjoining stream reaches.

5 REFERENCES

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