Black Creek at Rockcliffe Special Policy Area Flood Remediation and Transportation Feasibility Study, City of Toronto

Final Report

Toronto and Region Conservation Authority
Project # TPB198079

Prepared for:

Toronto and Region Conservation Authority
101 Exchange Avenue, Vaughan, ON L4K 5R6

07/23/2020

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07/23/2020

EXECUTIVE SUMMARY

In 2014, the Toronto and Region Conservation Authority (TRCA) and the City of Toronto completed separate studies to assess the riverine and urban flood risks respectively, associated with the Rockcliffe Special Policy Area (SPA), near the lower portion of the Black Creek as it confluences with the Humber River. The riverine flood risk study, "*Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment', March 2014,* prepared by Wood Environment & Infrastructure Solutions (Wood), proposed various riverine-based flood risk reduction measures for the Rockcliffe Special Policy Area.

Subsequently, through a higher resolution hydraulic modelling exercise (conducted by DHI on behalf of TRCA in April 2018) for the Black Creek and its tributary (Lavender Creek), it was determined that some of the previously proposed remediation measures, recommended in 2014, specifically flood control berms, may exacerbate flood risks in some locations, depending on their operative mechanics.

As a result of the foregoing, along with various uncertainties related to capital works implementation, including utilities and constructability matters, TRCA and the City of Toronto commissioned this Feasibility Study, as a potential pre-cursor to a future comprehensive Class Environmental Assessment (EA).

This Feasibility Study, has assessed a broad range of flood mitigation alternatives for the Rockcliffe Special Policy Area including the alternatives advanced by the 2014 Class EA, and other new alternatives, and has considered these both on a reach by reach basis, as well as in combination. The flood remediation alternatives have been evaluated by various technical disciplines (including transportation, natural systems, cultural heritage, structural, water resources and geotechnical engineering, SUE) to develop integrated solutions that may be further assessed as part of a future Class EA.

The preferred solutions, which are being advanced by the Feasibility Study, include the following flood mitigation alternatives:

- Flood protection wall/ berm upstream of the Weston Road bridge with a crest elevation of 107.4 m (0.5 m +/- wall height plus freeboard).
- Lowering and widening of the Black Creek channel reach from Alliance Avenue to Jane Street (50 m to 55 m wide) with average slope from Alliance Avenue to Jane Street (0.20 % +/-).
- Widening the Rockcliffe Boulevard bridge opening to 52 m via two 26 m span openings and lowering the invert of the opening.
- Widening the Jane Street crossing to a 102 m span bridge (72 m required for hydraulics) with three (3) support piers. Additional span width required to accommodate valley side slopes (due to geotechnical constraints).
- Widening, lowering and naturalizing the Lavender Creek channel from Symes Road to the confluence with Black Creek (22.5 m wide +/-) with an average channel slope (0.50 % +/-).
- Removing the unused private crossing on Lavender Creek.
- Replacing the northern Symes Road crossing on Lavender Creek with a 20 m span structure and lowering the invert of the structure.
- Replacing the Symes Road culvert on Lavender Creek with 2 side-by-side rectangular culverts (5.4 x 1.8 m) and lowering the invert by 1 m.

Subsequent to the adoption of this Feasibility Study the City of Toronto, in partnership with TRCA, is planning to initiate a Municipal Environmental Class EA to will satisfy the requirements of the Municipal Engineers Association (MEA) Class EA process and depending on the subject undertaking will either follow Schedule 'B' or Schedule 'C' to further assess the recommended flood mitigation alternatives, including consultation with agencies, stakeholder, public and engagement with Indigenous groups.

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1.0 Introduction

In 2014, the Toronto and Region Conservation Authority (TRCA) and the City of Toronto completed separate studies to assess the riverine and urban flood risks respectively, associated with the Rockcliffe Special Policy Area (SPA), near the lower portion of the Black Creek as it confluences with the Humber River (ref. Figure 1.1). The riverine flood risk study, "Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment', March 2014, prepared by Wood Environment & Infrastructure Solutions (Wood), proposed various riverine-based flood risk reduction measures for the Rockcliffe Special Policy Area.

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1.1 Study Area

The Rockcliffe Area of the Black Creek constitutes a subwatershed of the Humber River. It is located near the downstream limit of the subwatershed. The watercourse system has been highly altered within the study area (ref. Figure 1.1) through concrete lining and numerous bridge and culvert crossings. Notably, urban development has historically encroached into the watercourses' flood plain and this has resulted in a significant flood risk to both property and life. The TRCA has estimated that over 1,800 people are exposed to direct flood risk during a Regional Storm based on Hurricane Hazel centering itself over this subwatershed. The study area (although not explicitly demarked in Figure 1.1) was expanded over the course of the study to include the Weston Road crossing and the creek immediately upstream of Weston Road.

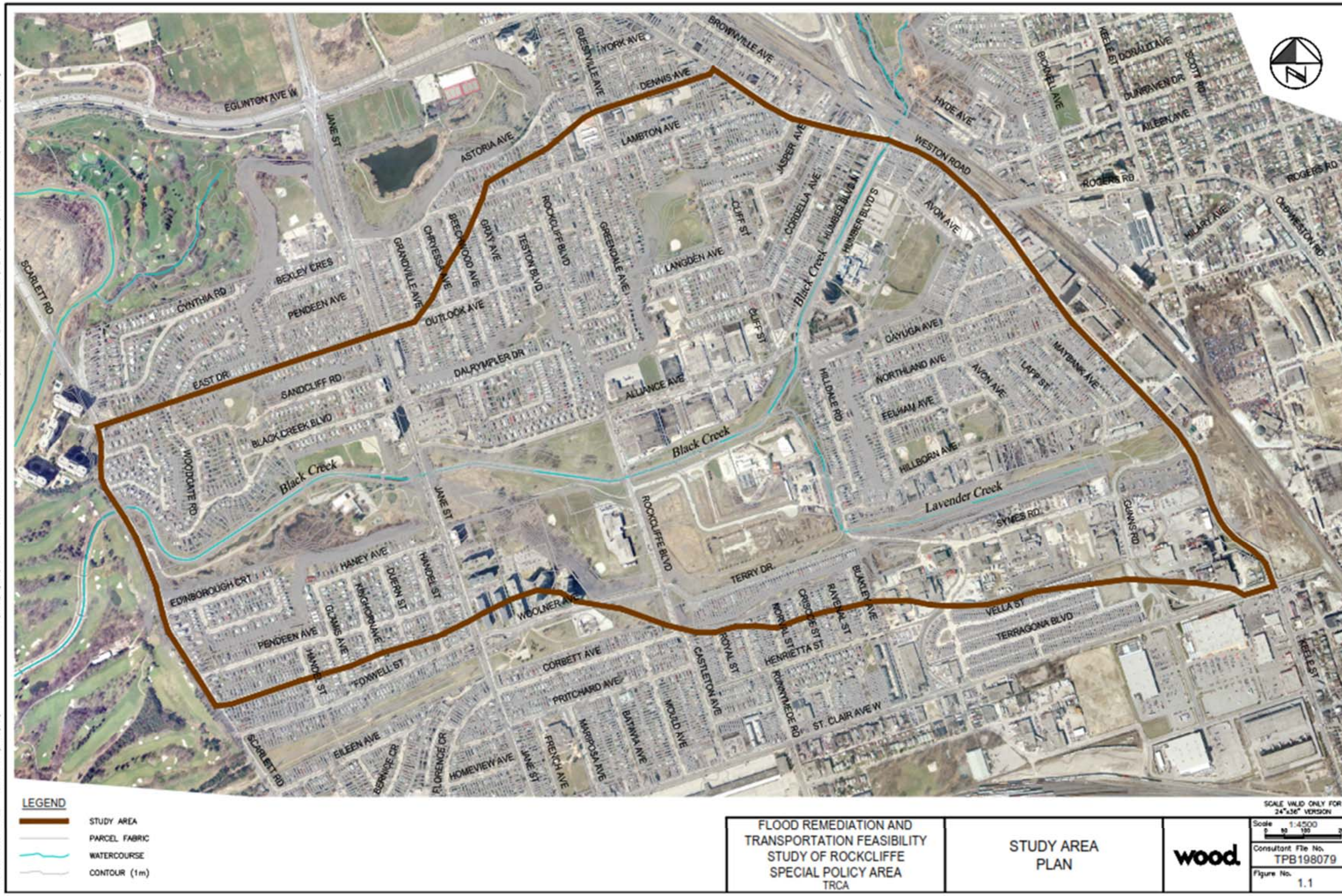

Figure 1.1. Study Plan Area

2.0 Background Review

2.1 General

2.1.1 Reports and Studies

The following reports and studies have been reviewed as part of this Feasibility Study:

Hydrology (Watershed/Subwatershed-based)

- Humber River Hydrology Update, June 2015, CIVICA Infrastructure Inc.
- Humber River Hydrology Update – Addendum, April 2018, CIVICA Infrastructure Inc.

Hydraulics (Riverine)

- Rockcliffe SPA 2D Flood Modelling and Mapping Update, April 2018, DHI.
- Summary of Area Recommendations to Address Flood Risk in Rockcliffe Area, Black Creek (Humber System) City of Toronto, TRCA, February 2017, Amec Foster Wheeler (now Wood)
- Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment, March 2014, AMEC (now Wood)

Natural Systems

- Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment (Wood, 2014);
- Toronto Municipal Code Chapter 658, Ravine and Natural Feature Protection (City of Toronto 2016);
- City of Toronto Official Plan (City of Toronto 2019);
- Department of Fisheries and Oceans Canada (DFO) Aquatic species at risk map (DFO 2018);
- Atlas of the Mammals of Ontario (AMO; Dobbyn 1994);
- Species at Risk Public Registry database (MECP 2019a);
- Bat Conservation International Inc. (BCI 2018);
- Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Information Centre (NHIC) database 1 km x 1 km squares 17PJ2036, 17PJ2037, 17PJ2136, 17PJ2137, 17PJ2236, 17PJ2237, 17PJ2336 and 17PJ2337 (MNRF 2019);
- Ontario Reptile and Amphibian Atlas 10 km x 10 km square 17PJ(ORAA; Ontario Nature 2019);
- Ontario Butterfly Atlas 10 km x 10 km square 17PJ (OBA, TEA 2019);
- eBird (2019);
- Ontario Breeding Bird Atlas 10 km x 10 km square 17PJ (ABBO, SBC et al. 2006);
- Online aerial imagery (Google Earth 2018);
- Land Information Ontario (LIO; MNRF 2019); and
- The following information provided by TRCA:
    - Ecological Land Classification (ELC); and
    - Flora and Fauna Records.

Geotechnical

- Various Borehole (BH) records in Study Area -10 BHs
- Various BH records in close vicinity of Study Area -8 BHs
- Geotechnical Report for Contract 14EY-14RD), April 2014, VVM – 2BHs
- Geotechnical Investigation for Contract 09EY-I8WS), December 2008, John Emery Geotechnical Engineering Limited – 13BHs
- Geotechnical Investigation for Contract 03D2-16WS), May 2003, Saheen & Peaker Limited – 2BHs

- Geotechnical Investigation for Selected Roadways in Etobicoke), June 2001, Candec Consultants Limited
- Geotechnical Investigation Keele Trunk Relief Sewer and), August 1991, Golder Associates Ltd.– BHs

Traffic and Transportation

- April 2010 traffic volumes on north bound Humber Boulevard, south of Weston Road;
- November 2011 traffic volumes on north bound Weston Road, south of Black Creek Drive;
- October 2012 Traffic volumes on south bound Jane Street, north of Haney Avenue; and
- 2017 AADT information at some of the Black Creek crossings at provided on the Structural Inspection Reports.
- Signal timing for signalized intersections

Utilities and Infrastructure

- Conceptual Design Report, Investigation of Basement Flooding Area 4, January 2015 R.V Anderson Associates Limited and XCG Consultants Ltd; and
- Environmental Study Report South Class Environmental Assessment Area Combined Sewer Overflow Control and Basement Flooding Areas 4 and 5', August 2014, XCG Consultants Ltd.

Cultural Heritage

- City of Toronto Heritage Register:
- City of Toronto Heritage Management Plan Phase 1 (2007);
- City of Toronto Master Plan of Archaeological Resources (2004);
- Humber River Watershed Plan (2008);
- Toronto Bridge Inventory;
- Humber Heritage Bridge Inventory (2011);
- Parks Canada Register of Historic Places (CRHP); and
- Canadian Heritage Rivers Register

2.1.2 Mapping and Drawings

The TRCA has provided the following GIS mapping layers:

Table 2.1. GIS Mapping Layers

• 2018 Aerial	• Floodlines	• Building footprints	• SPA Boundary
• Land use	• Roads	• Waterourses	• ELC, Flora and Fauna

The TRCA has provided the following topographic surveys and elevation data:

- 2015 and 2018 Lavender Creek conditions
- 2018 Black Creek conditions
- 3D Trianagular Irregular Network (TIN) based on 2018 LiDAR data

The City of Toronto has provided the following MicroStation layers:

Table 2.2. MicroStation Layers

• Buildings Footprint	• Sewers and appurtances in plan view	• Watermain and appurtenances in plan view	• Culvert locations
• Ditch lines	• Roads, lane ways, sidewalks, trails and parking lots	• Various pole locations	• Property boundaries
• Retaining walls	• Traffic signals	• TTC rail and bus shelters	• Treed Areas

The City has provided as built plans (drawings) for the following structures:

Weston Road Bridge at Humber Boulevard
Louvain Avenue and Humber Boulevard – Pedestrian Bridge
Symes Road (Lavender Creek to Glen Scarlett Road)
Symes Road Northern Crossing
Symes Road Southern Crossing
Rockcliffe Boulevard at Black Creek
Jane Street at Black Creek
Scarlett Road at Black Creek
Smythe Park Bridges

The following data sources have been downloaded from the City of Toronto's "Open Data Portal":

- Natural Heritage
  - Shapefiles for natural heritage areas
  - Ravine & natural feature protection areas
- Cultural Heritage
  - Shapefile for cultural spaces
  - Cultural Location Index spreadsheet
- Planned City projects
  - Capital budget plans / City programs by wards for 10 year periods, covering 2010 – 2027
- Planned Development
  - Summary of development applications (description, location, status, etc.)
- Emergency and Community Services
  - Toronto Fire services – run areas
  - Police boundaries
  - Multi-use trail entrance mapping

2.1.3 Site Walk

A site walk with TRCA was conducted on June 25, 2019 following the Start-up Meeting. A photographic reconnaissance record of the site walk is provided in Appendix C. General observations during the site walk included the following:

- The Black Creek concrete lined channel is in reasonable condition with limited vegetation and debris within the channel.
- A flood gate has been installed at 501 Alliance Avenue, an industrial property immediately upstream of the Rockcliffe Boulevard Crossing to prevent flooding at a loading bay.
- TRCA has an active flow depth gauge immediately downstream of the Alliance Avenue crossing. TRCA also has a staff gauge and camera system at the same location to complement TRCA's monitoring system.
- Hilldale Road has localized sag points. There are also a number of reverse slope driveways along the road.
- The Symes Road crossing of Lavender Creek appeared to be undersized based on the size of the culvert

2.2 Hydrology (Watershed/Subwatershed-based)

2.2.1 Reports and Studies

The following reports and studies have been reviewed related to Humber River Hydrology:

Humber River Hydrology Update, June 2015, CIVICA Infrastructure Inc.

TRCA initiated a Humber River Hydrology Update, completed by CIVICA Infrastructure Inc. (CIVICA) in June 2015, to update the hydrologic modelling to reflect the existing land use changes in the Humber River Watershed since the 2002 study (ref. Humber River Hydrology Update, Aquafor Beech Limited, 2002). The updated modelling initiative was completed using Visual OTTHYMO (VO) and was used to estimate peak flows for 2 to 500 year design storms and the Regional Storm event (Hurricane Hazel) under both existing and future land use scenarios, and aid in developing stormwater management criteria for future development.

Humber River Hydrology Update – Addendum, April 2018, CIVICA Infrastructure Inc.

CIVICA prepared a subsequent addendum in April 2018 to the previous hydrologic update from 2015, to address a number of inconsistencies related to the future conditions land use scenario. No alterations were made to the existing conditions models, as the focus of the additional study was to provide a revised watershed scale future conditions land use map consistent with land uses in the various Local and Regional municipalities, and subsequent future conditions model scenarios. The purpose of the April 2018 modelling exercise was to assess impacts of proposed future development on storm flows associated with the larger events including the 350 year, 500 year and Regional regulatory storms.

2.2.2 Modelling

The 2015 Humber River Hydrology Update included a revised Visual OTTHYMO (VO) hydrologic model representing 2014 land use conditions within the Humber River Watershed. Remaining consistent with the previous hydraulic work completed by DHI (ref. Rockcliffe SPA 2D Flood Modelling and Mapping Update, April 2018, DHI), the 2015 hydrologic model developed by CIVICA was used as the main source for existing conditions hydrologic data and flows for the Rockcliffe study area. The simulation scenarios included the 2, 5, 10, 25, 50, 100 and 350 year design storms under steady state flow conditions, and the Regional Storm Event under both steady and unsteady flow conditions. The drainage area contributing to the Rockcliffe Area, is considered to be built out, therefore, existing and future condition peak flows are essentially the same.

2.3 Hydraulics (Riverine)

2.3.1 Reports and Studies

The following reports and studies have been reviewed related to riverine hydraulics:

Rockcliffe SPA 2D Flood Modelling and Mapping Update, April 2018, DHI.

In 2018, DHI completed the study entitled "Rockcliffe SPA 2D Flood Modelling and Mapping Update" where an integrated 1D-2D MIKE FLOOD model was developed to update floodplain maps and to evaluate flood risks to the Rockcliffe Area under existing conditions and with proposed flood mitigation scenarios. The MIKE FLOOD model provides a dynamic coupling between the 1D MIKE 11 model used to represent the main channel of Black Creek, and the 2D MIKE 21 model used to represent overland flow caused by overbank flooding from Black Creek. The MIKE FLOOD model was executed in both steady state and unsteady state conditions, with the unsteady state modelling conducted to produce more realistic results, with reduced backwater and associated flow attenuation upstream of structures.

TRCA updated the integrated 1D-2D MIKE FLOOD model in 2019 to include an explicit representation of Lavender Creek as a separate branch of the 1D model rather than the original representation as an inflow boundary condition to Black Creek. In addition, due to the long run times of the previous MIKE FLOOD model, TRCA has updated the 2D model to use the flexible mesh, finite volume solution of MIKE 21 rather than the uniform grid, finite difference solution used in the previous model. The model has also been extended downstream of the Humber River confluence to limit boundary affects through the Rockcliffe study area, and peak flow values have been revised to ensure consistency with the 2018 Humber Hydrology Addendum. No formal documentation exists for this version of the model, however, TRCA has indicated the updated MIKE FLOOD model runs considerably faster than the previous version.

Summary of Area Recommendations to Address Flood Risk in Rockcliffe Area, Black Creek (Humber System) City of Toronto, TRCA, February 2017, Amec Foster Wheeler (now Wood)

This report summarized the area recommendations from the March 2014 Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment and the January 2015 Conceptual Design Report, Investigation of Basement Flooding Area 4. While the 2014 and 2015 studies were distinct to flood mechanisms (riverine versus urban), the respective leads, TRCA and the City of Toronto, had representation on each other's studies and thereby ensured continuity with respect to the findings of each, in particular where one set of system improvements (i.e. lowered river water levels) could provide companion benefits to the other, through for instance the performance of the local drainage system (i.e. improved storm sewer conveyance).

Each study developed a set of management strategies focussed on coordinated and system-based infrastructure improvements. The report provides a contextual outline of the respective priorities and implementation requirements stemming from each study, including the Environmental Assessment Act status and follow-on study requirements, expected timing, as well as capital and life cycle costs, including potential needs for land acquisition. An implementation framework was developed, which integrated the objectives and findings of each study providing guidance, to a coordinated strategy and program for addressing flood risk in the Rockcliffe Area.

Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment, March 2014, AMEC (now Wood)

This Conservation Ontario, Class Environmental Assessment, was initiated in response to major riverine flooding across TRCA's watershed, as part of TRCA's overall Flood Control Program. The Rockcliffe Area was originally ranked fifth (5th) out of thirty-one (31) flood damage centres in terms of overall priority within TRCA's jurisdictional area; currently, (as of 2020) the Rockcliffe Area is ranked first (1st) out of the thirty-one (31) damage centres (pers. communication Chipps: Lorrain, July 6, 2020). The study used the Conservation Ontario Class EA process (reference 2002, updated 2009) as the basis to assess the problem of riverine flooding along the Black Creek.

The riverine flood risk for this area was assessed using HEC-RAS one dimensional (1D) hydraulic modelling (i.e. to determine flood depths, elevations and velocities along and within the Black Creek floodplain). The 2002 Humber River study (ref. Humber River Watershed Hydrology Update, Aquafor Beech Limited, 2002) provided the peak flow rates for the Rockcliffe Area, which were used in the hydraulic model to determine the level of flood risk. The Rockcliffe Area was divided into four (4) distinct reaches for the flood risk assessment that have different hydraulic characteristics. For each reach, the level of risk and the number of properties at risk were determined, with a total of 226 properties at risk for the 100 year storm event and 413 properties at risk for the Regional Storm (Hurricane Hazel).

The study determined that flood risk can be reduced by lowering flood levels, decreasing the frequency of flooding and thereby removing some of the properties from flood risk by flood proofing properties and/or buildings. Further, by increasing the conveyance capacity including hydraulic crossing sizes (e.g. Jane Street Crossing), channel widths and floodplain geometry, flow conveyance can be increased in this area. Flood proofing measures included earthen berms, flood walls and improvements to buildings. A flood protection berm/wall was recommended for the flood risk area of Hilldale Avenue, downstream of the Symes Road crossing of Lavender Creek based on the original steady state 1D hydraulic analysis. The subsequent 2018 MIKE coupled 1D/2D unsteady state modelling, determined that a flood protection berm may not be the preferred flood protection alternative; as such further assessment of the Hilldale Avenue area has been conducted herein.

2.3.2 Mapping

As part of the *Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment, March 2014, AMEC (now Wood),* reach based floodline plans were prepared indicating the 5 year, 100 year and Regional Storm floodlines for existing conditions (ref. Figure 2.1, Figure 2.2, Figure 2.3 and Figure **2.4**), Preferred Solutions (ref. Figure 2.5), Change in Flood Risk (ref. Figure 2.6) and the Flood Risk for the Preferred Alternatives (ref. Figure 2.7).

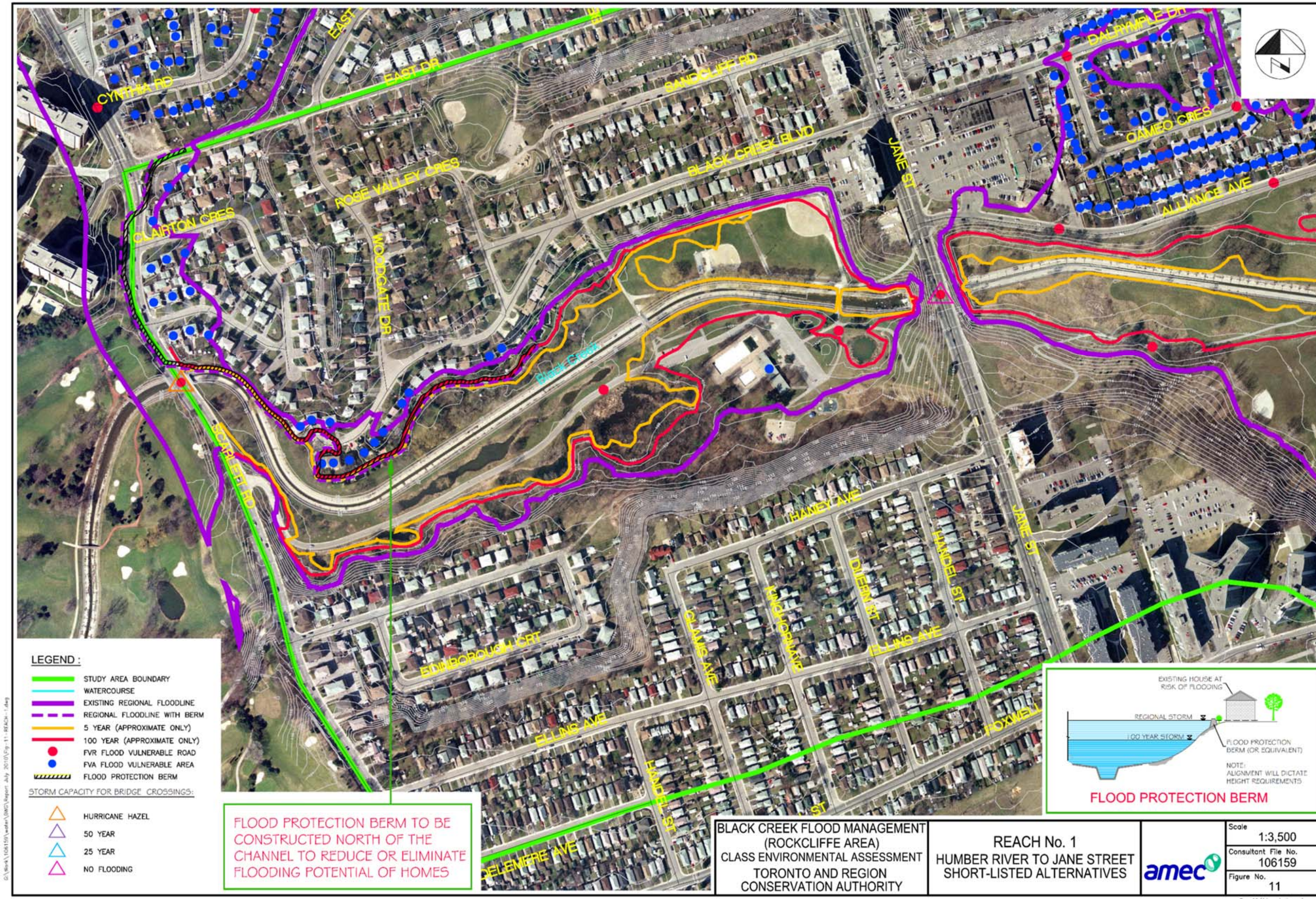

Figure 2.1. Reach No. 1 – Humber River to Jane Street Class EA Short-Listed Alternatives

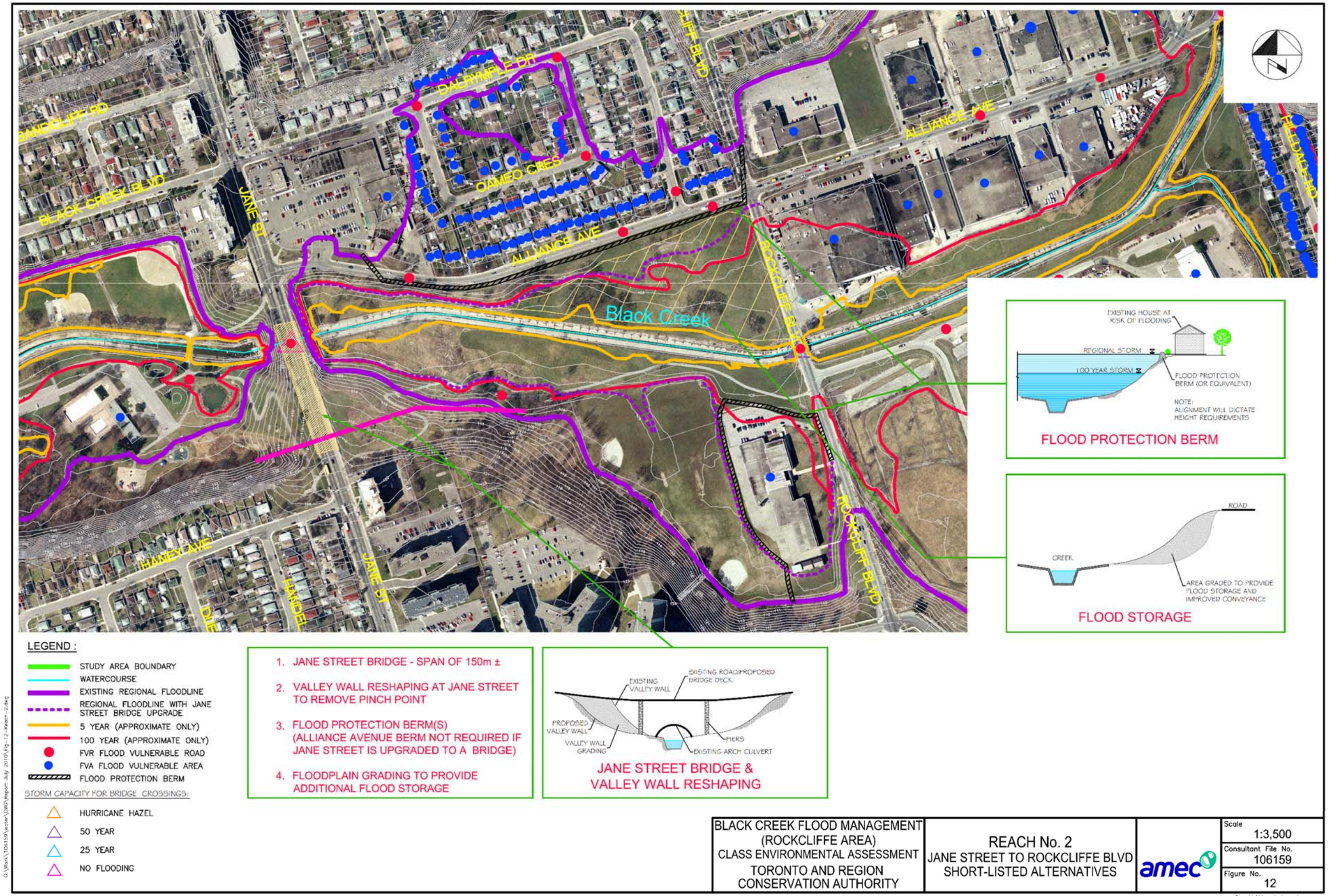

Figure 2.2. Reach No. 2 – Jane Street to Rockcliffe Boulevard Class EA Short-Listed Alternatives

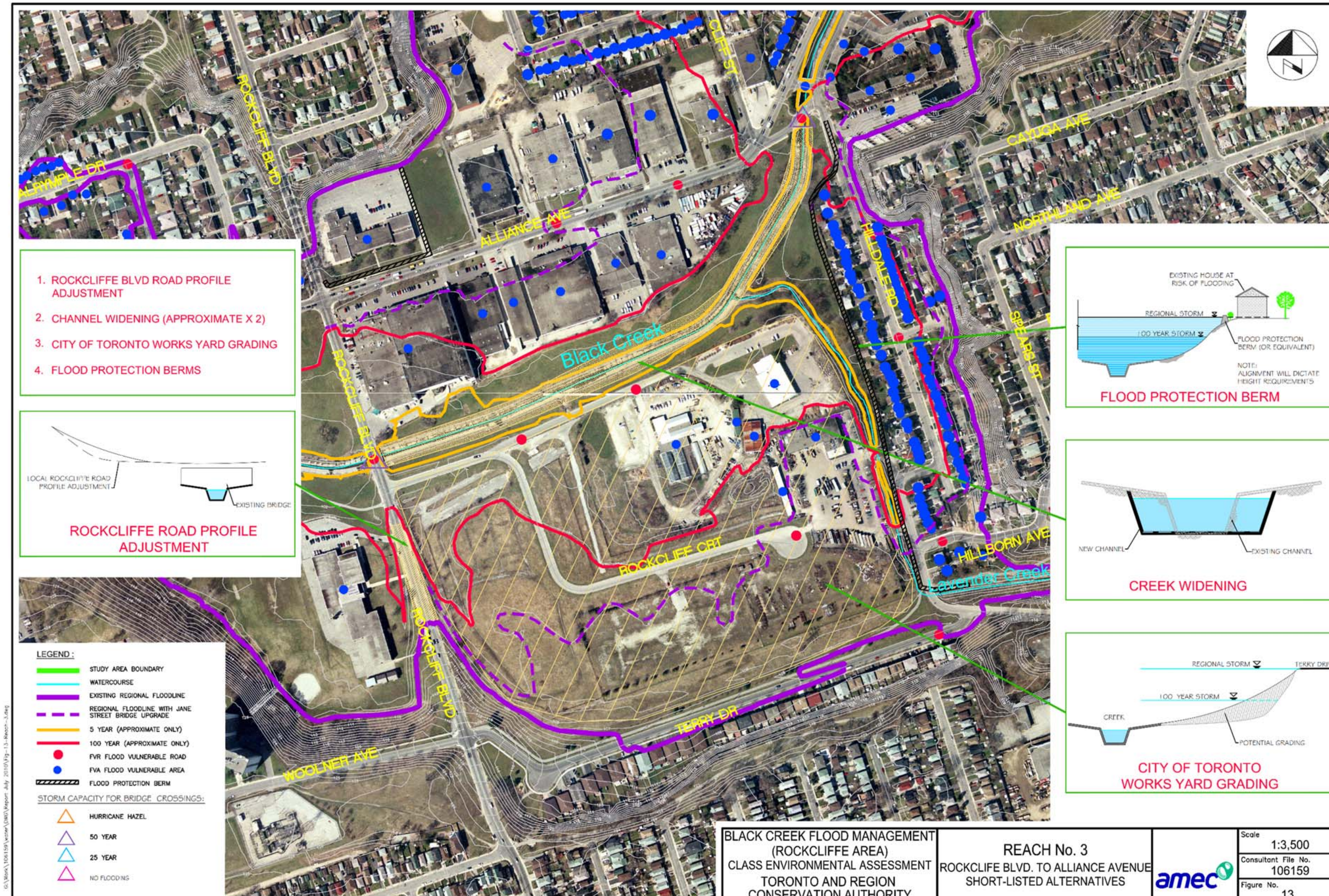

Figure 2.3. Reach No. 3 – Rockcliffe Boulevard to Alliance Avenue Class EA Short-List Alternatives

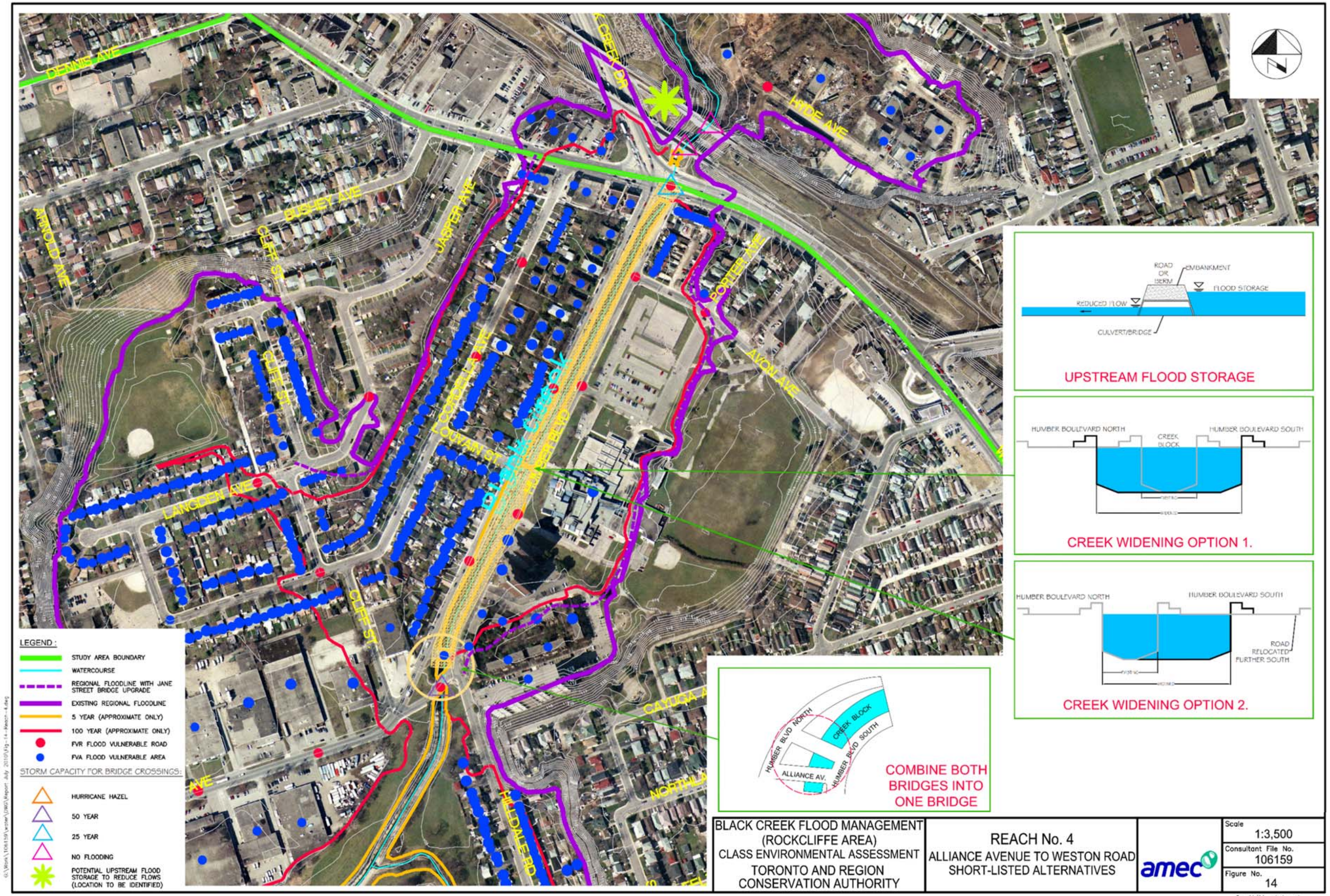

Figure 2.4. Reach No. 4 – Alliance Avenue to Weston Road Class EA Short-Listed Alternatives

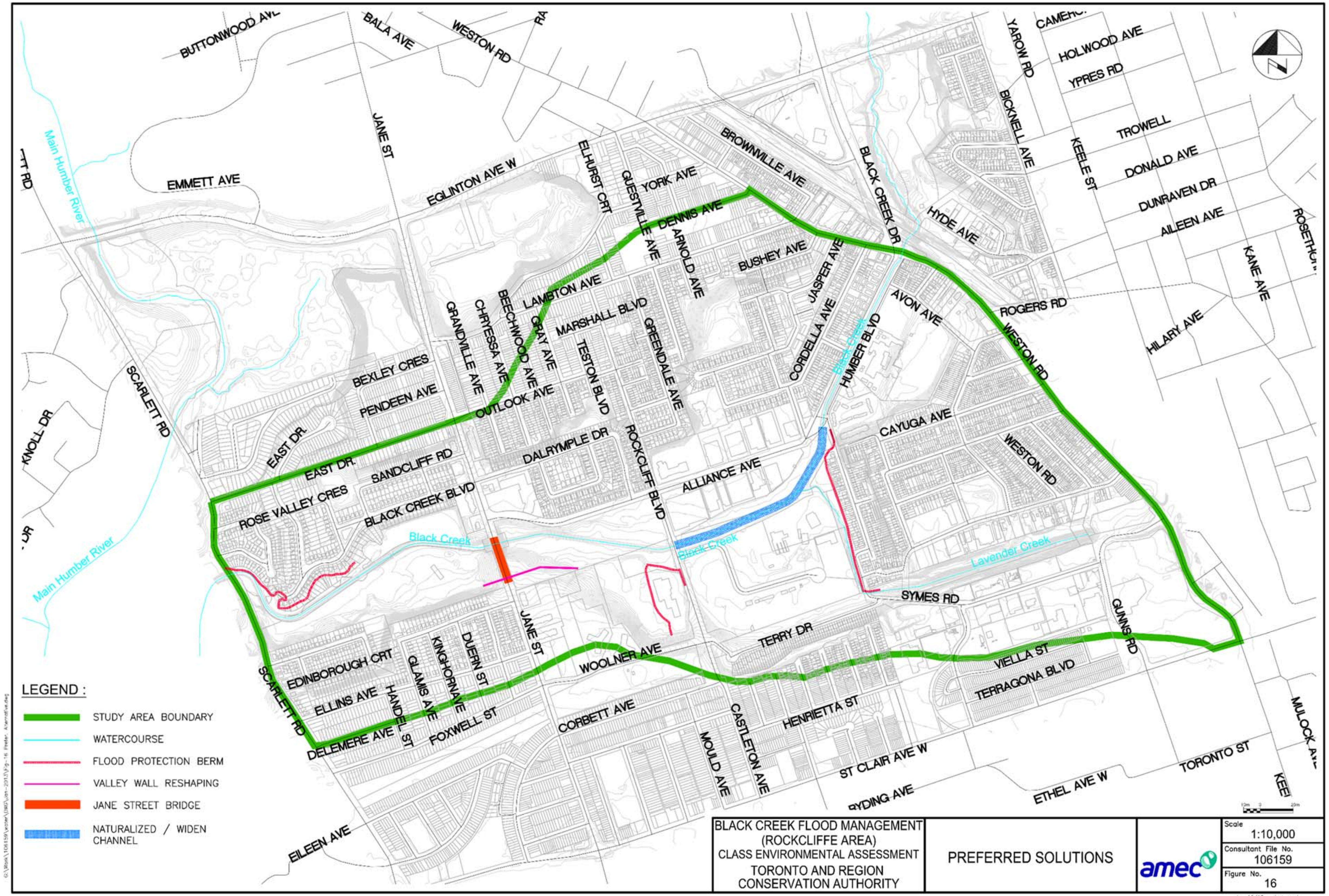

Figure 2.5. Preferred Solutions (Class EA)

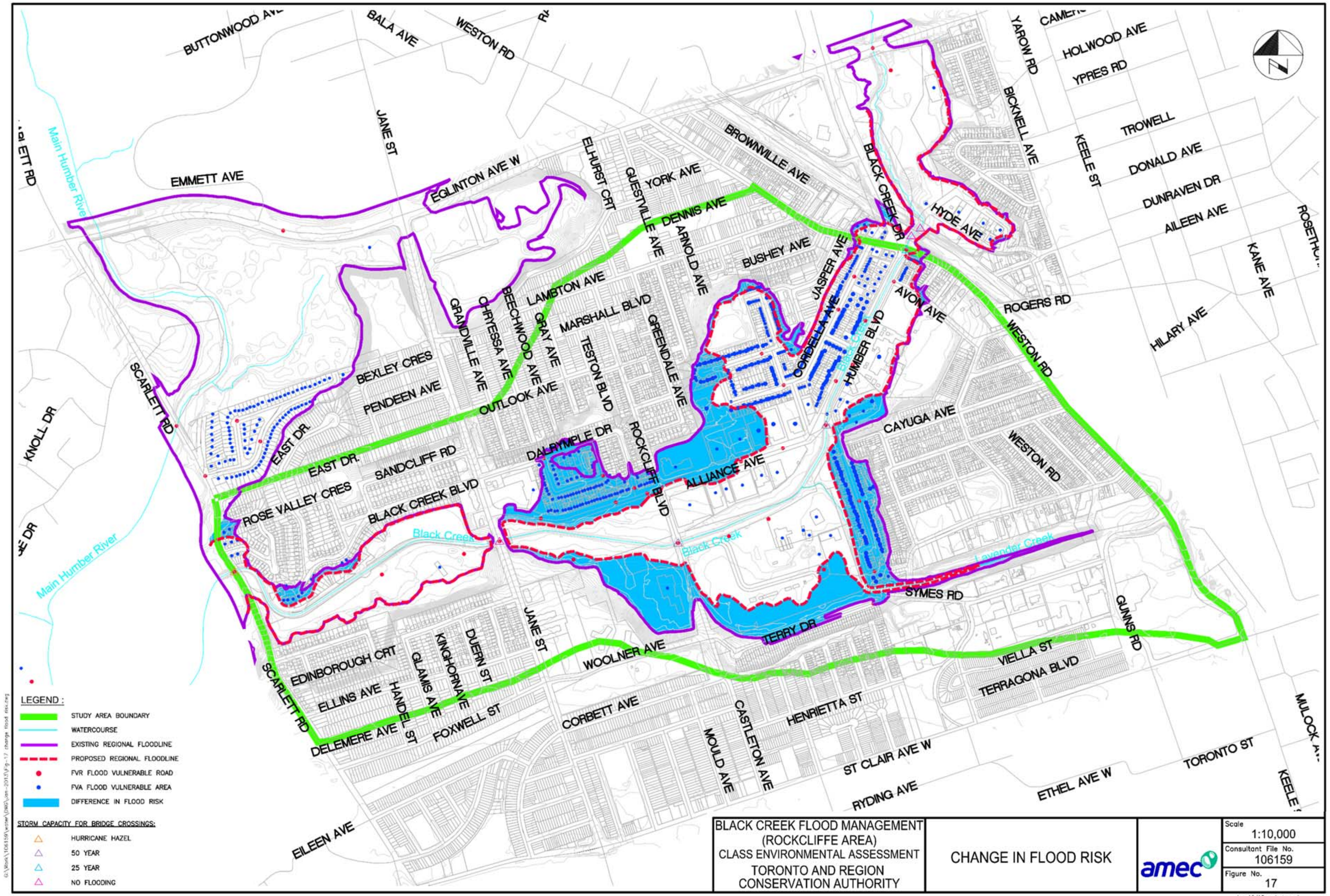

Figure 2.6. Change in Flood Risk per Class EA

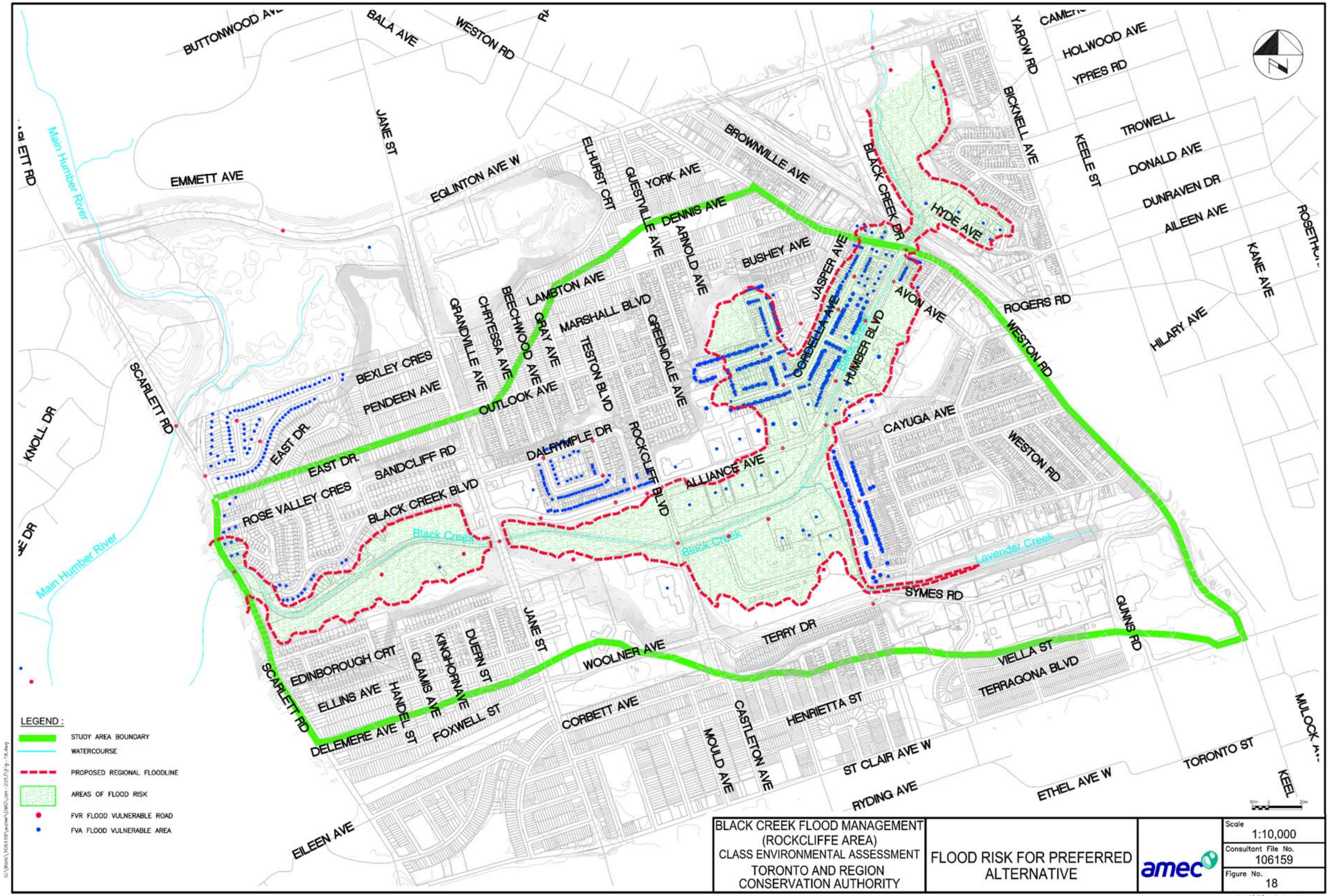

Figure 2.7. Flood Risk for Preferred Alternative (Class EA)

2.3.3 Modelling

As part of the *Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment, March 2014, AMEC (now Wood),* TRCA provided the Humber River HEC-RAS version 3.1.3 hydraulic model including the Black Creek. The hydraulic model was used to determine the existing flood risk and assess flood mitigation alternatives.

TRCA has subsequently used MIKE 11 and 21 to model the Black Creek as per the April 12, 2018 *Rockcliffe SPA 2D Flood Modelling and Mapping Update* by DHI.

As mentioned in Section 2.3.1, the updated MIKE FLOOD model for the Rockcliffe SPA area includes two major changes from the MIKE FLOOD model prepared by DHI for the "Rockcliffe SPA 2D Flood Modelling and Mapping Update", notably:

1. In the previous MIKE FLOOD model, the inflow contributions from Lavender Creek were represented as a point source inflow boundary condition derived from the hydrology model of the area. As such, Lavender Creek was not explicitly included as a separate branch of 1D riverine model. However, TRCA has determined that the flooding observed along Hilldale Road is caused by overbank flooding from Lavender Creek and any flood mitigation options need to consider Lavender Creek as well. As a result, TRCA has added Lavender Creek as a separate 1D branch in the model and included the associated hydraulic structures along the channel.
2. In the previous MIKE FLOOD model the 2D overland flow was modelled using the uniform grid, finite difference solution of the MIKE 21 software. The updated MIKE FLOOD model uses the flexible mesh, finite volume solution of the MIKE 21 software because it is able to leverage a GPU to significantly reduce the simulation time.

No formal documentation for the updated MIKE FLOOD model was provided, however, TRCA has verbally confirmed that the hydraulic structures coded for the 1D model branch of Lavender Creek, represent the results of a field survey conducted by TRCA staff.

Other than the changes mentioned above, the updated MIKE FLOOD model setup is very similar to the previous MIKE FLOOD model of the Rockcliffe SPA area (DHI, 2018). The 1D model is used to represent the main channel of Black Creek and Lavender Creek, while the 2D model is used to represent the land surface and building structures outside the main channels and extending slightly beyond the expected limited of flooding. The 1D model is dynamically coupled to the 2D model along the top of channel banks on either side of the channel, such that when the water level in the channel rises above the top of the bank, it spills into the 2D model, and vice-versa.

The previous MIKE FLOOD model results showed significant depths of flooding adjacent to the creek for the 10, 25, and 50 years storm events as well.

For the 50 year storm event (ref. Figure 2.8):

- The depth of flooding upstream of Humber Boulevard is 1.2 – 2.0 m adjacent to the channel and 6.0 – 6.3 m in the channel.
- The depth of flooding upstream of Rockcliffe Boulevard is 3.3 – 4.0 m adjacent to the channel and 6.7 – 7.0 m in the channel.
- The depth of flooding upstream of Jane Street is 4.6 – 5.0 m adjacent to the channel and 7.1 – 7.5 m in the channel.

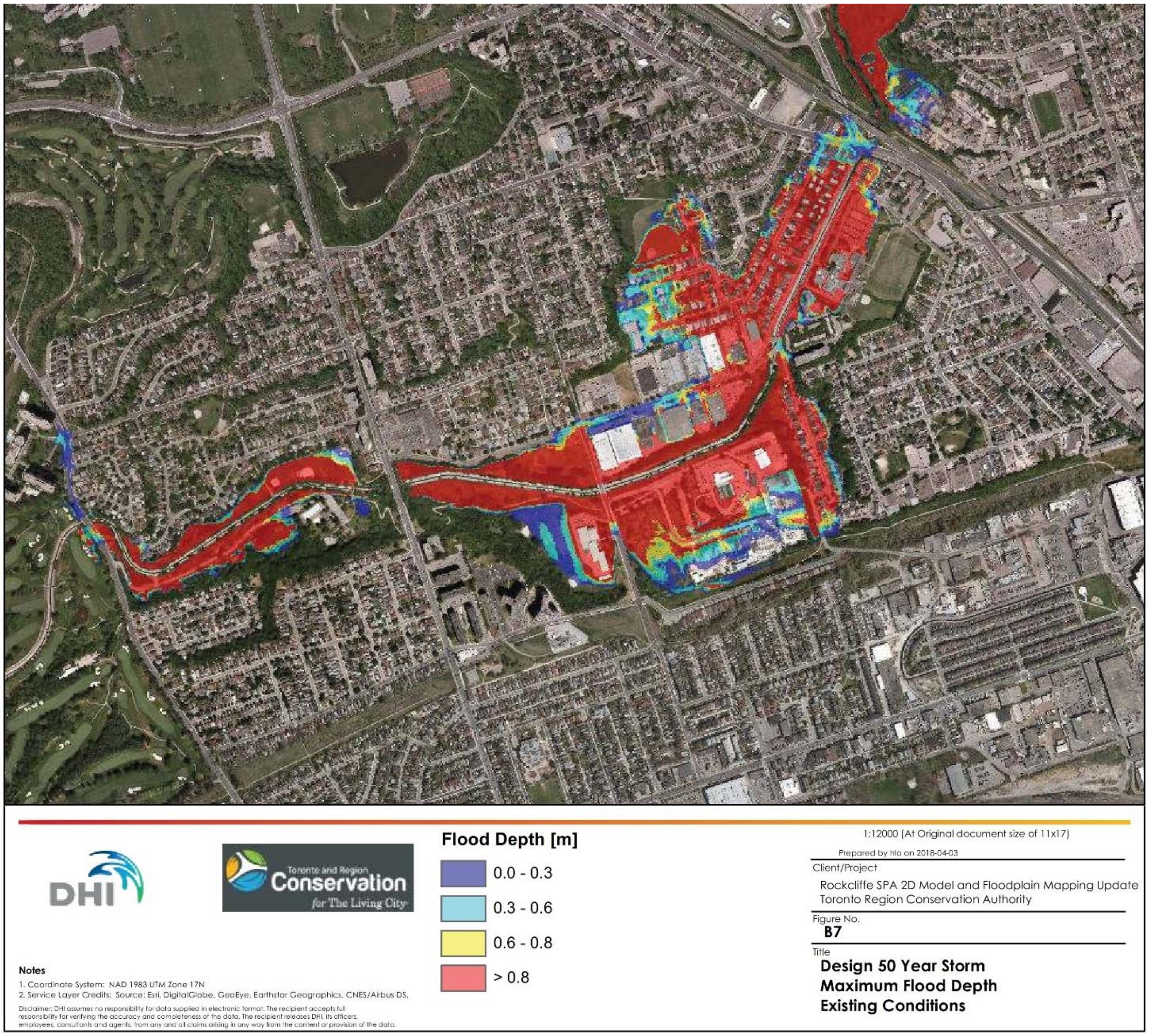

Figure 2.8. Design 50 Years Return Period Event Maximum Flood Depth Existing Conditions

For the 25 year storm event:

- The depth of flooding upstream of Humber Boulevard is 0.5 – 1.5 m adjacent to the channel, and 5.0 – 5.5 m in the channel
- The depth of flooding upstream of Rockcliffe Boulevard is 2.5 – 3.0 m adjacent to the channel and 5.7 – 6.0 m in the channel
- The depth of flooding upstream of Jane Street is 3.6 – 3.9 m adjacent to the channel and 6.0 – 6.2 m in the channel

For the 10 year storm event:

- The depth of flooding upstream of Humber Boulevard is below 0.2 m adjacent to the channel and 4.5 – 5.0 m deep in the channel.
- The depth of flooding upstream of Rockcliffe Boulevard is 1.3 – 2.0 m adjacent to the channel and 4.5 – 4.8 m in the channel.
- The depth of flooding upstream of Jane Street is 2.5 – 2.8 m adjacent to the channel and 4.8 – 5.2 m in the channel.

For each event, the depth of flooding adjacent to the channel is 5-30% of the total depth of water in the channel at Humber Boulevard, 40-60 % at Rockcliffe Boulevard, and beyond 60 % at Jane Street. This suggests that the results from these events may also be adversely impacted by momentum adjustments caused by significant quantities of flow being added from the 2D model to the 1D model. Based on the foregoing, additional investigation of the updated MIKE FLOOD model is required to confirm.

Suggested Improvements to the Updated MIKE FLOOD model

One method to improve the performance of the existing model is to expand the width of the 1D model channel beyond the main channel of Black Creek such that the flow in the channel is proportionally increased, and so the depth of adjacent flooding compared to the depth in the channel, is proportionally decreased. This will serve to reduce the impact of the momentum adjustment in the 1D model. The drawback of this method is that it assumes flows in the 1D model are unidirectional and ignores the transverse flows which are observed between buildings, along streets, and at deep detention areas.

Another approach to address this potential problem, is to develop the model entirely as a 2D model representation and eliminate the use of the 1D model. This approach will eliminate any potential problems associated with the absence of momentum transfer between the 1D and 2D models, as well as remove the problems caused by the momentum adjustments when flow is added from the 2D model to the 1D model. Developing the entire model as a 2D flexible mesh model would allow the flow in the channel to exchange seamlessly with overland flow. Using a quadrangle mesh for river channel and a triangle mesh for the floodplain, the volume and momentum exchange between the creek and the floodplain could be represented entirely in the 2D model.

A fully 2D model of the domain between Weston Road and Jane Street was prepared and was executed for the Regional Storm event and the results were compared with the previous MIKE FLOOD model results. Figure 2.9 compares the water depth between Weston Road and Jane Street. The extent of flooding is roughly the same, however in the 2D model, the inundation is deeper on the right bank at the upstream side of Humber Boulevard bridge, and shallower at the south end close to Terry Drive. However, the flow velocity in the flood impacted areas is consistently higher in the fully 2D model (ref. Figure 2.10). The existing model shows flow velocity mostly below 1 m/s, but the fully 2D model shows substantially more momentum with various areas incurring flow velocities beyond 1.4 m/s, which would be expected.

Through discussion with TRCA and a review of the coupled 1D/ 2D modelling results, it was decided that the modelling would precede using a the coupled 1D/2D results, as a fully 2D model would differ in results from previous modelling completed for TRCA and the 1D/2D coupled modelling approach has been tried and vetted by TRCA's modelers.

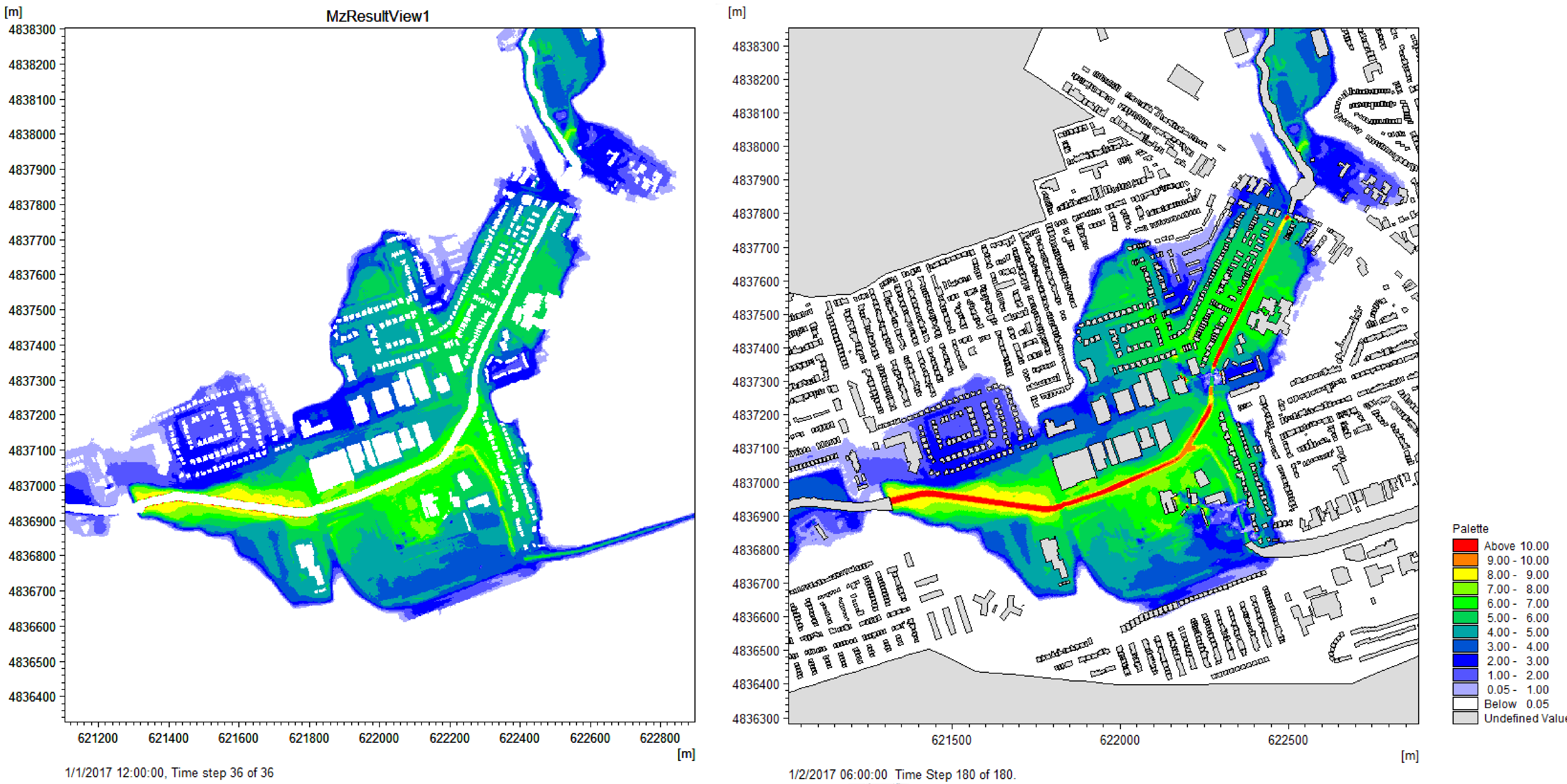

Figure 2.9. Water Depth between Weston Road and Jane Street in Existing Model (Left) and 2D Model (Right)

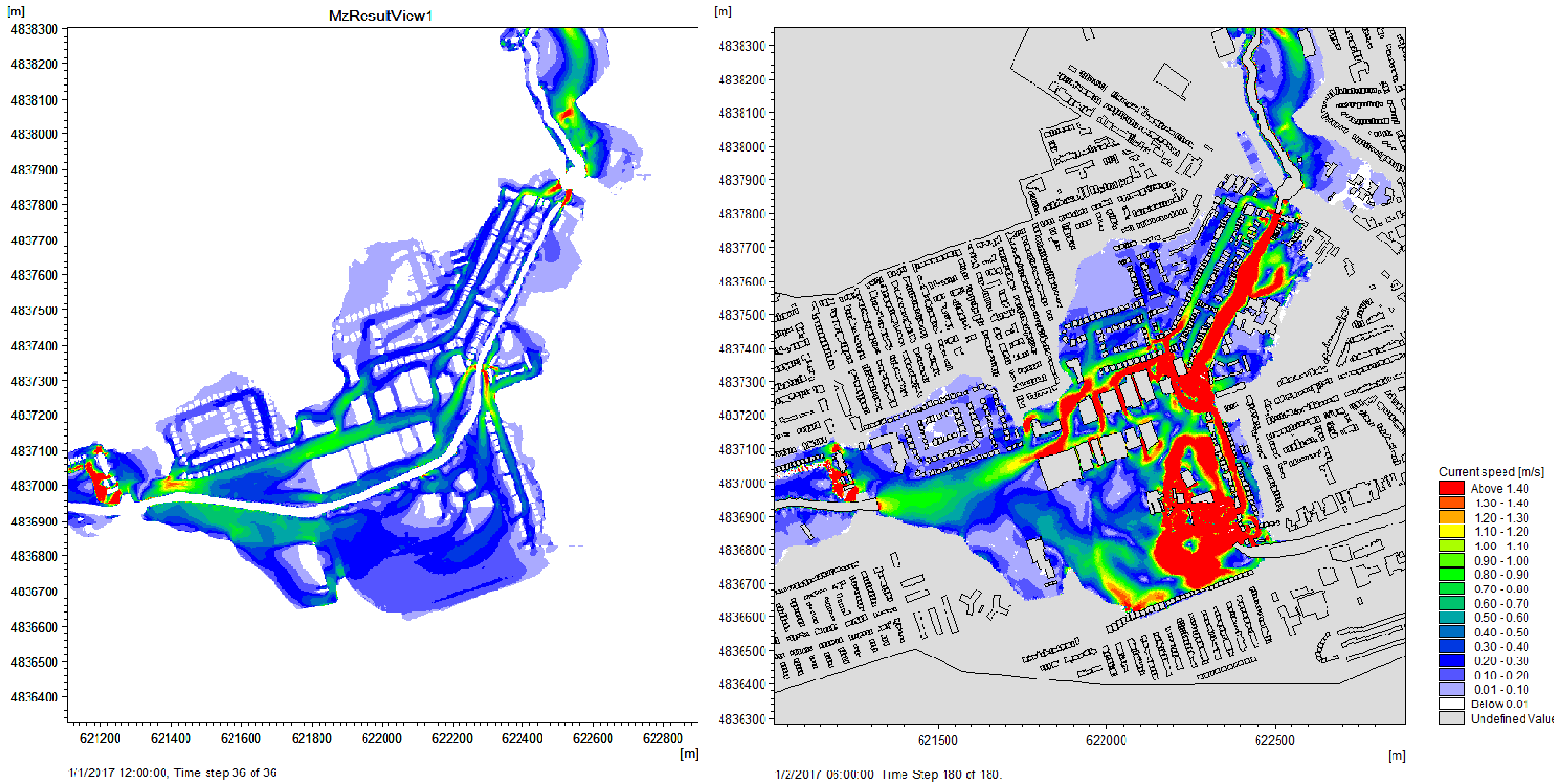

Figure 2.10. Water Velocity between Weston Road and Jane Street in Existing Model (Left) and 2D Model (Right)

2.4 Natural Systems

2.4.1 Background Review

Secondary sources for natural systems were reviewed to determine available aquatic and terrestrial biological information and establish a base for the gap analysis. Background information reviewed included the following:

- Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment (Wood, 2014);
- Toronto Municipal Code Chapter 658, Ravine and Natural Feature Protection (City of Toronto 2016);
- City of Toronto Official Plan (City of Toronto 2019);
- Department of Fisheries and Oceans Canada (DFO) Aquatic species at risk map (DFO 2018);
- Atlas of the Mammals of Ontario (AMO; Dobbyn 1994);
- Species at Risk Public Registry database (MECP 2019a);
- Bat Conservation International Inc. (BCI 2018);
- Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Information Centre (NHIC) database 1 km x 1 km squares 17PJ2036, 17PJ2037, 17PJ2136, 17PJ2137, 17PJ2236, 17PJ2237, 17PJ2336 and 17PJ2337 (MNRF 2019);
- Ontario Reptile and Amphibian Atlas 10 km x 10 km square 17PJ(ORAA; Ontario Nature 2019);
- Ontario Butterfly Atlas 10 km x 10 km square 17PJ (OBA, TEA 2019);
- eBird (2019);
- Ontario Breeding Bird Atlas 10 km x 10 km square 17PJ (ABBO, SBC et al. 2006);
- Online aerial imagery (Google Earth 2018);
- Land Information Ontario (LIO; MNRF 2019); and
- The following information provided by TRCA:
    - Ecological Land Classification (ELC); and
    - Flora and Fauna Records.

The 2014 Class Environmental Assessment provided general information regarding the natural systems within the Study Area. No formal field studies or inventories were completed as part of the 2014 Class EA, as it was largely supported by existing information provided by the TRCA, and desktop review. Based on the information provided, the majority of the flora/faunal species are located downstream of Jane Street and Smythe Park. Terrestrial species composition are those considered common to Southern Ontario, with no species-at-risk identified. Aquatic species noted are warmwater species, which are typically observed in more urbanized areas like the subject Study Area. Given the absence of natural heritage information, this data gap analysis aims to build upon the information documented within the 2014 Class EA, by performing a review of readily available secondary source information pertaining to the Study Area. The review of this information will help inform project constraints and future work requirements.

2.4.2 Existing Conditions

The majority of the Study Area is heavily developed with residential and commercial developments, with the creek largely channelized throughout. Natural areas are present, generally in proximity to Black Creek and Lavender Creek. Ecological land classification (ELC) data were provided by TRCA and are provided in Appendix E.

Records of Species at Risk (SAR) are present within the Study Area. Habitat for some of these species are present within the Study Area and field investigations would be required to assess their presence and the extent of suitable habitat. A summary of all the species recorded in the background information reviewed is provided in Appendix E. Field surveys during the appropriate times of the year are recommended to confirm presence and/or absence of SAR species, as well as to confirm presence and/or absence of significant wildlife habitat. Field surveys should follow standard protocols.

It is important to note that the Atlas of the Breeding Birds of Ontario (ABBO), Ontario Reptile and Amphibian Atlas (ORAA) and the Ontario Butterfly Atlas (OBA) utilize a province wide 10 km x 10 km (100 km2) square grid system while the Natural Heritage Information Centre (NHIC) uses a 1 km x 1 km system. Additionally, the Atlas of Mammals of Ontario (AMO) is interpreted based on range maps as no usable grid system is available. As such, the spatial extent for which SAR occurrence has occurred is quite large, whereby the potential presence of these SAR within a given area should be interpreted with caution.

Raw data and mapping related to natural systems within the Study Area are provided in Appendix E.

2.4.2.1 Aquatic Ecosystem

Black Creek is part of the Humber River watershed and confluences with the Humber River downstream of Jane Street, outside of the Study Area. Black Creek flows through the Study Area from east to west, with Lavender Creek flowing into Black Creek in the eastern half of the Study Area. The Rockcliffe Area is located near the downstream limit of the Black Creek subwatershed. Black Creek has been heavily modified through straightening, concrete lining and the construction of several bridge crossings. A section of Lavender Creek, between the confluence with Black Creek and Symes Road has not been straightened or lined with concrete. A narrow strip of riparian trees is present through much of the Study Area, adjacent to the watercourses. The majority of the natural riparian area occurs downstream of Jane Street, where Smythe Park is located.

Hydrological characteristics of the system, such as water levels and flashy flows and channel characteristics, could impede fish movement at several locations throughout the Study Area. The elevation change at the Jane Street culvert would impede fish moving upstream into the culvert during certain conditions such as low water levels and during/after heavy rain when the water velocity would be increased. Additionally, the elevation change at the confluence of Black Creek and Lavender Creek would impede fish moving upstream into Lavender Creek during low water levels. Additionally, low water levels were observed at several locations during the site walk in July 2019, which would impede fish movement.

Fish records within the Study Area include 98 common warmwater and coolwater species such as Blacknose Dace, Blacknose Shiner, Bluntnose Minnow, Brook Stickleback, Fathead Minnow and Common Carp (Ref. Appendix E for fish data records). Additionally, there are records of American Brook Lamprey, which is a coldwater species. Fish records include one (1) endangered SAR (Redside Dace), however characteristics within the Study Area are not considered suitable for this species (ref. Section 2.4.2.3). No critical habitat or SAR are identified within the Study Area on the DFO aquatic SAR map. Fish inhabiting the watercourses in the Study Area would require tolerance for urban runoff into the drainage system.

Upon determination of the flood remediation methods, during the future Class EA, a project screening process following that outlined by the Department of Fisheries and Ocean (DFO) will need to occur to determine whether or not further consultation with DFO will be required through a Request for Review.

2.4.2.2 Terrestrial Ecosystem

The organizational framework contained within the ELC protocol (Lee et al., 1998) describes communities according to six (6) nested levels: Site Region, System, Community Class, Community Series, Ecosite, and Vegetation Type. These nested levels vary in spatial scale, with the Ecoregion classifying communities at the largest spatial scale, and Vegetation Type describing communities at the finest spatial scale (Lee et al., 1998).

There are two (2) Ecoregions in Southern Ontario: 6E and 7E (Lee et al., 1998). The Study Area is situated within Ecoregion 7E, the Lakes Erie-Ontario Ecoregion, which occupies the southern portion of Ontario. ELC and vegetation data provided by the TRCA included 18 ELC classification, 69 noted species comprised of trees, shrubs and herbaceous plants and is provided in Appendix E, with community types illustrated.

Based on the review of available literature and databases, 74 species of plants, 112 species of birds, 25 species of mammals, 17 species of amphibians, 16 species of reptiles and 98 species of insects are reported to occur within the region encompassing the Study Area. A tabulation of compiled species lists are provided in Appendix E. It should be noted that the TRCA terrestrial data (ELC, flora and fauna species) are considered up to date for Smythe Park only and data were not available for all natural areas within the Study Area (i.e. no terrestrial inventory data have been collected for the natural area immediately east of Smythe Park).

Plants

Review of available background information identified 74 species of plants for the Study Area, including one (1) endangered SAR (Butternut; ref. Section 2.4.2.3). At the time of the future Class EA, Wood recommends a plant inventory during the appropriate timing window to confirm presence and/or absence of SAR species and habitat present.

Birds

Review of available background information identified 112 species of birds for the Study Area, including 5 threatened and 4 special concern SAR (Section 2.4.2.3). Given the vegetative characteristics and habitat suitability within the Study Area, there is a probability for SAR birds, as well as other nesting birds, to occur within the Study Area. At the time of the future Class EA, Wood recommends formal breeding bird surveys be completed in accordance with Ontario Breeding Bird Atlas Guide for Participants during the appropriate timing window to confirm presence and/or absence of the SAR species.

Mammals

Review of available background information identified 25 species of mammals with habitat ranges that overlap the Study Area, including four (4) endangered SAR (Section 2.4.2.3). Bat Conservation International (BCI) ranges for bats in Ontario includes eight (8) species whose ranges encompass the Study Area. It is important to note that the exact locations of species occurrences are not available from the atlas or BCI. Given the habitat identified, there is the potential for SAR bats, as well as non-SAR bats, to occur in the Study Area. As such, if tree removals will be required, all trees to be removed will need to be surveyed to determine suitability as potential maternity roosts. At the time of the future Class EA, two surveys would be required, one during leaf-on conditions and one during leaf-off.

Herpetofauna

Review of available background information identified 17 species of amphibians and 16 species of reptiles, including two (2) endangered, two (2) threatened and four (4) special concern SAR (ref. Section 2.4.2.3). Based on background information and habitat characteristics within the Study Area, SAR reptiles and/or amphibians may be present and will require field investigations. Field surveys should follow standard protocols as outlined in the Marsh Monitoring Program (MMP) protocol.

Insects

Review of available background information identified 98 species of insects, including one (1) extirpated, one (1) endangered and one (1) special concern SAR (ref. Section 2.4.2.3). It is important to note that the exact locations of species occurrences are not available from these sources. Consequently, it is possible that some of these species do not occur in the Study Area. Based on the ELC and species information provided by TRCA, as well as field observations, meadow habitat is present, as well as Swamp Milkweed, and therefore, the probability of Monarch presence is considered moderate to high.

2.4.2.3 Species at Risk

In addition to generating compiled species lists, secondary source searches were conducted to identify potential presence of SAR. These secondary sources indicated the potential for 17 extirpated, endangered or threatened SAR and nine (9) special concern SAR in the vicinity of the Study Area, and are summarized in Table 2.3. SAR designated as extirpated, threatened or endangered are protected under the ESA, along with their habitats. Species designated as special concern are not afforded protection under the ESA, however, due diligence should be enforced if special concern species or their habitat is determined to be present. Consultation with regulatory agencies was not part of this background review and should occur as part of the future EA process.

It is important to note that the ABBO, ORAA and ABO utilize a province wide 10 km x 10 km (100 km^2) square grid system while the NHIC uses a 1 km x 1 km system. Additionally, the AMO is interpreted based on range maps no usable grid system is available. As such, spatial extent for which SAR occurrence has occurred is quite large, whereby the potential presence of these SAR within the Study Area should be interpreted with caution.

Given the habitat characteristics of the above noted SAR, in conjunction with existing conditions observed during the field survey and background information, an assessment of the probabilities of each SAR to occur is provided below. Additional SAR may come into the area or species already occurring in the area may be up-listed at any time. For this reason, ongoing communication with the MECP is strongly recommended to ensure compliance with the ESA (2007). The probabilities of occurrence are defined as ‘High’, ‘Moderate’, ‘Low’, and ‘None’ and are based on the following definitions:

- *High*: Those species recorded in the vicinity of the Study Area (typically within 10 km and recorded in the past 20 years) and whose preferred habitat is abundant within the Study Area. Species with high probability of occurrence would be expected to breed within or frequently use the habitats available within the Study Area and would be known to have a high relative abundance within the region (i.e., compared to other regions in Ontario);
- *Moderate*: Those species in the vicinity of the Study Area but have limited suitable habitat within the Study Area. Species with moderate probabilities of occurrence may not occur within the Study Area frequently, but may intermittently use it for foraging, migration or movement to other parts of their home-range;
- *Low*: Those species recorded in the vicinity of the Study Area, but whose preferred habitat does not occur or is extremely limited within the Study Area. These species may intermittently move through the Study Area but are unlikely to become permanent residents;

- *None*: Those species whose preferred habitat is completely absent from the Study Area and may only migrate intermittently through the Study Area.

Future works identified in Table 2.3 would have to be conducted through either a future Class Environmental Assessment or through detailed design assignments, depending upon the scope and time constraints of the future Class EA,.

Table 2.3. Species at Risk to Potential Occurrence

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Plants			
Butternut *(Juglans cinereal)* SARA: Endangered ESA: Endangered S-Rank: S3? Source: NHIC (2002)	Generally, grows in rich, moist, and well-drained soils often found along streams. It may also be found on well-drained gravel sites, especially those made up of limestone. It is also found, though seldom, on dry, rocky and sterile soils. In Ontario, the Butternut generally grows alone or in small groups in deciduous forests as well as in hedgerows (Poisson & Ursic, 2013).	**Moderate** – dry-fresh deciduous forest communities present.	Botanical surveys recommended during the appropriate field season.
Birds			
Bank Swallow (*Riparia riparia*) SARA: Threatened ESA: Threatened S-Rank: S4B Source: ABBO, NHIC (2017)	Nesting occurs in a variety of naturally and anthropogenically created vertical or near-vertical banks of substrate such as fine sand or silt, such as eroding lake bluffs and river banks, topsoil piles in construction areas and extraction faces in aggregate pits. Foraging occurs in a variety of open terrestrial and aquatic habitats (Falconer et. al. 2016).	**Low** – minimal suitable habitat present, this species could use the Study Area for foraging periodically.	No dedicated surveys required, breeding bird surveys recommended to confirm presence and/or absence of other bird species would document Bank Swallow should it occur.
Barn Swallow (*Hirundo rustica*) SARA: Threatened ESA: Threatened S-Rank: S4B Source: ABBO	Often found feeding in a range of open habitats including fields, marshes, meadows, and ponds. They primarily use man-made structures such as building, bridges, and culverts for nesting (COSEWIC 2011a).	**Moderate** – suitable nesting habitat present in Study Area and in proximity to Black Creek.	Breeding Bird surveys in accordance with ABBO to be performed during appropriate timing.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Bobolink (*Dolichonyx oryzivorus*) SARA: Threatened ESA: Threatened S-Rank: S4B Source: ABBO	Bobolink nest primarily in forage crops, hayfields and pastures are their preferred habitat. Bobolink also occur in wet prairie, graminoid peatlands and abandoned fields dominated by tall grasses, no-till cropland, small-grain fields, and reed beds. This species does not generally occupy fields of row crops or pastures with high shrub density or intensively grazed pastures (COSEWIC 2010).	**Low** – suitable nesting habitat not present within the Study Area. Open areas of grass are maintained. Dense urban development surrounding areas of open grass.	No dedicated surveys required, breeding bird surveys recommended to confirm presence and/or absence of other bird species would document Bobolink should it occur.
Chimney Swift (*Chaetura pelagica*) SARA: Threatened ESA: Threatened S-Rank: S4B,S4N Source: ABBO, TRCA (2017)	Nesting and roosting habitat is generally a dark, sheltered spot with vertical surfaces to attach the nest to. Hollow trees were the main nesting habitat prior to European settlement. Artificial structures became commonly used after European settlement, including chimneys and barns. Feeding often occurs near water due to the abundance of insects (COSEWIC 2007).	**High** – suitable habitat present within Study Area and observed within the Study Area.	Breeding Bird surveys in accordance with ABBO to be performed during appropriate timing.
Eastern Meadowlark (*Sturnella magna*) SARA: Threatened ESA: Threatened S-Rank: S4B Source: ABBO	A bird most common in native grasslands, pastures and savannas. It also uses a wide variety of other anthropogenic grassland habitats. As with other grassland bird species, the suitability of grassland habitat for this species involves a combination of landscape and patch characteristics (COSEWIC 2011b).	**Low** – suitable nesting habitat not suitable within the Study Area. Open areas of grass are maintained. Dense urban development surrounding areas of open grass.	No dedicated surveys required, breeding bird surveys recommended to confirm presence and/or absence of other bird species would document Eastern Meadowlark should it occur.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Eastern Wood-Pewee (*Contopus virens*) SARA: Special Concern ESA: Special Concern S-Rank: S4B Source: ABBO, NHIC	Associated with deciduous and mixed forests. Within mature and intermediate age stands it prefers areas with little understory vegetation as well as forest clearings and edges (MECP 2019b).	**Low** – Small wooded areas are present within Study Area. However they are surrounded by development.	No dedicated surveys required, breeding bird surveys recommended to confirm presence and/or absence of other bird species would document Eastern Wood-Pewee should it occur.
Peregrine Falcon (*Falco peregrinus*) SARA: Special Concern ESA: Special Concern S-Rank: S2 Source: ABBO	Generally, nest on tall, steep cliff ledges adjacent to large waterbodies (MECP 2019c).	**None** – nesting habitat not present.	No dedicated surveys required, breeding bird surveys recommended to confirm presence and/or absence of other bird species would document Peregrine Falcon should it occur.
Red-headed Woodpecker (*Melanerpes erythrocephalus)* SARA: Threatened ESA: Special Concern S-Rank: S3B Source: ABBO	Generally, prefer open oak and beech forests, grasslands, forest edges, orchards, pastures, riparian forests, roadsides, urban parks, golf courses, cemeteries, as well as along beaver ponds and brooks (MECP 2019d).	**Moderate** - habitat is present.	Breeding Bird surveys in accordance with ABBO to be performed during appropriate timing.
Wood Thrush (*Hylocichla mustelina*) SARA: Threatened ESA: Special Concern S-Rank: S4B Source: ABBO	Nests mainly in second- growth and mature deciduous and mixed forests, with saplings and well-developed understory layers. Prefers large forest mosaics, but may also nest in small forest fragments (MECP, 2019e).	**Moderate** – deciduous woodlots are present within the Study Area, particularly within and adjacent Smythe Park.	Breeding Bird surveys in accordance with ABBO to be performed during appropriate timing.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Mammals			
Eastern Small-footed Myotis (*Myotis leibii*) SARA: No Status ESA: Endangered S-Rank: S2S3 Source: AMO, BCI	The Eastern Small-footed Myotis roosts under rocks or in rock outcrops, in buildings, under bridges in caves or hollow trees. Caves and mines serve as significant hibernacula while streams and ponds serve as foraging areas (MECP 2019f).	**Moderate** – woodlots, bridges and buildings may provide suitable nesting in Study Area.	Conduct surveys to determine suitability of roosting habitat during appropriate timing.
Little Brown Myotis (*Myotis lucifugus*) SARA: Endangered ESA: Endangered S-Rank: S3 Source: AMO, BCI	Roosts in tree cavity, including small spaces or crevices found in loose bark, hollow trees, rock faces and human structures such as attics, walls and bat boxes. Hibernates in caves and abandoned mines during the winter months. Typically forages over water with surrounding open habitat (COSEWIC 2013).	**Moderate** – potential roost trees in woodlots within the Study Area.	Conduct surveys to determine suitability of roosting habitat during appropriate timing.
Northern Myotis (*Myotis septentrionalis*) SARA: Endangered ESA: Endangered S-Rank: S3 Source: AMO, BCI	Roosts in usually decaying tree cavity, including small spaces or crevices found in loose bark, hollow trees, rock faces and human structures such as attics, walls and bat boxes. Hibernates in caves and abandoned mines during the winter months. Typically forages for primarily terrestrial insects (COSEWIC 2013, Environment Canada 2015).	**Moderate** – potential roost trees in woodlots within the Study Area.	Conduct surveys to determine suitability of roosting habitat during appropriate timing.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Tri-colored bat (*Perimyotis subflavus*) SARA: Endangered ESA: Endangered S-Rank: S3? Source: AMO, BCI	Roosting habitat includes large trees, dead clusters of leaves or arboreal lichens on trees. Barns or similar structures may also be used. Foraging occurs over water and along forest streams. Caves and mines that remain above 0˚C provide overwintering habitat (COSEWIC 2013, MECP 2019g).	**Moderate** – potential roost trees in woodlots within the Study Area.	Conduct surveys to determine suitability of roosting habitat during appropriate timing.
<u>Reptiles</u>			
Blanding's Turtle (*Emydoidea blandingii*) Great Lakes – St. Lawrence population SARA: Threatened ESA: Threatened S-Rank: S3 Source: ORAA, TRCA (2018)	Prefers high nutrient organic wetlands with slow flow, shallow water and dense aquatic vegetation. Upland habitat is used as travel corridors and hatchling dispersal. Females nest in substrates including sand, organic soil, gravel and cobblestone. Overwintering occurs in a variety of habitats, generally with pools averaging 1 m deep (Ontario Nature 2019b).	**Moderate** – suitable habitat may be present in Smythe Park.	Requirements for targeted survey to be confirmed with MECP following consultation.
Eastern Hog-nosed Snake (*Heterodon platirhinos*) SARA: Threatened ESA: Threatened S-Rank: S3? Source: ORAA (1916)	Inhabits fields, forests, shrubland, beaches and old dune habitats. Generally found in habitats with sandy, well-drained soils, into which this snake burrows, such as beaches (Ontario Nature 2019c).	**None** – suitable habitat not present. The most recent record is from 1952.	No targeted surveys required.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Eastern Musk Turtle (*Sternotherus odoratus*) SARA: Special Concern ESA: Special Concern S-Rank: S3 Source: ORAA (1952)	The Eastern Musk Turtle is found in a wide variety of waterbodies with little current and soft bottoms (COSEWIC 2012).	**Moderate** – suitable habitat may be present within the Study Area, in swamp and marsh habitat in Smythe Park. The most recent record is from 1952.	Requirements for targeted survey to be confirmed with MECP following consultation.
Eastern Ribbonsnake (*Thamnophis sauritis*) SARA: Special Concern ESA: Special Concern S-Rank: S3 Source: NHIC, ORAA (1931)	Generally occur along the edges of shallow ponds, streams, marshes, swamps, or bogs bordered by dense vegetation that provides cover. Abundant exposure to sunlight is also required, and adjacent upland areas may be used for nesting (MECP 2019h).	**Moderate** – suitable habitat may be present within the Study Area. Most recent record is from 1931.	Requirements for targeted survey to be confirmed with MECP following consultation.
Northern Map Turtle (*Graptemys geographica*) SARA: Special Concern ESA: Special Concern S-Rank: S3 Source: ORAA (2018)	Inhabits rivers and lakeshores, requiring high-quality water that supports the mollusc prey of the female. Basking sites, such as rocks and logs, with unobstructed views are required (Ontario Nature 2019d).	**None** – suitable habitat to support mollusc prey not present in Study Area.	No targeted surveys required.
Queensnake (*Regina septemvittata*) SARA: Endangered ESA: Endangered S-Rank: S2 Source: NHIC (1858)	An aquatic species rarely found more than a few metres from water. It prefers rivers, streams and lakes with clear water, rocky or gravel bottoms, lots of hiding places, and abundant crayfish. Some hibernation sites include old bridge abutments and crevices in bedrock (Ontario Nature 2019e).	**None** – suitable habitat not present in Study Area. Most recent record is from 1858.	No targeted surveys required.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Snapping Turtle *Chelydra serpentine* SARA: Special Concern ESA: Special Concern S-Rank: S3 Source: NHIC, ORAA, TRCA (2018)	Snapping Turtles prefer slow-moving waters with a soft mud bottom and dense aquatic vegetation. Established populations are most often located in ponds, sloughs, shallow bays or river edges and slow streams and wetlands. Individuals can also exist in developed areas (e.g., golf course ponds, irrigation canals); however, it is unlikely that populations persist in such habitats. Snapping Turtles can occur in highly polluted waterways, but environmental contamination is known to limit reproductive success (COSEWIC 2008).	**High** – habitat is present and sightings have occurred in recent years within the Study Area.	Requirements for targeted survey to be confirmed with MECP following consultation.
Amphibians			
Jefferson/Blue-spotted Salamander Complex (*Ambystoma laterale – (2) jeffersonianum*) SARA: Endangered ESA: Endangered S-Rank: S2 Source: ORAA (1983)	Inhabits deciduous or mixed upland forests containing, or in close proximity to, suitable ponds for breeding. Mating, oviposition and larval development occurs in breeding ponds located in or near high quality forest habitats, including in limestone sinkhole ponds, kettle ponds and vernal pools that have a sufficiently long hydro period. These ponds generally dry up by mid to late summer. Breeding ponds must be devoid of predatory fish and have sufficient egg mass attachment sites in the water, such as shrubs, twigs, fallen branches or vegetation (Linton et. all 2018).	**Low** – small tree stands within the study area. Not known if suitable pond habitat is present.	Requirements for targeted survey to be confirmed with MECP following consultation.

Species Name, Status (SARA[1], ESA[2], S-Rank[3]), and Data Source[4]	Preferred Habitat	Potential SAR Habitat / Occurrence in the Study Area	Recommended Future Work
Insects			
American Burying Beetle (*Nicrophorus americanus*) SARA: Extirpated ESA: Extirpated S-Rank: SH Source: NHIC (1896)	Has been found in many habitats, though undisturbed deciduous forest seems to be preferred. Despite extensive surveys, the last record occurred in 1972 (MECP 2019i)	**None**- species no longer present in Ontario.	No targeted surveys required.
Monarch Butterfly (*Danaus plexippus*) SARA: Special Concern ESA: Special Concern S-Rank: S4B Source: OBA (2018)	Exist primarily wherever milkweed and wildflowers exist; abandoned farmland, along roadsides, and other open spaces (MECP 2019j).	**Moderate** – Swamp Milkweed and other wildflowers observed within the Study Area.	No targeted surveys required. Observation of species will be through incidental observations during other recommended surveys.
Mottled Duskywing (*Erynnis martialis*) SARA: No Status ESA: Endangered S-Rank: S2 Source: OBA (1906)	Inhabits usually dry habitats with sparse vegetation, including open barrens, sandy patches among woodlands, and alvars. In Ontario eggs are deposited on two plants only: New Jersey tea and prairie redroot (MECP 2019k).	**Low** – suitable habitat not observed within Study Area.	No targeted surveys required.
Fish			
Redside Dace (*Clinostomus elongatus*) SARA: Endangered ESA: Endangered S-Rank: S2 Source: NHIC (1991)	Inhabits pools and slow moving areas of small streams and headwaters with a gravel bottom. Habitat generally contains overhanging grasses and shrubs (MECP 2019l).	**None** – suitable habitat not observed within Study Area.	No targeted surveys required.

[1] *Species At Risk Act, 2002* (SARA). Schedule 1 status.
[2] *Endangered Species Act, 2007* (ESA).
[3] S1 - Extremely rare throughout its range in the province; S2 - Rare throughout its range in the province; S3 - Uncommon or vulnerable species; S4 - Apparently Secure Species; S5 - Secure Species; SX - Extirpated; B - Breeding; N - Non-breeding; ? - Uncertainty
[4] Dates shown are the most recent record, where available. NHIC = Natural Heritage Information Centre, ABBO = Atlas of the Breeding Birds of Ontario, AMO = Atlas of Mammals of Ontario, ORAA = Ontario Reptile and Amphibian Atlas; TEA = Toronto Entomologists Association: Ontario Butterfly Atlas.

2.4.2.4 Natural Heritage Features

Key natural heritage features are defined as those that contain wetlands, fish habitat, woodlands, valleylands, habitat for endangered and threatened species, wildlife habitat, and ANSIs. All of these features are important for their environmental and social values as defined within the Planning Act and explained within the PPS (MMAH, 2014)

Significant Wetlands and Fish Habitat

Wetlands are defined as areas that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to, or at, the surface (Lee et al., 1998). A significant wetland is an area identified as a Provincially Significant Wetland (PSW) by the MNRF using evaluation procedures established by the Province, as amended from time to time (Lee et al., 1998).

Fish habitats are identified as spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly and or indirectly, in order to carry out their life processes (Lee et al., 1998). Fish habitats commonly occur in many natural heritage areas such as wetlands, valleylands, woodlands and Areas of Natural and Scientific Interest (ANSI).

Based on review of the MNRF Make a Map: Natural Heritage Areas and NHIC Data, the Study Area contains a small PSW within Smythe Park, however this is not identified in the City Official Plan mapping identifying PSWs (ref. Appendix E). Black Creek provides warm and cool water fish habitat. Consultation with agencies will be needed to confirm requirements regarding these features.

Woodlands

Woodlands are treed areas that provide environmental or economic benefits such as erosion prevention, water retention, recreation and the sustainable harvest of woodland products. Woodlands include treed areas, woodlots or forested areas, and vary in their level of significance (MMAH, 2014). Woodland significance is typically determined by evaluating key criteria which relate to woodland size, ecological function, uncommon woodland species, and economic and social value. It is noted that larger woodlands are more likely to contain a greater diversity of plant and animal species and communities than smaller woodlands, and are better buffered against edge effects or agricultural and urban activities.

Woodlands are present within the Study Area, and are part of the Natural Heritage System identified by the City of Toronto (ref. Appendix E). Further botanical information will need to be collected with respect to this feature during the appropriate field season as part of a future Class Environmental Assessment.

Valleylands

The PPS (MMAH, 2014) identifies significant valleylands as a “natural area that occurs in a valley or landform depression that has “water” for some period of the year. TRCA has confirmed that the Black Creek valley is considered a significant valleyland.

Areas of Natural and Scientific Interest

The PPS (2014) defines ANSIs as areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education. The Areas of Natural and Scientific Interest (ANSIs) program designates natural features in two (2) broad biophysical categories, earth science (geological) or life science (biological) depending on the features present. Specifically, a life science ANSI can contain specific types of forests, valleys, prairies and/or wetlands of ecological importance (MNRF, 2010). That is, they represent examples that are relatively undisturbed in terms of vegetation community and/or landforms associated with that vegetation (MNRF, 2010). Those listed as provincially significant life science ANSIs are the best examples of that particular natural heritage feature in the Province (MNRF, 2010). In contrast, earth science ANSIs are representative examples of geological processes in Ontario (i.e., exposed bedrock on road cuts, fossils and landforms) (MNRF, 2010).

Based on review of the MNRF Make a Map: Natural Heritage Areas and the City of Toronto Official Plan, there are no ANSIs located within the Study Area.

2.4.2.5 Wildlife Habitat

Wildlife habitat is defined as areas where plants, animals and other organisms live and are able to find adequate amounts of food, water, shelter and space needed to sustain their populations. Specific wildlife habitat of concern may include areas where species concentrate at a point in their annual life cycle, and those areas which are important to migratory and non-migratory species.

A wildlife habitat is considered "significant" if it is deemed ecologically important in terms of feature, function, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or Natural Heritage System (MMAH, 2014). According to the Significant Wildlife Habitat Ecoregion Criteria Schedules for Ecoregion 7E (MNRF, 2015), significant wildlife habitat may consist of:

- Seasonal concentration areas for animals;
- Rare vegetation communities;
- Specialized habitat for wildlife; and
- Habitat for species of conservation concern.

Seasonal Concentration Areas

Seasonal Concentration Areas are those habitats where large numbers of a single species or many species congregate at one (or several) times a year. The SWH Criterion Schedules (SWHCS) for Ecoregion 7E outlines a series of seasonal concentration areas. The following information is based on available background information (Table 2.4).

Table 2.4. Seasonal Concentration Areas

Habitat	ELC Communities	Comments
Waterfowl Stopover & Staging Areas (Terrestrial)	Mineral Cultural Meadow & Thicket (CUM1, CUT1) with annual spring flooding	Narrow strip of Exotic Deciduous Thicket identified along a portion of Lavender Creek. Field work required.
Waterfowl Stopover & Staging Areas (Aquatic)	Meadow Marsh (MAM1-6), Shallow Marsh (MAS1-3), Shallow Water (SAS1, SAM1, SAF1), & Deciduous Swamp (SWD1-7)	ELC communities present, additional field work required.
Shorebird Migratory Stopover Area	Beach/Bar (BBO1-2, BBS1-2, BBT1-2), Sand Dune (SDO1, SDS1, SDT1), & Meadow Marsh (MAM1-5)	A very small area of suitable ELC community present (MAM2-10). Additional field work required.
Raptor Wintering Area	Combination of Forest (FOD, FOM, FOC) & Upland Cultural (CUM, CUT, CUS, CUW) sites	ELC communities present however area is less than the required 20 hectares (50 acres).
Bat Hibernacula	Crevice (CCR1-2) & Cave (CCA1-2)	ELC communities absent.

Habitat	ELC Communities	Comments
Bat Maternity Colonies	Mature Deciduous or Mixed Forests (FOD, FOM) with >10 ha large diameter (>25 cm dbh) trees per hectare	ELC communities present, however the area is less than the 10 ha required.
Bat Migratory Stopover Area	No specific ELC communities. Location & characteristics of habitat unknown & being determined.	This identification of stopover areas is relatively unknown in the Province of Ontario. Consultation with MECP required.
Turtle Wintering Areas	Swamp (SW), Marsh (MA), Open & Shallow Water (OA, SA), Open Bog (BOO), & Open Fen (FEO)	ELC Communities present; additional field work required.
Snake Hibernaculum	Talus (TA), Rock Barren (RB), Crevice & Cave (CC), Alvar (AL), & other dry ecosites	ELC communities absent.
Colonially-Nesting Bird Breeding Habitat (Bank & Cliff)	Mineral Cultural (CUM1, CUT1, CUS1), Bluff (BLO1, BLS1, BLT1), Carbonate Cliff (CLO1, CLS1, CLT1), & other areas with eroding banks, sandy hills, borrow pits, steep slopes, sand piles, cliff faces, bridge abutments, silos or barns	CUT1-c ELC Community present; however, characteristics are unlikely to support Colonially-Nesting Bird Breeding Habitat (Bank & Cliff).
Colonially-Nesting Bird Breeding Habitat (Trees and Shrubs)	Deciduous & Mixed Swamp (SWD1-7, SWM2-3, SWM5-6), & Treed Fen (FET1)	ELC Communities Present, field work required.
Colonially-Nesting Bird Breeding Habitat (Ground)	Meadow & Shallow Marsh (MAM1-6, MAS1-3), & Cultural (CUM, CUS, CUT) with rocky islands or peninsulas or in close proximity to watercourse	ELC Communities present, additional field work required.
Migratory Butterfly Stopover Areas	Combination of Cultural field (CUM, CUS, CUT) & Forest/Plantation (FOD, FOM, FOC, CUP) that are >10 ha & within 5 km of Lake Ontario and Lake	Study Area is more than 5 km from Lake Ontario and Lake Erie.
Landbird Migratory Stopover Areas	Forest (FOD, FOM, FOC), & Swamp (SWD, SWM, SWC) that are >10 ha & within 5 km of Lake Ontario and Lake Erie	Study Area is more than 5 km from Lake Ontario and Lake Erie.
Deer Winter Congregation Areas	Forest (FOD, FOM, FOC), & Swamp (SWD, SWM, SWC) that are >100 ha	ELC communities present, however the area is less than 100 ha as required.

Rare Vegetation Communities

Rare Vegetation Communities are those that contain provincially rare vegetation communities, or those which are rare to the area. The following information is based on background information reviewed (Table 2.5).

Table 2.5. Rare Vegetation Communities

Habitat	ELC Communities	Comments
Cliffs & Talus Slopes	Open, Shrub & Treed Talus (TAO, TAS, TAT) Open, Shrub & Treed Cliff (CLO, CLS, CLT)	ELC communities absent.
Sand Barren	Open, Shrub & Treed Sand Barren (SBO1, SBS1, SBT1)	ELC communities absent.
Alvar	Open, Shrub & Treed Alvar (ALO1, ALS1, ALT1) Dry-Fresh Pine or Cedar Coniferous Forest (FOC1, FOC2) Bedrock Cultural Meadow, Thicket, Savannah & Woodland (CUM2, CUT2-1 CUS2, CUW2)	ELC communities absent.
Old Growth Forest	Deciduous, Coniferous & Mixed Forest (FOD, FOC, FOM)	ELC community present however habitat is unlikely. Further evaluation of community required during appropriate field season.
Savannah	Tallgrass Savannah (TPS1, TPS2) Tallgrass Woodland (TPW1, TPW2) Bedrock Cultural Savannah (CUS2)	ELC communities absent.
Tallgrass Prairie	Open Tallgrass Prairie (TPO1, TPO2)	ELC communities absent.
Other Rare Vegetation Communities	Provincially rare S1-S3 vegetation communities.	Field investigation required to confirm presence and/or absence of S1-S3 vegetation communities.

Specialized Habitats for Wildlife

Specialized Habitats for Wildlife consist of that which support wildlife that have highly specific habitat requirements (e.g., nesting habitat – vernal pools), those areas that contain high species and community diversity and those which provide habitat that can greatly enhance species survival (MNRF, 2000). Similar to seasonal concentration areas, the assumptions and presence of specialized habitats for wildlife is based on background information review (Table 2.6).

Table 2.6. Specialized Habitats for Wildlife

Habitat	ELC Communities	Comments
Waterfowl Nesting Area	Include all upland areas that are adjacent to: Meadow & Shallow Marsh (MAM, MAS), Shallow Water (SA), Bedrock & Mineral Thicket Swamp (SWT1, SWT2), & Mineral Deciduous Swamp (SWD1, SWD2, SWD3, SWD4)	ELC communities present, however based on existing characteristics, habitat is unlikely. Additional field work required.
Bald Eagle & Osprey Nesting, Foraging & Perching Habitat	Deciduous, Mixed & Coniferous Forest (FOD, FOM, FOC), & Deciduous, Mixed & Coniferous Swamp (SWD, SWM, SWC) communities adjacent to riparian areas	ELC communities present, however based on existing characteristics, habitat is unlikely. Additional field work required.

Habitat	ELC Communities	Comments
Woodland Raptor Nesting Habitat	Deciduous, Mixed & Coniferous Forest (FOD, FOM, FOC), Deciduous, Mixed & Coniferous Swamp (SWD, SWM, SWC), & Coniferous Plantation (CUP3)	ELC communities present, however size is less than 40 ha required.
Turtle Nesting Areas	Exposed mineral soil areas (sand/gravel) adjacent to: Meadow Marsh (MAM), Shallow Marsh (MAS), Shallow Water (SA), Open Bog (BOO1) & Open Fen (FEO1)	ELC Communities present, however characteristics of those communities are unlikely to support Turtle Nesting Areas.
Seeps & Springs	Any forested ecosite (FOD, FOM, FOC) located in headwater areas.	ELC communities present, however characteristics of the Project Location unlikely to support seeps and springs due to its location to headwater systems.
Amphibian Breeding Habitat (Woodland)	Deciduous, Mixed & Coniferous Forest (FOD, FOM, FOC), & Deciduous, Mixed & Coniferous Swamp (SWD, SWM, SWC)	ELC communities present.
Amphibian Breeding Habitat (Wetlands)	Swamp (SW), Marsh (MA), Fen (FE), Bog (BO), Open water (OA) & Shallow Water (SA)	ELC Communities present.
Woodland Area- Sensitive Bird Breeding Habitat	Deciduous, Mixed & Coniferous Forest (FOD, FOM and FOC), & Deciduous, Mixed & Coniferous Swamp (SWD, SWM, SWC)	ELC communities present, however woodlots are less than the 30 ha required.

Habitat for Species of Conservation Concern

Habitats for Species of Conservation Concern are those that contain species that are rare or substantially declining, or have high percentage of their global population in Ontario and are rare or uncommon in the planning area. These habitats are often associated with special concern species as identified under the ESA or the Species at Risk in Ontario (SARO) list. Assumptions of presence of habitat for species of conservation concern is based on background information review (Table 2.7).

Table 2.7. Habitat for Species of Conservation Concern

Habitat	ELC Communities	Comments
Marsh Bird Breeding Habitat	Meadow Marsh (MAM), Shallow Water (SA), Open Fen (FEO1) & Open Bog (BOO1)	ELC communities present.
Open Country Bird Breeding Habitat	Mineral & Bedrock Cultural Meadow (CUM1, CUM2)	ELC communities present.
Shrub/Early Successional Bird Breeding Habitat	Cultural Thicket (CUT1, CUT2), Cultural Savannah (CUS1, CUS2), & Cultural Woodland (CUW1, CUW2)	ELC communities present however area is less than the required 10 ha in size.
Terrestrial Crayfish	Meadow Marsh (MAM) & Shallow Marsh (MAS)	ELC communities present.
Special Concern (SC) & Rare (S1-S3, SH) Wildlife Species	Ecosites associated with any SC, S1-S3 or SH plant or animal element occurrences within 1 or 10 km from project location.	Future surveys required to confirm presence and/or absence of special concern (SC) and rare wildlife species.

Wildlife Movement Corridors

Wildlife movement corridors are habitats that link two (2) or more other wildlife habitats that are critical to the maintenance of a population of a particular species or group of species. The key ecological function of wildlife movement corridors is to enable wildlife to move between areas of significant habitat or core natural areas with minimum mortality.

Wildlife movement corridors can provide critical links between shelter, feeding, watering, growing and nesting locations (Lee et al., 1998). Wildlife and/or habitat corridors can help increase genetic diversity and aid in the re-establishment of populations after random events such as fires or disease outbreaks. These corridors can help to increase biodiversity and population stabilization (Lee et al., 1998).

According to the Significant Wildlife Habitat Ecoregion Criteria Schedules for Ecoregion 7E (MNRF, 2015), wildlife movement corridors to be considered include amphibian movement corridors.

Based on the Criteria Schedule 7E, amphibian movement corridors are determined based on identifying significant breeding habitat. Field work is required at the appropriate time when species are expected to be migrating or entering their breeding sites. This will also further confirm the presence of significant wildlife habitat.

2.4.3 Future Work Requirements

A future Class Environmental Assessment (EA), pending the review of the outcomes of this Feasibility Study, is expected to be required for the preferred Flood Remediation Project, which will involve consultation with regulatory agencies, stakeholders and the public and field investigations to fill information gaps. Based on Wood's understanding of the Study Area, the following is recommended as related to the natural systems in reference to the future Cass EA:

- Preparation of a terms of reference to be approved by TRCA and the City of Toronto;
- Anuran call surveys (total of three (3) surveys) to be completed in accordance with the Marsh Monitoring Program;
- Breeding bird surveys (total of two (2) surveys) to be completed in accordance with the Atlas of Breeding Birds Ontario protocol;
- A botanical survey (early spring and mid-summer months) to capture all species and create vegetation community mapping according to ELC;
- Consultation with MECP regarding the requirements for targeted SAR surveys;
- Consultation with TRCA and the City regarding requirements for permit and survey requirements;
- Completion of surveys and plans associated with permitting requirements (botanical species, tree preservation plan, tree removal plan, restoration plan, etc.)
- Completion of a project screening process following that outlined by DFO for the proposed Flood Remediation strategy chosen to determine whether or not a Request for Review will be required;
- Documentation of incidental observations of all wildlife during the above-listed required surveys; and
- Formalized recommendations and mitigation measures; and a summary of permit and approval requirements.

2.4.4 Mapping

Based on the data and mapping sources outlined herein, the following mapping has been provided in Appendix E to identify Natural Systems within the Study Area:

- Ecological Land Classification (TRCA) (ref. Figure 4 in Appendix E);
- Ecological Land Classification and Flora and Fauna Records Locations (TRCA) (ref. Figure 2 in Appendix E);
- Natural Heritage System (ref. Figure 1, Figure 2 in Appendix E) and Special Policy Areas (ref. Figure 3 in Appendix E); and
- Natural Heritage Information Centre.

2.5 Geotechnical

2.5.1 Reports, Studies and Data

The following information has been provided by the City of Toronto related to the Geotechnical Assessment:

- Various Borehole (BH) records in Study Area -10 BHs
- Various BH records in close vicinity of Study Area -8 BHs
- Geotechnical Report for Contract 14EY-14RD), April 2014, VVM – 2BHs
- Geotechnical Investigation for Contract 09EY-I8WS), December 2008, John Emery Geotechnical Engineering Limited – 13BHs
- Geotechnical Investigation for Contract 03D2-16WS), May 2003, Saheen & Peaker Limited – 2BHs
- Geotechnical Investigation for Selected Roadways in Etobicoke), June 2001, Candec Consultants Limited
- Geotechnical Investigation (Keele Trunk Relief Sewer and Nashville Trunk Relief Sewer), August 1991, Golder Associates Ltd. – BHs

In addition to foregoing BH records and reports, BH records have been downloaded from the Ontario Geological Survey (OGS) and the Ministry of Transportation (MTO). Based on a review of the information provided by the City of Toronto, OGS and MTO, the data that have provided the most utility, are from the OGS and MTO, due to the BH locations and extent of data provided.

2.5.2 Mapping

Wood has not received Geotechnical Mapping for this Feasibility Study.

2.5.3 Geotechnical Work Plan

Wood in consultation with TRCA and the City, developed a proposed Borehole Location Plan (Ref. Appendix B) to determine soil conditions at the locations of recommended 2104 Class EA flood remediation alternatives and various stream crossings. Wood obtained cut permits and authorization from the City, not including Street Occupation Permits, to drill the boreholes as per the Borehole Location Plan. Street Occupancy Permits were secured shortly based on confirming drillers for the month of September 2019.

Using the available geotechnical information from the City of Toronto, OGS and the MTO, soil conditions at the proposed borehole locations have been determined as per the following:

The proposed flood protection berms (Boreholes 1, 2 and 3) located east of Scarlett Road within Smythe Park:

Ontario Geological Survey Borehole ID 642757 located at the toe of the slope within Smythe Park had encountered loose sand, silt, clay, gravel, organics extending to 4.3m below existing grade (geodetic elevation of 91.4m) underlain by soft silt, clay extending to 7.0m below existing grade (geodetic elevation of 88.7m) followed by hard clay, silt, sand and gravel extending to the borehole termination depth of 9.1m below existing grade (geodetic elevation of 86.6m).

Due to presence of the above noted soft clay, silt, Wood extended Boreholes 1 and 3 from 10 m to approximately 15m below existing grade, so as to obtain samples of the soft material for consolidation testing.

Jane Street Bridge (Boreholes 4 and 5):

Ontario Geological Survey Borehole ID 644508 located within Smythe Park, south of Black Creek had encountered loose sand, silt, clay, gravel, organics extending to 3.4m below existing grade (geodetic elevation of 96.2m) underlain by compact gravel, sand, silt, shells, clay extending to 10.7m below existing grade (geodetic elevation of 88.9m), followed by a thin layer of an unknown stiff material to a soft clay, silt, gravel extending to a depth of 14.3m below existing grade (geodetic elevation of 85.3m), followed by dense silt, clay extending to a depth of 17.4m below existing grade (geodetic elevation of 82.2m), followed by hard till sand extending to the borehole termination depth of 18.3m below existing grade (geodetic elevation of 81.3m).

It is understood that the existing structure is supported by steel piles likely extended several metres into the dense / hard subgrade encountered at 17.4m below existing grade. As such, Wood extended the proposed boreholes a minimum of 30m below the existing road to allow for preliminary data for foundation design.

Rockcliffe Boulevard Bridge (Boreholes 6 and 7) and flood protection berm (Boreholes 8 and 10):

Ontario Geological Survey Borehole ID 643861 located within Smythe Park and west of Rockcliffe Boulevard encountered loose to dense fill extending to 2.4m below existing grade (geodetic elevation of 96.8m) underlain by dense sand, silt, clay extending to 7.0m below existing grade (geodetic elevation of 92.2m), followed by silt, sand of unknown consistency extending to 13.1m below grade (geodetic elevation of 86.1m), followed by a 1.5m thick seam of firm clay, silt, gravel followed by dense sand gravel clay till extending from 14.6m below existing grade to the borehole termination depth of 18.6m below existing grade (geodetic elevation of 80.6m).

It is understood that the existing Rockcliffe Blvd. bridge structure is supported by piles likely extended several metres into the dense subgrade encountered at 14.6m below existing grade.

The proposed bridge boreholes were extended a minimum of 30m below existing road to be sufficient to allow for preliminary data for foundation design.

The proposed flood berm boreholes were extended approximately 15m, below existing grade to be sufficient to allow for preliminary data for berm design.

Rockcliffe Court, Symes & Hilldale Road flood protection berm & culvert replacement (Boreholes 9, 11, 12 and 13):

Ontario Geological Survey Borehole ID 646649 located Hilldale Court east of Symes Road encountered 0.9m of material described as soil underlain by sand, silt extending to 2.4m below existing grade (geodetic elevation of 101.6m) underlain by silt, organic material extending to 4.0m below existing grade (geodetic elevation of 100.0m), followed by silt extending to the borehole termination depth of 7.6m below existing grade (geodetic elevation of 96.4m). Soil consistencies were not available.

The proposed flood berm and culvert replacement boreholes were extended a minimum of 5m below existing grade to be sufficient to allow for preliminary data for berm design.

Alliance Avenue and Hilldale Road bridges (Boreholes 14, 15 and 16) and Louvain Street pedestrian bridge (Boreholes 17 and 18):

Ontario Geological Survey Borehole ID 646664 located along Humber Boulevard South and east of Hilldale Road encountered sand, silt organics of unknown consistency extending to 3.4m below existing grade (geodetic elevation of 111.5m) underlain by sand, gravel, silt, clay of unknown consistency extending to 7.3m below existing grade (geodetic elevation of 107.6m), followed by dense sand, clay, silt extending to 13.4m below grade (geodetic elevation of 101.5m), followed by dense sand extending to the borehole termination depth of 15.5m below existing grade (geodetic elevation of 99.4m).

The foundation system for the Alliance Avenue and Hilldale Road bridges is unknown, however based on the above noted borehole data, deep foundations are likely employed.

The proposed bridge boreholes were extended a minimum of 30m below existing road to be sufficient to allow for preliminary data for foundation design.

It is understood that the existing Louvain Street pedestrian bridge structure is supported by wood piles extended approximately 10m below existing grade (geodetic elevation of 92.5m).

The proposed pedestrian bridge boreholes were extended a minimum of 10m below existing grade, As a result of the foundation design details, Wood extended the two boreholes to 15m below existing grade.

Weston Road bridge (Boreholes 19 and 20)

MTO - Northwest Metro Arterial Borehole 1 located near the southeast corner of Weston Road and Black Creek Drive had encountered fill extending to 2.1m below existing grade (geodetic elevation of 102.9m) generally underlain by very stiff to hard clayey silt extending to 19.5m below existing grade (geodetic elevation of 85.5m), followed by compact sand extending to 20.1m below grade (geodetic elevation of 84.9m), followed by dense glacial till extending to the borehole termination depth of 21.8m below existing grade (geodetic elevation of 83.2m).

The foundation system for the Weston Road bridge is unknown, however, it is understood that the CNR and CPR structures located immediately east of the Weston Road and Black Creek Drive intersection are supported by deep piles.

The proposed bridge boreholes were extended a minimum of 30m below existing road to be sufficient to allow for preliminary data for foundation design.

It is understood that the existing Louvain Street pedestrian bridge structure is supported by wood piles extended approximately 10m below existing grade (geodetic elevation of 92.5m).

The proposed pedestrian bridge boreholes were extended a minimum of 10m below existing grade. As a result of the foundation design details. Wood extended the two boreholes to 15m below existing grade.

2.6 Stream Crossings

2.6.1 Existing Conditions

In total, thirteen (13) bridge and culvert structures have been identified to be present within the Study Area. Data on the structures have been provided by the City of Toronto, in the form of design drawings and as-built plans, structural condition sheets and a stream crossing inventory, conducted by Wood on July 24, 2019 (ref. Appendix D).

Black Creek Structures

Scarlett Road Bridge over Black Creek (#360)

The Scarlett Road Bridge over Black Creek, constructed in 1983, is a 19.5m wide cast-in-place concrete rigid frame structure with a 15.4m span and is located on Scarlett Road approximately 65m south of the Clairton Crescent intersection. The bridge carries four lanes of traffic (two in each direction) with a posted speed of 50km/hr. There are sidewalks and parapet walls on each side of the bridge. The bridge spans north-south with flows along the Black Creek travelling east-west. Multiple utilities are present on this structure including a gas main on the east soffit, a watermain near the west soffit, one light duct in each of the parapet walls, and six ducts in each of the sidewalks (six hydro ducts in west sidewalk, two bell ducts and four hydro ducts in east sidewalk).

Smythe Park Pedestrian Bridge #1 over Black Creek Tributary West (#308521)

The Smythe Park Pedestrian Bridge #1 over Black Creek Tributary West, constructed in 2000, is a 1.22m wide timber deck steel I-beam bridge with a 9.3m span and is located approximately 365m east of Scarlett Road off of the Black Creek Trail. The bridge allows for pedestrian crossing over the Black Creek Tributary West connecting the Edinborough residential area to the Black Creek Trail. The bridge spans north-south with flows along the Black Creek Tributary West travelling east-west.

No structural drawings were found for this bridge. However, the 2017 OSIM inspection found the structure to be in generally poor condition with a Bridge Condition Index (BCI) of 49.89 and recommended its replacement within 6-10 years. This was due to the severe corrosion found along the girders and floor beams.

Smythe Park Pedestrian Bridge #2 over Black Creek (#308522)

The Smythe Park Pedestrian Bridge #2 over Black Creek, constructed in 1980, is a 3.07m wide steel deck prefabricated steel truss bridge with a 20.3m span and is located approximately 100m south of the intersection between Black Creek Boulevard and Sandcliffe Road. The bridge allows for pedestrian crossing over the Black Creek connecting Black Creek Boulevard to the Black Creek Trail. The bridge spans north-south with flows along the Black Creek Tributary West travelling east-west.

The bridge is supported on a 2m tall abutment with piles. The abutment is protected from scouring by the concrete lined Black Creek channel.

No information is available regarding the rehabilitation history of this structure. However, the 2017 OSIM inspection found the structure to be in generally fair condition with a BCI of 68.98. The inspection found light to moderate flaking of the patina and light corrosion throughout the steel elements of the bridge.

Smythe Park Pedestrian Bridge (3) over Black Creek (#308523)

The Smythe Park Pedestrian Bridge #3 over Black Creek, constructed in 1980, is a 2m wide steel deck T-beam bridge with a 22.1m span and is located approximately 106m west of Jane Street along the Black Creek Trail. The bridge allows for pedestrian crossing over the Black Creek continuing the Black Creek Trail from the north to the south. The bridge spans north-south with flows along the Black Creek Tributary West travelling east-west.

Rehabilitation was carried out in 2014 to repair perform general concrete repairs and install a new railing. The 2017 OSIM inspection found the structure to be in generally good condition with a BCI of 72.45.

Jane Street Culvert over Black Creek (#091)

The Jane Street Culvert over Black Creek is a 57.25m long cast-in-place concrete arch structure with a 10.7m span and is located on Jane Street approximately 70m south of the Alliance Avenue intersection. The culvert carries four lanes of traffic (two in each direction) with a posted speed of 50 km/hr. Traffic volumes as of 2017 were found to be approximately 11,823 AADT. There are sidewalks and guiderails on each side of the roadway. There is approximately 6.0m of earth fill on top of the culvert and the watercourse flows from east to west through the culvert. It is suspected that there may be embedded utility ducts within each sidewalk.

The existing structure is the product of two major construction projects from the past. The original central segment of the culvert was constructed in 1948 and is approximately 36.58m long. In 1964, extensions on both ends of the culvert were constructed. The extension project also saw the construction of wingwalls at all four quadrants. The foundations for the extended portion of the culvert and the wingwalls were supported by the use of steel piles embedded into the ground to varying depths. Although no other information is available on previous rehabilitation work, it is suspected that general repairs and maintenance like concrete patching and concrete surface cleaning has taken place due to the existing condition of the structure.

As part of provincial requirements, any structures carrying public traffic and meeting the criteria of the Ontario Structure Inspection Manual (OSIM) require bi-ennial inspections. The latest OSIM inspection for this structure (2017) found that the structure is generally in good condition with a Bridge Condition Index (BCI) of 70.09. The BCI is a value developed by the Ministry of Transportation of Ontario (MTO) to provide an indication of the overall condition of the structure. In general, a BCI of 70-100 equates to a good condition rating, 60-70 equates to a fair condition rating, and 60 or less equates to a poor condition rating.

Rockcliffe Boulevard Bridge over Black Creek (#702)

The Rockcliffe Boulevard Bridge over Black Creek, constructed in 1963, is a 14.3m wide cast-in-place concrete rigid frame structure with a 15.2m span and is located on Rockcliffe Boulevard approximately 35m north of the Rockcliffe Court intersection. The bridge carries two lanes of traffic (one in each direction) with a posted speed of 50 km/hr. there are sidewalks and parapet walls on each side of the bridge. The bridge spans north-south with flows along the Black Creek travelling east-west. Along the west exterior soffit, ten utility ducts are secured to a hangar.

In 2007, the structure was widened as part of a major rehabilitation project. This project also included the replacement of the sidewalks and parapet walls along with general patch repairs to the concrete on the bridge.

The 2017 OSIM inspection found that the structure is generally in good condition with a BCI of 77.14.

Alliance Avenue Bridge over Black Creek (#704)

The Alliance Avenue Bridge over Black Creek, constructed in 1975, is a 10.74m wide concrete slab on prestressed girder bridge with a 20.9m span and is located on Alliance Avenue approximately 60m east of the Humber Boulevard North intersection. The bridge has a 34° skew angle and carries two lanes of eastbound traffic only. Traffic volumes as of 2017 were found to be approximately 4,460 AADT. There is a sidewalk on the south only and a wide curb on the north with a steel railing system and chain link fence on both sides. The bridge spans east-west with flows along the Black Creek travelling north-south.

No information is available regarding the rehabilitation history of this structure. However, the 2017 OSIM inspection found the structure to be in generally good condition with a BCI of 72.15.

Humber Boulevard Bridge over Black Creek (#703)

The Humber Boulevard Bridge over Black Creek, constructed in 1975, is a 10.76m wide concrete slab on prestressed girder bridge with a 12.1m span and is located on Hilldale Road between Humber Boulevard North and Humber Boulevard South. The bridge carries two lanes of westbound traffic only. Traffic volumes as of 2017 were found to be approximately 4,660 AADT. There is a sidewalk on the north only and a wide curb on the south with a steel railing system and chain link fence on both sides. The bridge spans east-west with flows along the Black Creek travelling north-south.

No information is available regarding the rehabilitation history of this structure. However, the 2017 OSIM inspection found the structure to be in generally good condition with a BCI of 72.79.

Humber Boulevard Pedestrian Bridge over Black Creek (#705)

The Humber Boulevard Pedestrian Bridge over Black Creek, constructed in 2014, is a 2.49m wide prefabricated steel truss bridge with a 12.1m span and is located near the Humber Boulevard North and Louvain Street intersection. The bridge allows for pedestrian crossing over the Black Creek connecting Humber Boulevard South to Humber Boulevard North. The bridge spans east-west with flows along the Black Creek travelling north-south.

The original bridge at this this location was constructed in 1943 and was later replaced in 1975. The existing bridge is the latest structure replacing the one constructed in 1975.

The 2017 OSIM inspection found the structure to be in generally good condition with a BCI of 87.13.

Weston Road Bridge over Black Creek (#092)

The Weston Road Bridge over Black Creek, constructed in 1980, is a 37.8m wide cast-in-place concrete rigid frame structure with a 10.9m span and is located on Weston Road at the Humber Boulevard North/Black Creek Drive intersection. The bridge carries six lanes of traffic (four westbound and two eastbound) including two westbound turning lanes with a posted speed of 50km/hr. Traffic volumes as of 2017 were found to be approximately 19,162 AADT. There are sidewalks and parapet walls on each side of the bridge. A concrete median is also present along the centre of the roadway separating the eastbound and westbound traffic lanes. The bridge spans east-west with flows along the Black Creek travelling north-south. There are two gas pipes at the north and south soffit exteriors along with an electrical duct on the south exterior.

In 2006, the structure underwent a rehabilitation which included the application of a new waterproofing membrane and asphalt wearing surface including patching of any deteriorated areas on the deck top. Additionally, new sidewalks, new parapet walls, new railing systems, new median, and general concrete patch repairs were also included as part of this assignment.

Currently, based on the 2017 OSIM inspection, the structure was found to be in generally good condition with a BCI of 74.51.

No information is available regarding the rehabilitation history of this structure. However, the 2017 OSIM inspection found the structure to be in generally good condition with a BCI of 74.37.

Lavender Creek Structures

Three structures were identified along Lavender Creek that were within the study area. The structures included two concrete bridges and one concrete culvert. as per the following:

Structure #1 (#709)

The first structure along the Lavender Creek, is a 13.4 m wide reinforced concrete box-type girder bridge with a 4.8m span and is located off of Symes Road, approximately 25m north of the Orman Avenue intersection. The bridge provides access to the nearby private business (Bothwell Accurate). Generally, the structure appears to be in poor to fair condition with typical signs of concrete deterioration on the soffit (delamination, spalling, cracking, efflorescence, etc.). The bridge spans east-west with flows along the Lavender Creek travelling south-north.

Structure #2 (#708)

The second structure along the Lavender Creek, is a 7.9m wide reinforced concrete box-type girder bridge with a 4.8m span and is located off of Symes Road, approximately 50m south of the Orman Avenue intersection. The bridge does not serve a function as the west side is fenced off by the private business. Generally, the structure appears to be in poor to fair condition with typical signs of concrete deterioration on the soffit (delamination, spalling, cracking, efflorescence, etc.). The bridge spans east-west with flows along the Lavender Creek travelling south-north.

Structure #3 (ID #898)

The third structure along the Lavender Creek, is a 40.2 m long rectangular cast-in-place concrete culvert with a 3.66m span and is located on Symes Road, approximately 50m south of the Hillborn Avenue intersection. The culvert allows for the flow of the Lavender Creek under Symes Road. Due to the low vertical clearance of the structure (approximately 1m), the culvert could not be physically accessed to perform a visual inspection. The culvert spans north-south with flows along the Lavender Creek travelling east-west.

2.7 Traffic and Transportation

2.7.1 Reports and Studies

The City of Toronto has provided the following traffic data as part of this Feasibility Study:

- April 2010 traffic volumes on north bound Humber Boulevard, south of Weston Road;
- November 2011 traffic volumes on north bound Weston Road, south of Black Creek Drive;
- October 2012 Traffic volumes on south bound Jane Street, north of Haney Avenue; and
- 2017 AADT information at some of the Black Creek crossings at provided on the Structural Inspection Reports.
- Signal timing for signalized intersections

2.7.2 Mapping and Drawings

For the transportation assessment, digital base mapping was provided by the City of Toronto which included essential information of the Study Area, including property information, ROW, existing infrastructure, certain private utilities etc. This base map (ref. Figure 2.11 and 2.12) has been used in the assessment herein.

A 3-dimensional Digital Terrain Model (DTM) based on LiDAR data with 1m contour interval has been provided by TRCA. The DTM covers the study area and beyond. This 3D information has been used in setting horizontal alignment and vertical profiles for proposed road improvements and/or connections. It has been used in generating cross-sectional views of existing and proposed roads.

2.8 Utilities and Infrastructure

2.8.1 Reports and Studies

Wood did not receive separate reports or studies regarding utilities (bell, hydro, gas, cable etc.); a SUE investigation though was undertaken over the course of the Feasibility Study. Wood has been provided the following reports from the City of Toronto related to Study Area infrastructure:

- *Conceptual Design Report, Investigation of Basement Flooding Area 4, January 2015 R.V Anderson Associates Limited and XCG Consultants Ltd;* and
- *Environmental Study Report South Class Environmental Assessment Area Combined Sewer Overflow Control and Basement Flooding Areas 4 and 5', August 2014, XCG Consultants Ltd.*

2.8.2 Mapping and Drawings

The City has provided a utilities contact list, which has been used by Wood to collect utility mapping and data from the utility companies (bell, hydro, gas, cable etc.). Wood received utility mapping from private utilities (ref. Appendices F and L).The City has provided municipal infrastructure mapping as outlined in Section 2.1.

2.8.3 SUE Investigation (T2UE)

A Subsurface Utility Engineering (SUE) investigation has been conducted by T2 Utility Engineers (T2UE) through which private and public utilities have been identified. Utility conflicts with the proposed flood mitigation alternatives have been identified and utility relocation recommendations outlined as per the Appendix L.

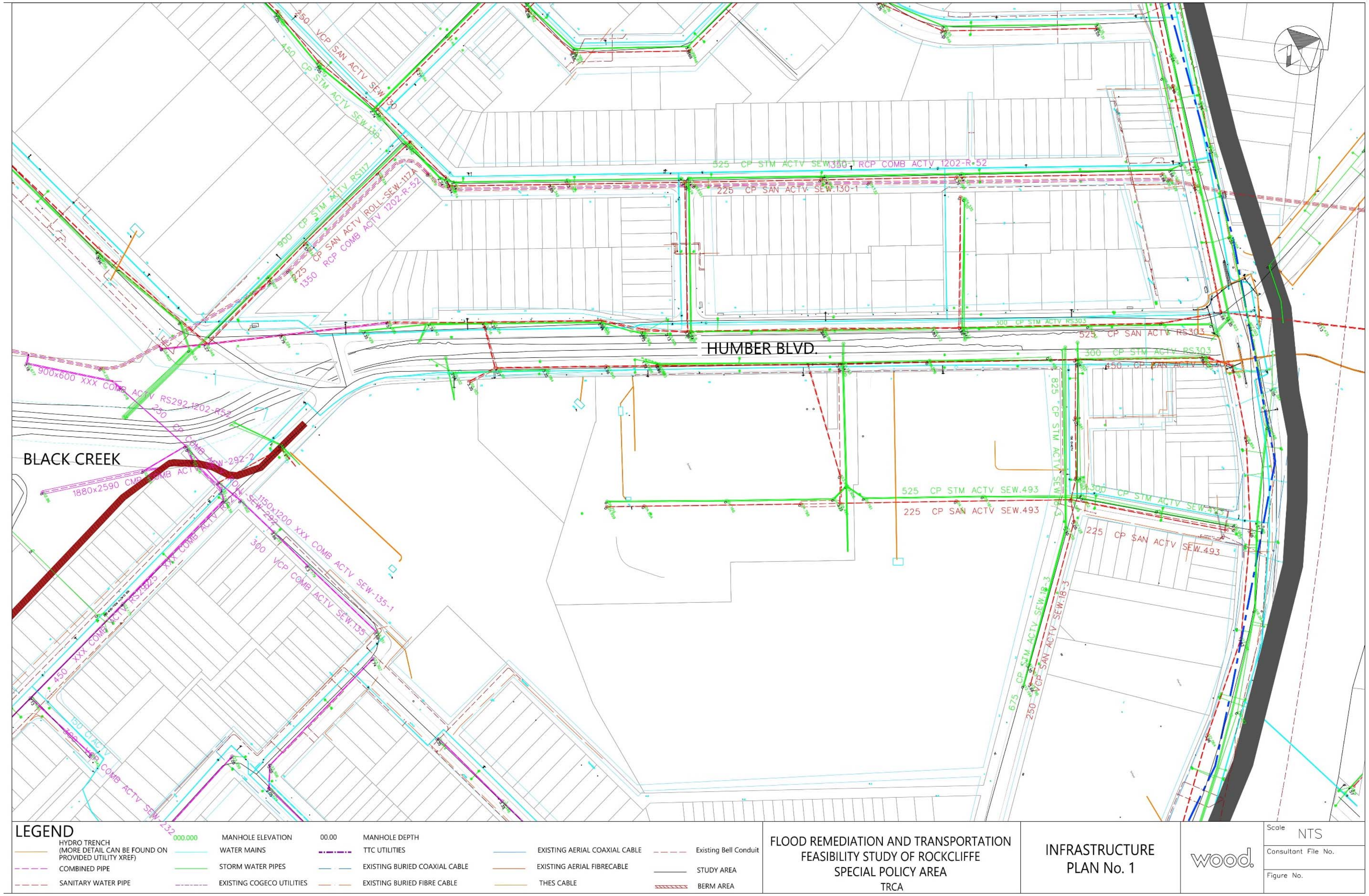

Figure 2.11. Study Area Infrastructure (North Section)

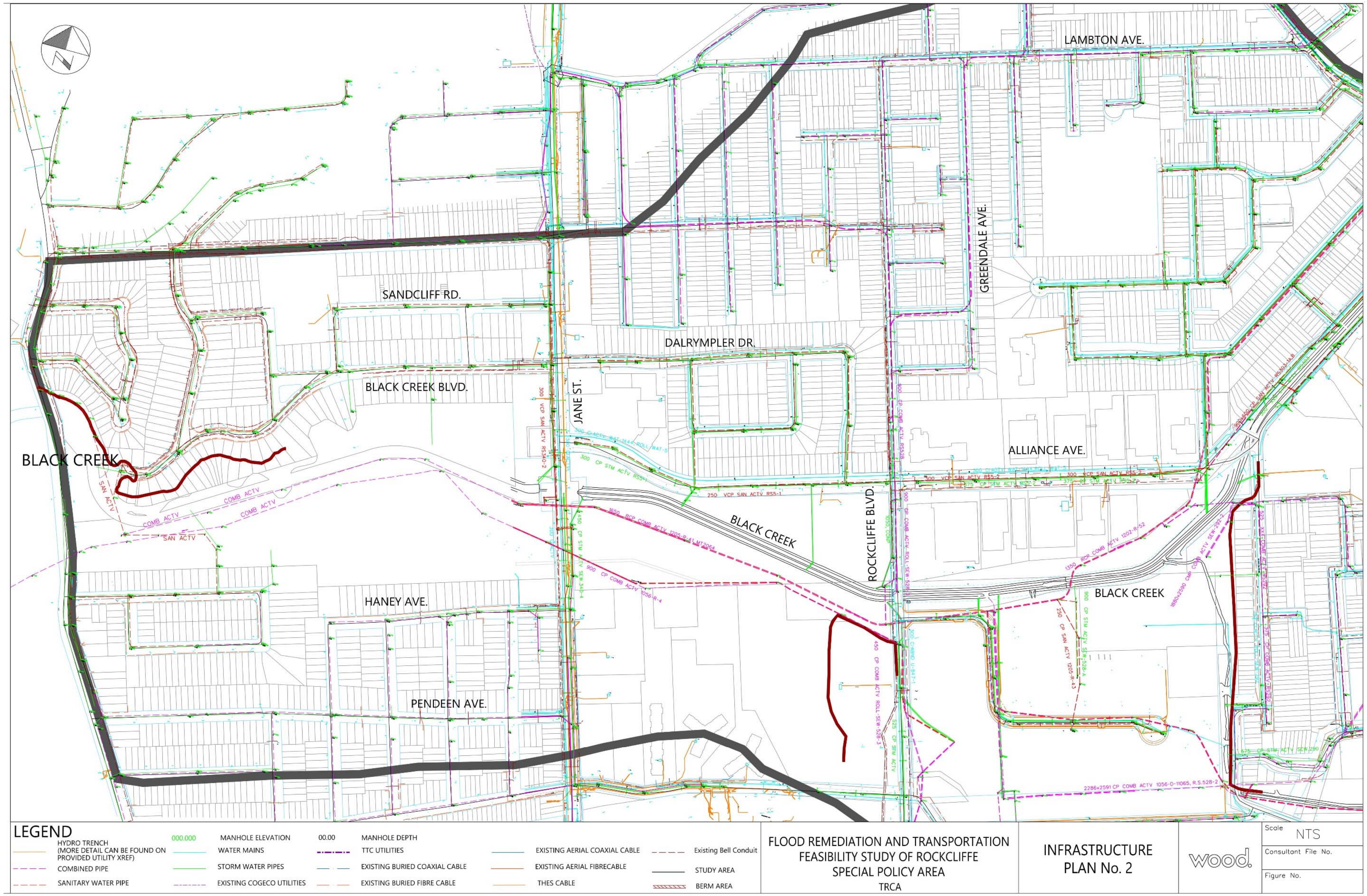

Figure 2.12. Study Area Infrastructure (South Section)

2.9 Cultural Heritage

2.9.1 Reports and Studies

The study area includes ten (10) built features which were flagged at the onset of this Feasibility Study as being of potential cultural heritage value or interest. This includes one (1) culvert, two (2) pedestrian bridges, and seven (7) road/vehicular bridges along the Black Creek within the boundaries of the identified study area. These features range in date of construction, the oldest being constructed in 1948, the most recent being constructed in 2006.

Several reports, studies and inventories have been consulted in order to a) trace the development of the area over time and b) confirm the presence of any previously identified cultural heritage resources and cultural heritage landscapes; this includes (but is not limited to), the City of Toronto Heritage Register, the City of Toronto Heritage Management Plan Phase 1 (2007), the City of Toronto Master Plan of Archaeological Resources (2004), the Humber River Watershed Plan (2008), the Toronto Bridge Inventory, the Humber Heritage Bridge Inventory (2011), the Parks Canada Register of Historic Places (CRHP), and the Canadian Heritage Rivers Register. According to a preliminary review of these inventories, the study area does not include any previously identified Cultural Heritage Resources which are considered *protected* under *Provincial Policy Statement*, being either designated under the *Ontario Heritage Act* or subject to a Heritage Conservation Easement. Further, the Humber River Heritage Bridge Inventory (2011) does not identify any significant built features within the boundary of the identified study area.

The study area does not include, nor is it part of an identified Cultural Heritage Landscape. However, the study area includes a portion of the Black Creek, which is a tributary of the Humber River. The Humber River was officially designated as a Canadian Heritage River System (CHRS) in 1999 for its association with human transportation and settlement for over 10,000 years and its associations with 'The Carrying Place'.

While no cultural heritage resources or landscapes have been previously identified, a Cultural Heritage Evaluation Report has been prepared in order to review the study area in detail and screen for those which warrant a detailed evaluation as per *Ontario Regulation 9/06* for determining cultural heritage value or interest (ref. Appendix K).

2.9.2 Mapping and Drawings

MHBC Planning reviewed several mapping resources as well as drawings, including historic maps of the study area and broader context such as a map of the Toronto Carrying Place (1619-1793), Map of the Former Districts of the Counties of Upper Canada (1818), Map of the Original Plan of the Toronto Purchase (1787-1805), Browne's 1851 Map of the Township of York, Tremaine's 1860 map of York, the 1887 Miles & Co. Illustrated Historical Atlas of the County of York (South West York), Fire Insurance Plans, as well as various historical topographical maps and aerial photographs dating to the 20th century. A review of these maps and various resources allowed for a detailed analysis of the development of the area through the late 18th, 19th, and 20th centuries (ref. Appendix K). The Ministry of Tourism, Culture and Sport and the Ministry of Transportation identify a rolling 40-year threshold for screening for potential cultural heritage resources.

Engineering plans and drawings have been reviewed in detail as related to the ten (10) crossings over Black Creek and Lavender Creek within the study area, in order to evaluate built features as it relates to their design/physical value and associations with any significant architects/builders. The City of Toronto Bridge Inspection Forms have also been reviewed in order to accurately describe the features and provide comments as they relate to their condition and heritage integrity. Several historical photographs of a number of the bridges/culvert have been located on the City of Toronto Public Library website in digital format. The photographs have been reviewed in order to provide further information related to the integrity of the features and how they have changed over time in relation to the surrounding landscape.

2.10 Transportation and Traffic

The study area, which was confirmed with the City, is bound by Jane Street to the west, Weston Road to the east, Humber Boulevard to the north, and Terry Drive (ref. Appendix J).

2.10.1 Data Collection

Intersection operations have been assessed using the Synchro 9 software which utilizes the Highway Capacity Manual (HCM) 2000 methodology published by the Transportation Research Board National Research Council. The Synchro 9 software can analyze both signalized and unsignalized intersections in a road corridor or network considering the spacing, interaction, queues and operations between intersections.

Intersection operations performance metrics are reported in terms of Level of Service (LOS), volume to capacity (v/c) ratios, and 95th percentile queues. Level of Service is based on the average control delay per vehicle for a given movement. Delay is an indicator of how long a vehicle must wait to complete a movement and is represented by a letter between 'A' and 'F', with 'F' being the longest delay. Table 2.8 summarizes the LOS criteria for signalized and unsignalized intersections.

Table 2.8. Intersection Level of Service Criteria

Level of Service	Average Control Delay per Vehicle (second / vehicle)	
	Signalized Intersection[1]	Unsignalized Intersection[1]
A	≤ 10	≤ 10
B	>10 and ≤ 20	>10 and ≤ 15
C	> 20 and ≤ 35	> 15 and ≤ 25
D	> 35 and ≤ 55	> 25 and ≤ 35
E	> 55 and ≤ 80	> 35 and ≤ 50
F	> 80	> 50

Note 1: HCM 2000 Methodology

Existing traffic volumes have been obtained from traffic count surveys conducted on October 8, 2019 by Traffic Survey Analysis Inc. (TSA) during the AM peak period (7:00 a.m.to 9:00 a.m.) and PM peak period (4:00p.m. to 6:00 p.m.).The traffic count surveys were conducted for the study intersections listed in Table **2.9** and detailed turning movement counts are provided in Appendix J. The existing signal timing plans were obtained from the City of Toronto, which are provided in Appendix J.

Table 2.9. Traffic Count Surveys

No.	Intersection	Control Type	Count Date
1	Jane Street / East Drive-Outlook Avenue	Signalized	October 8, 2019
2	Jane Street / Sandcliff Road	Unsignalized	October 8, 2019
3	Jane Street / Black Creek Boulevard	Unsignalized	October 8, 2019
4	Jane Street / Alliance Avenue	Signalized	October 8, 2019
5	Jane Street / Haney Avenue	Signalized	October 8, 2019
6	Rockcliffe Boulevard / Alliance Avenue	Signalized	October 8, 2019
7	Rockcliffe Boulevard / Rockcliffe Court	Unsignalized	October 8, 2019
8	Rockcliffe Blvd / Terry Drive-Woolner Avenue	Unsignalized	October 8, 2019
9	Symes Road / Terry Drive	Unsignalized	October 8, 2019
10	Symes Road / Hillborn Avenue	Unsignalized	October 8, 2019
11	Symes Road / Orman Avenue	Unsignalized	October 8, 2019
12	Cliff Street/Alliance Avenue / Humber Boulevard N	Unsignalized	October 8, 2019
13	Humber Boulevard N / Hilldale Road	Unsignalized	October 8, 2019
14	Alliance Avenue / Humber Boulevard S/Hilldale Road	Unsignalized	October 8, 2019
15	Humber Boulevard N / Louvain Street	Unsignalized	October 8, 2019
16	Humber Boulevard S / Avon Avenue	Unsignalized	October 8, 2019
17	Humber Boulevard N / Black Creek Drive and Weston	Signalized	October 8, 2019
18	Weston Road / Porter Avenue	Unsignalized	October 8, 2019
19	Weston Road / Rogers Road	Signalized	October 8, 2019
20	Weston Road / Avon Crescent	Unsignalized	October 8, 2019
21	Avon Avenue / Avon Crescent	Unsignalized	October 8, 2019
22	Avon Avenue / Porter Avenue	Unsignalized	October 8, 2019

2.10.2 Existing Traffic Conditions

The existing intersection operations have been analyzed using the study area road network illustrated in **Error! Reference source not found.**. and existing balanced peak hour volumes shown in Figure 2.14. For comparison purposes, the existing unbalanced peak hour traffic volumes are also provided in Figure 2.15.

The overall signalized intersection operation results are summarized in Table 2.10 and graphically represented in Figure 2.16 and Figure 2.17 including critical movements. The critical movements have been identified based on the following criteria:

- The v/c ratio for overall intersection or shared through/turning movements is 0.85 or greater;
- The v/c ratio for an exclusive movement is 1.00 or greater; or,
- The LOS for overall intersection or any movement is 'E' or 'F'.

Table 2.10. Intersection Capacity Analysis – Existing Conditions

Intersection	AM Peak Hour		PM Peak Hour	
	v/c	LOS	v/c	LOS
Jane Street / East Drive and Outlook Avenue	0.57	B	0.53	B
Jane Street / Alliance Avenue	0.53	B	0.59	B
Jane Street / Haney Avenue	0.43	A	0.39	A
Rockcliffe Boulevard / Alliance Avenue	0.78	C	0.79	C
Humber Blvd N and Black Creek Dr / Weston Rd	**0.85**	D	0.79	D
Weston Road / Rogers Road	**0.87**	D	**0.94**	D

Detailed analysis results and the Synchro reports are provided in Appendix J.

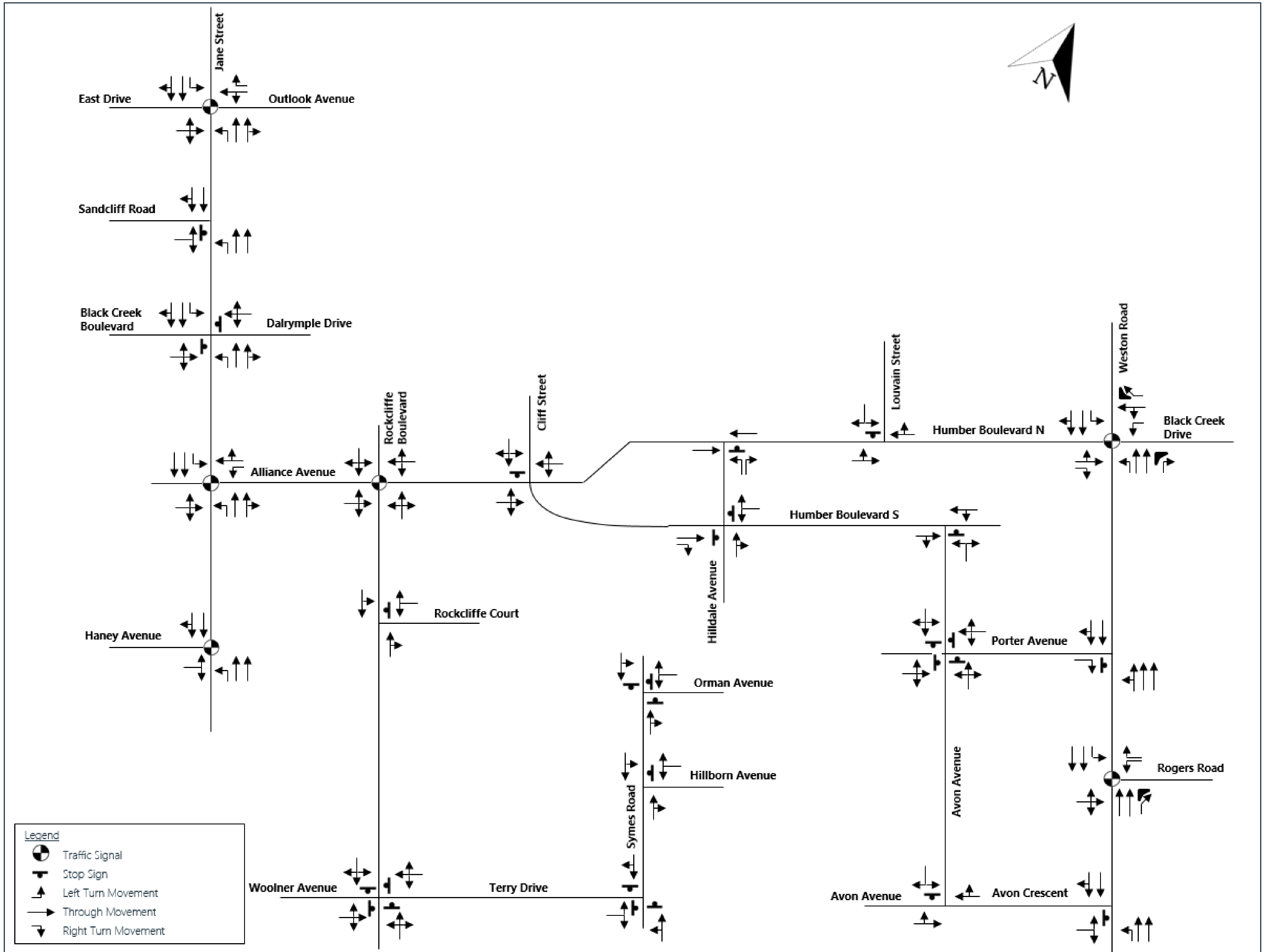

Figure 2.13. Existing Lane Configurations

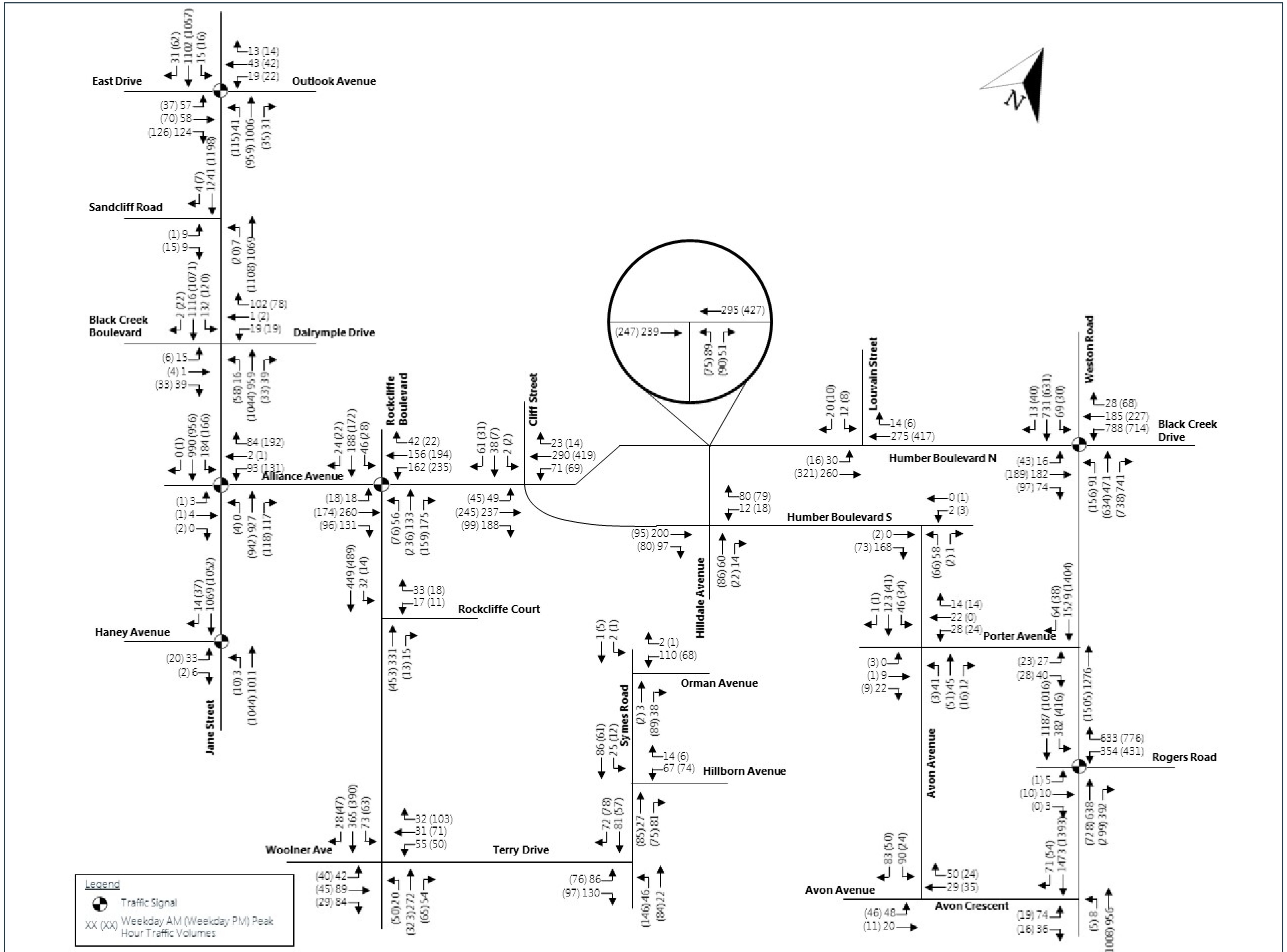

Figure 2.14. 2019 Existing Balanced Volumes

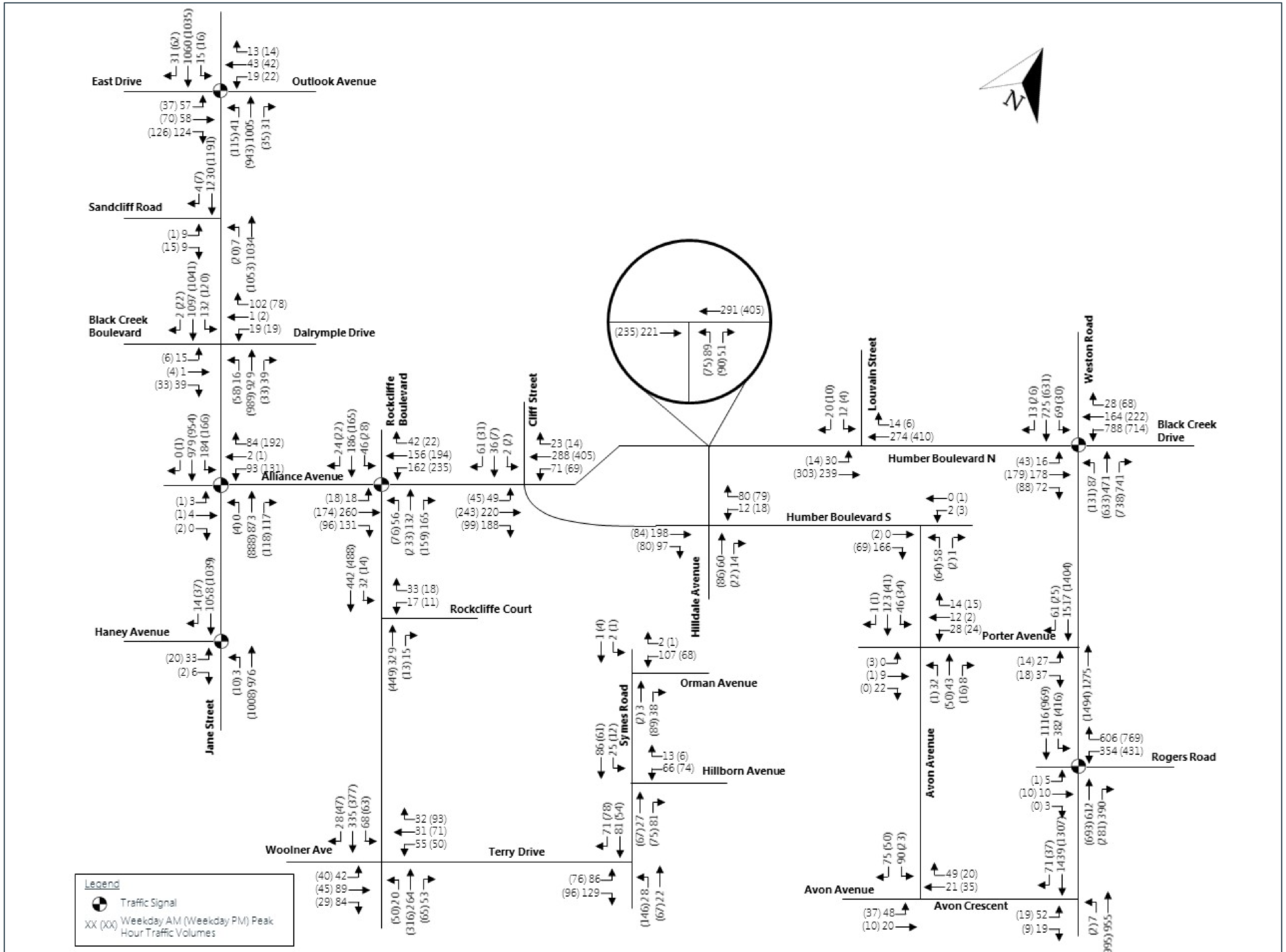

Figure 2.15. 2019 Existing Unbalanced Volumes

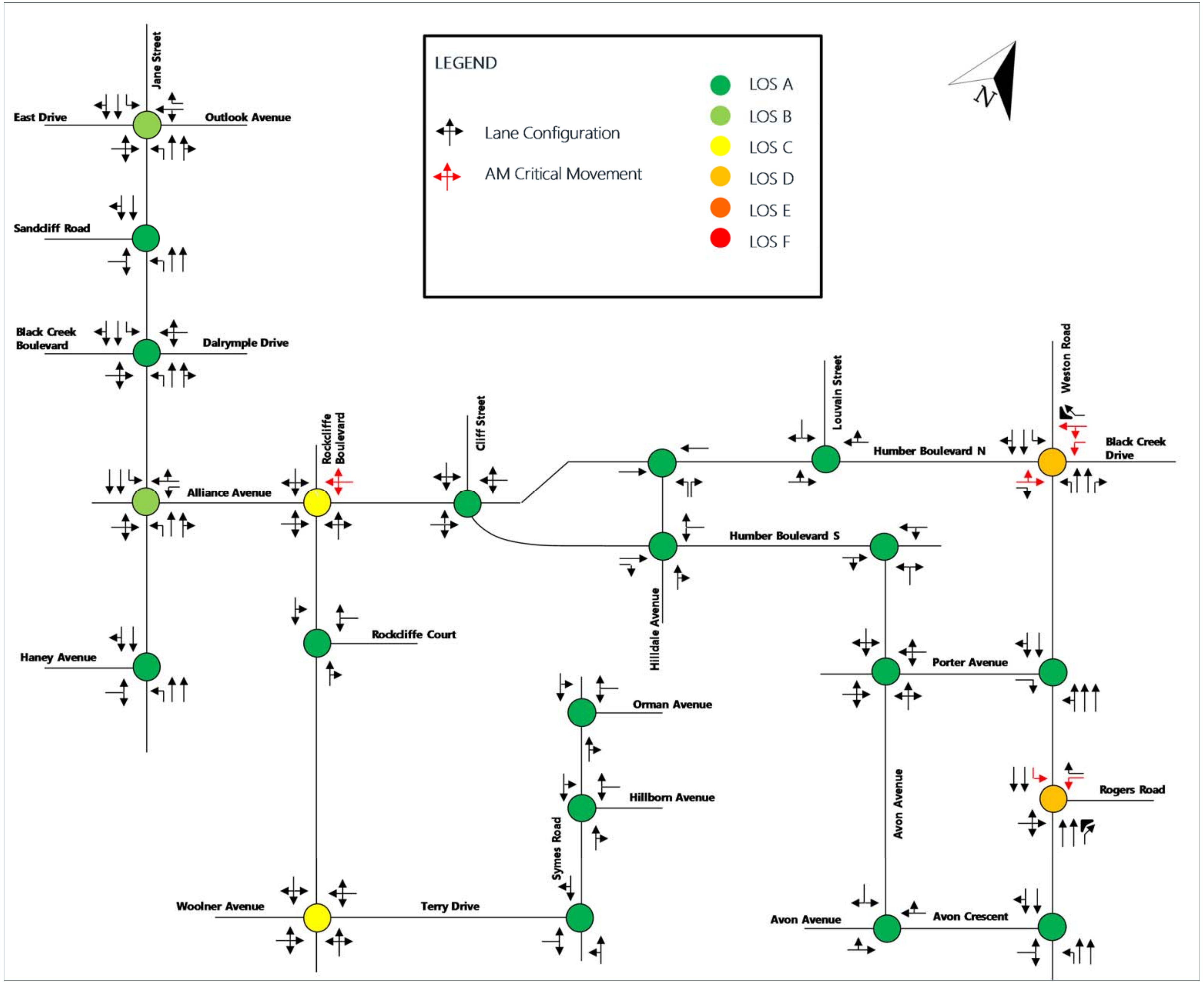

Figure 2.16. Existing Intersection LOS – AM Peak Hour

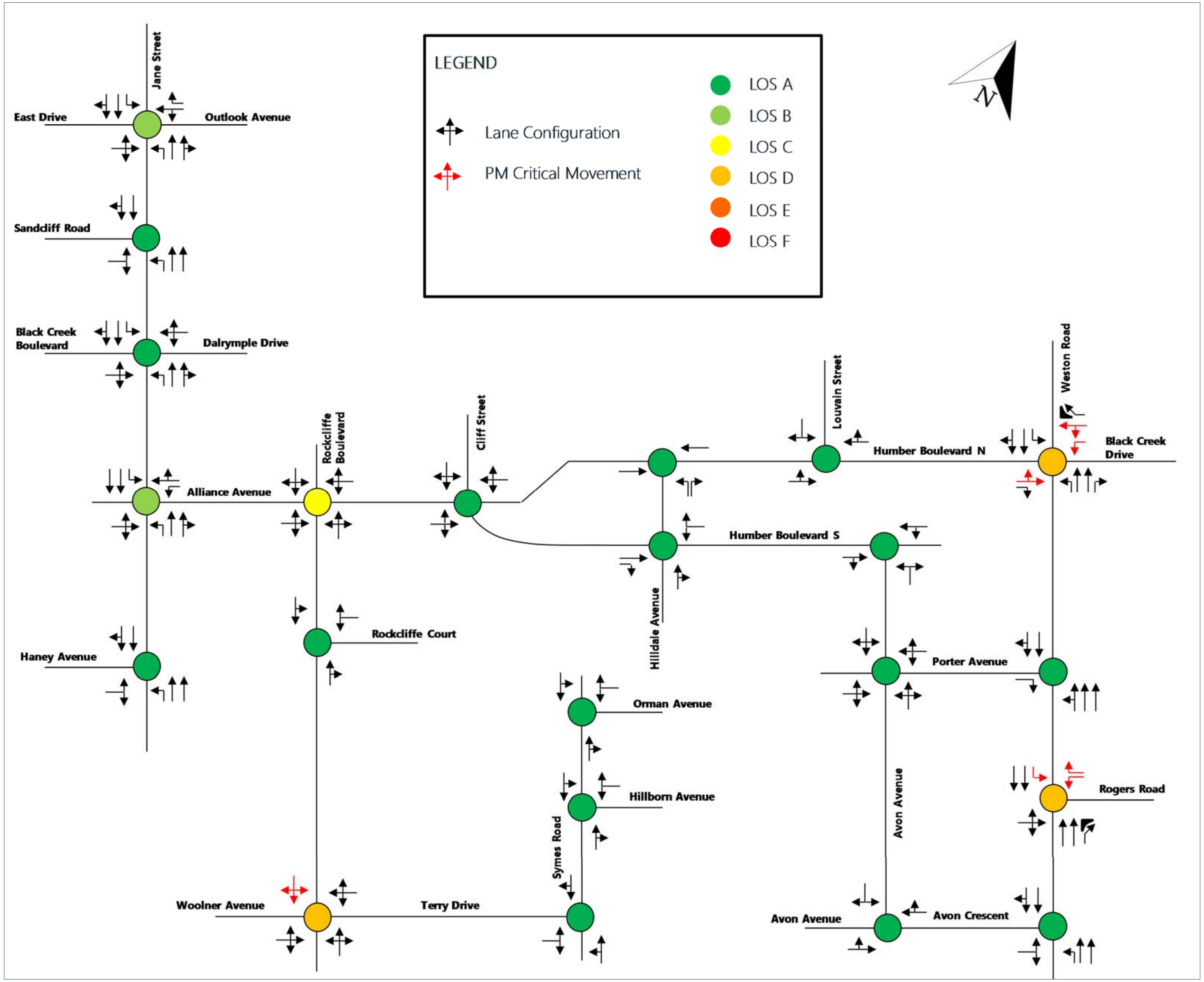

Figure 2.17. Existing Intersection LOS – PM Peak Hour

The results of the overall signalized intersection capacity analysis in **Error! Reference source not found.** indicate that all study intersections are operating with residual capacity and an acceptable level of service except for the intersection of Humber Boulevard North and Black Creek Drive / Weston Road which is operating with a v/c ratio of 0.85 during the AM peak hour and the intersection of Weston Road and Rogers Road which is operating with v/c ratios of 0.87 and 0.94 during the AM and PM peak hours, respectively.

The detailed analysis results provided in Appendix J indicate the following movements at the intersection of Weston Road / Rogers Road are operating at level of service 'F' and a v/c ratio over 1.00.

- Westbound left turn movement during the PM peak hour (v/c ratio = 1.03)
- Southbound left turn movement during the AM peak hour (v/c ratio = 1.03)
- Southbound left turn movement during the PM peak hour (v/c ratio = 1.08)

The results of the analysis suggest that the westbound and southbound operations exceed capacity. However, it is not theoretically possible for an existing movement to be over capacity, since the existing counted traffic was accommodated by the intersection. This indicates that the Synchro analysis parameters are likely conservative and therefore underestimate the actual available capacity of the intersection.

The 95th percentile queue lengths for all movements at signalized intersections within the study area were extracted from the Synchro9 analysis for the weekday AM and PM peak hours and were compared to the available storage lengths. The analysis results in Appendix J indicate that all existing queues can be accommodated within the available storage lengths except for the following movements:

- Humber Boulevard N / Black Creek Drive-Weston Road
    - Southbound through movement during the AM peak hour (exceeds available storage length by 61 m)
    - Southbound through movement during the PM peak hour (exceeds available storage length by 32 m)
- Weston Road / Rogers Road
    - Southbound left turn movement during the AM peak hour (exceeds available storage length by 78 m)
    - Southbound left turn movement during the PM peak hour (exceeds available storage length by 89 m)

The queue lengths at two key study intersections are shown in Figure 2.18 and Figure 2.19. Detailed queuing results and the Synchro reports are provided in Appendix J.

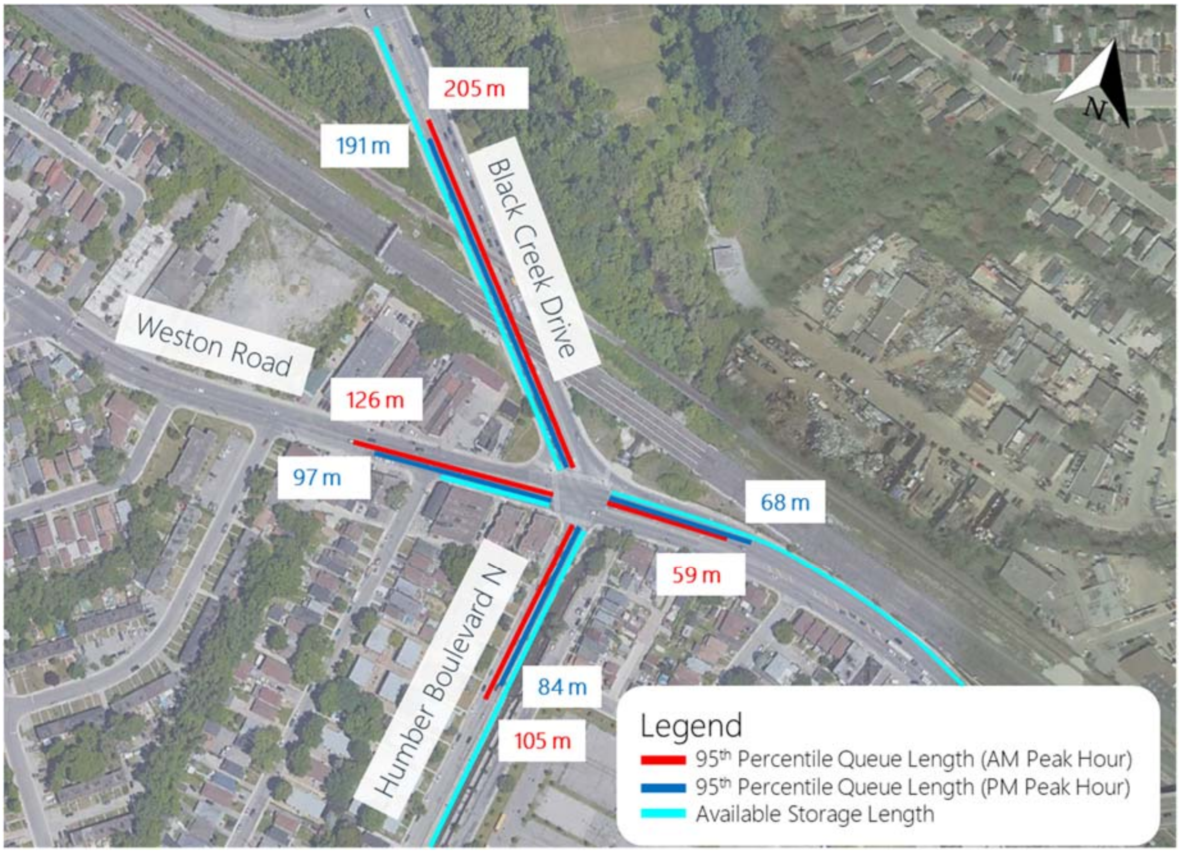

Figure 2.18. Black Creek Drive and Weston Road – Existing 95th Percentile Queue Lengths

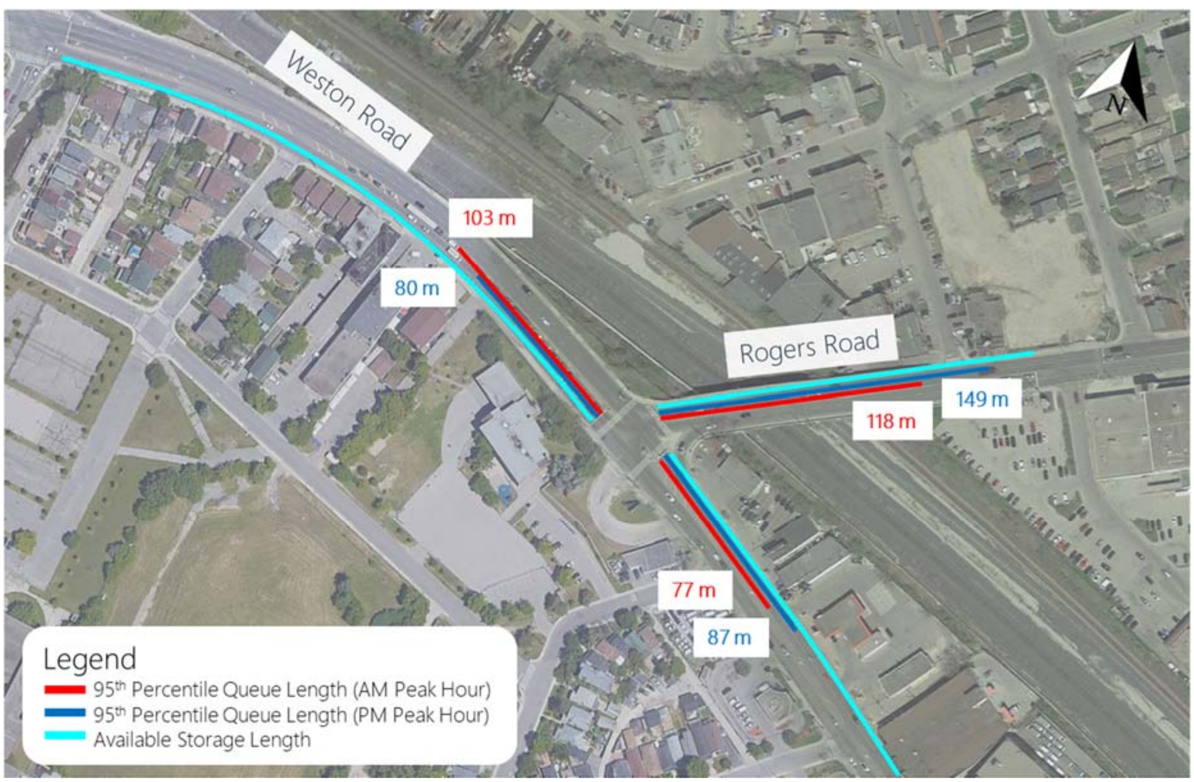

Figure 2.19. Weston Road and Rogers Road – Existing 95th Percentile Queue Lengths

2.10.3 Background Growth

Future background traffic volumes consist of the following components: traffic growth from outside the study area and traffic generated within the study area from adjacent proposed developments. A review of historical traffic data and traffic reports for other developments in the vicinity of the study area was carried out to determine the background growth rate. Detailed calculations for the growth rate are provided in Appendix J. It was noted that there was a negative growth along Weston Road which ranges from -1.6% to -2.2% while the growth rate along Jane Street ranges from 1.3% to 1.8%.

In addition, available traffic reports for other background developments (i.e. Proposed Expansion of George Syme Community School TIS, 611 & 623 Keele Street Proposed Self-Storage study) were also reviewed to help determine a reasonable growth rate for the analysis. It was noted that no growth was used in these traffic reports. Therefore, a growth rate of 0.5% compounded per annum was applied to the existing balanced volumes to determine the future (2031) traffic volumes.

2.10.4 Future Conditions

Traffic operations under future (2031) conditions were analyzed for the peak hours during the weekday AM (7:00 a.m. to 9:00 a.m.) and weekday PM (4:00 p.m. to 6:00 p.m.) periods using the Synchro 9 software. The following two scenarios were assessed under Future (2031) conditions:

- **Scenario 1:** Without Proposed Improvements ("Do Nothing")
- **Scenario 2:** With Proposed Improvements and LRT along Jane Street

Based on the proposed flood mitigation alternatives improvements not being able to be firmly established until after the Class EA, Scenario 2 results have been provided in Appendix J and are discussed in the preferred alternative section. The future (2031) intersection operations for Scenario 1 were analyzed using the existing study area road network. The future (2031) total traffic volumes were determined by applying a growth rate of 0.5% compounded per annum to the existing balanced volumes and are shown in Table 2.11.

The overall signalized intersection operation results are summarized in **Error! Reference source not found.** and graphically represented in Figure 2.16 and Figure 2.17 including critical movements.

Table 2.11. Intersection Capacity Analysis – Future (2031) Conditions (Scenario 1)

Intersection	AM Peak Hour		PM Peak Hour	
	v/c	LOS	v/c	LOS
Jane Street / East Drive and Outlook Avenue	0.60	B	0.60	B
Jane Street / Alliance Avenue	0.57	B	0.63	C
Jane Street / Haney Avenue	0.45	A	0.41	A
Rockcliffe Boulevard / Alliance Avenue	**0.85**	**C**	0.84	C
Humber Blvd N and Black Creek Dr / Weston Rd	**0.90**	**D**	**0.85**	**D**
Weston Road / Rogers Road	**0.92**	**D**	**1.00**	**E**

Detailed analysis results and the Synchro reports are provided in Appendix J.

The analysis results for Scenario 1 (Do Nothing) indicate that all movements at the study area intersections are expected to operate with residual capacity and acceptable level of service under future (2031) conditions except for several movements that are expected to operate with a volume to capacity ratio of 0.85 or greater as shown in Figure 2.20.

The following movements at the study area intersections of are expected to operate at or over capacity.

- Weston Road / Rogers Road
  - Westbound left turn movement during the PM peak hour (v/c ratio = 1.09)
  - Westbound right movement during the PM peak hour (v/c ratio = 1.12)
  - Southbound left turn movement during the AM peak hour (v/c ratio = 1.10)
  - Southbound left turn movement during the PM peak hour (v/c ratio = 1.14)
- Rockcliffe Boulevard / Terry Drive - Woolner Avenue
  - Southbound left-through-right movement during the PM peak hour (v/c ratio = 1.02)
- Humber Boulevard N / Black Creek Drive and Weston Road
  - Eastbound left-through movement during the AM peak hour (v/c ratio = 1.05)
  - Westbound left movement during the PM peak hour (v/c ratio = 1.06)
  - Westbound through movements during the PM peak hour (v/c ratio = 1.07)

In general, 95th percentile queues lengths can be accommodated within available storage lengths under the future (2031) conditions except for the following movements:

- Humber Boulevard N / Black Creek Drive and Weston Road
  - Southbound through movement during the AM peak hour (exceeds available storage length by 80 m)
  - Southbound through movement during the PM peak hour (exceeds available storage length by 39 m)
- Weston Road / Rogers Road
  - Southbound left turn movement during the AM peak hour (exceeds available storage length by 89 m)
  - Southbound left turn movement during the PM peak hour (exceeds available storage length by 99 m

A comparison of existing and future traffic results is provided in Appendix J.

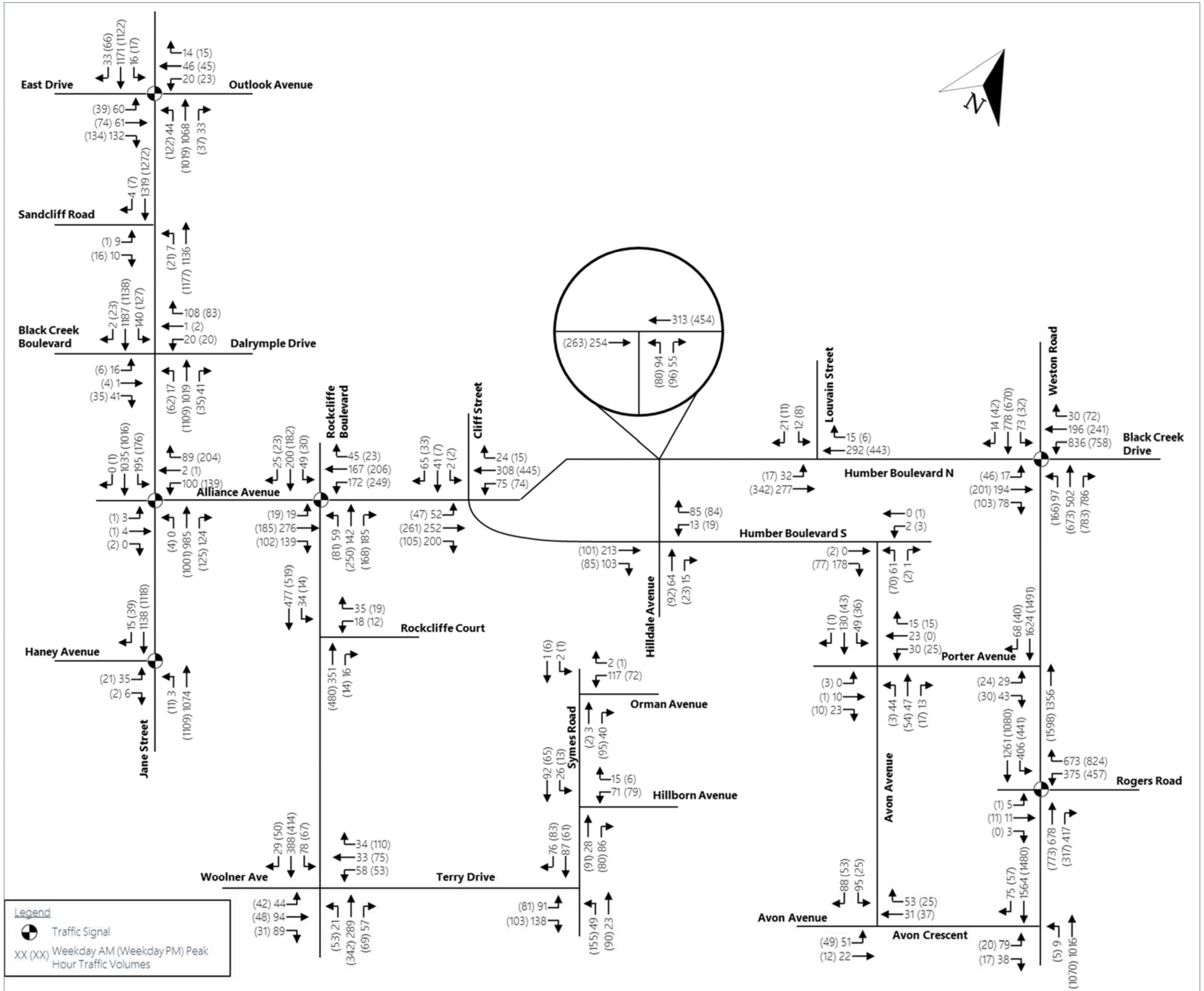

Figure 2.20. Future (2031) Traffic Volumes – Scenario 1 (Do Nothing)

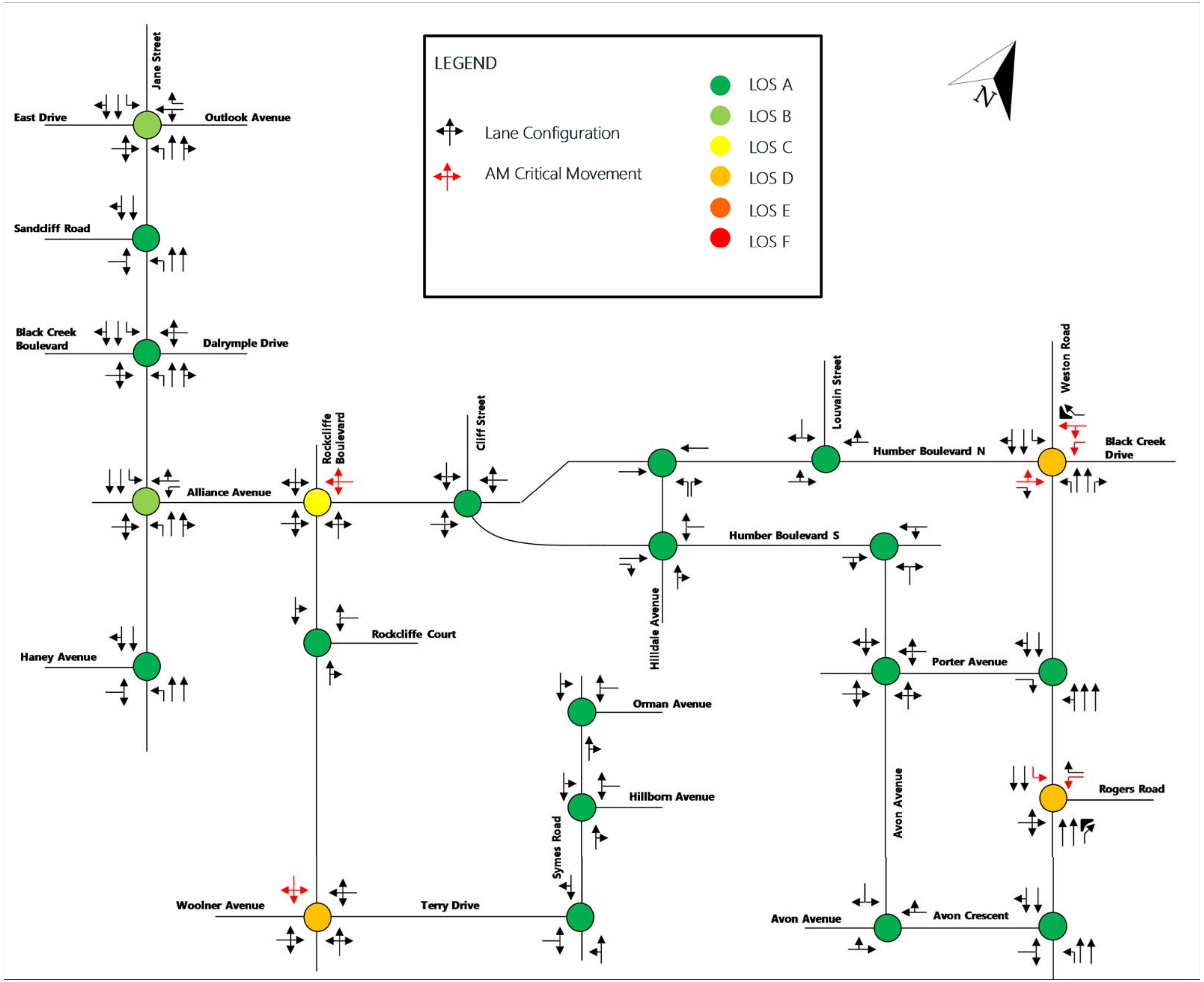

Figure 2.21. Future (2031) Intersection LOS – Scenario 1 – AM Peak Hour

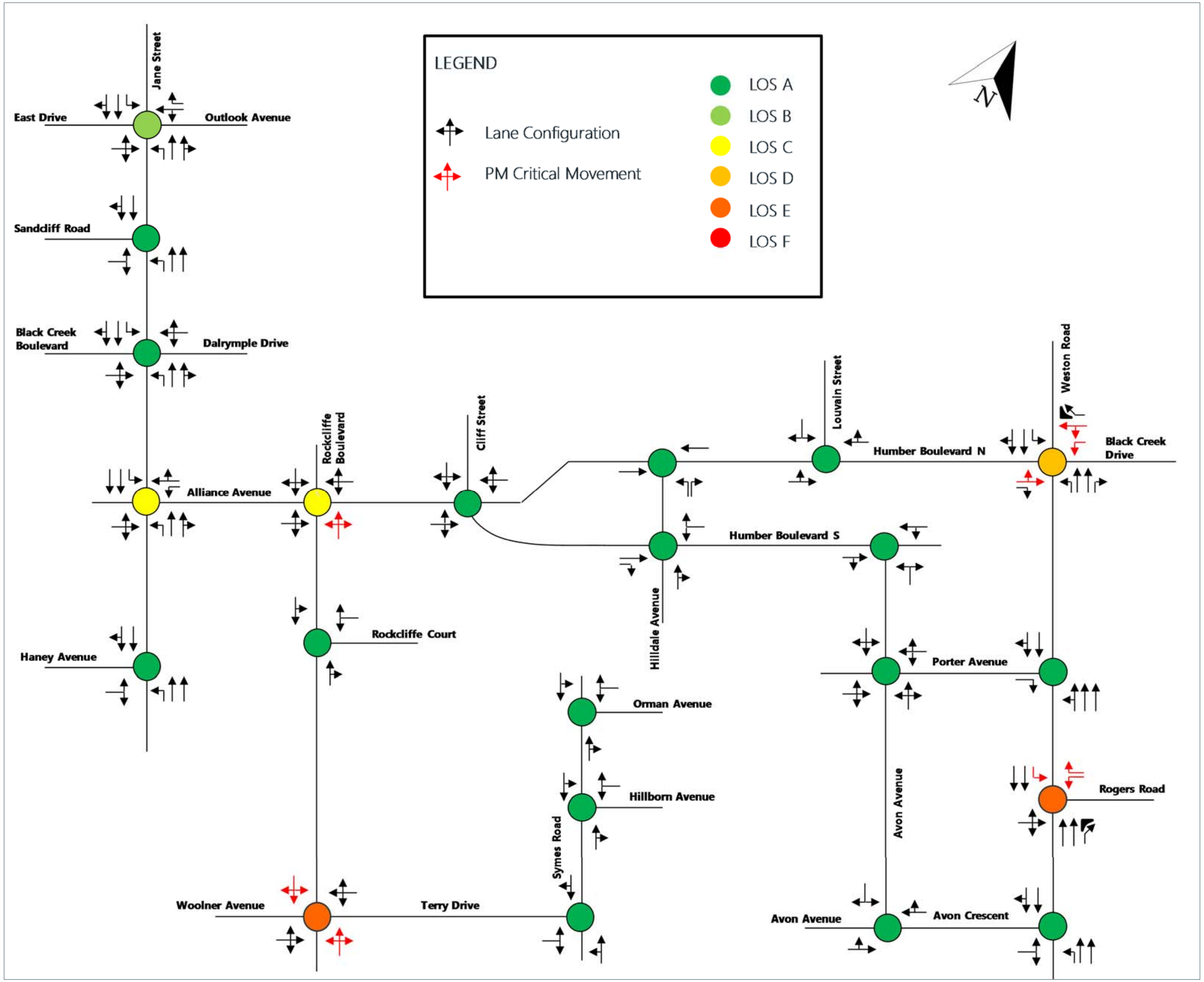

Figure 2.22. Future (2031) Intersection LOS – Scenario 1 PM Peak Hour

3.0 Existing Riverine Hydraulic Modelling

3.1 HEC-RAS Hydraulic Model

As part of the Black Creek (Rockcliffe Area) Riverine Flood Management Class Environmental Assessment, March 2014, AMEC (now Wood), TRCA provided the Humber River HEC-RAS version 3.1.3 hydraulic model including the Black Creek. The hydraulic model was used to determine the existing flood risk and assess flood mitigation alternatives. The model as provided by TRCA, is now being executed in HEC-RAS version 5.0.3, to provide guidance in alternatives being assessed through the MIKE hydraulic model.

3.2 MIKE Hydraulic Model

As outlined in Section 2.3.3, TRCA has used MIKE 11 and 21 to model the Black Creek as per the April 2018 *Rockcliffe SPA 2D Flood Modelling and Mapping Update* by DHI. TRCA has conducted updates to the 2018 modelling, as indicated below:

1. TRCA has added Lavender Creek as a separate 1D branch in the model and included the associated hydraulic structures along the channel.
2. The update MIKE FLOOD model is using the flexible mesh, finite volume solution of the MIKE 21 software because it is able to leverage a GPU to significantly reduce the simulation time.

As stated earlier, no formal documentation for the updated MIKE FLOOD model was provided, however, TRCA has verbally confirmed that the hydraulic structures coded for the 1D model branch of Lavender Creek, represent the results of a field surveyed conducted by TRCA staff.

Other than the changes mentioned above, the updated MIKE FLOOD model setup is very similar to the previous MIKE FLOOD model of the Rockcliffe SPA area. The 1D model is used to represent the main channel of Black Creek and Lavender Creek, while the 2D model is used to represent the land surface and building structures outside the main channels and extending slightly beyond the expected limited of flooding. The 1D model is dynamically coupled to the 2D model along the top of channel banks on either side of the channel, such that when the water level in the channel rises above the top of the bank, it spills into the 2D model, and vice-versa.

This type of setup for MIKE FLOOD models is common but it has potential problems when the amount of water exchanged between the 1D model and the 2D model represents a significant portion of the total flow in the 1D model. The reason this can be problematic is because there is no momentum transfer between the 1D and 2D model as the only flow direction in a 1D model is in the downstream or upstream direction. When flow from the 2D model is added to the 1D model, there is an adjustment of the momentum in the 1D model to account for the additional volume of water added. This adjustment typically reduces the velocity of flow in the channel. Hence, if the amount of water being added to the 1D model represents a significant portion of the overall flow in the channel, then the adjustment may artificially lower the flow in the channel.

In addition, the following recommendations were made to improve the representation of the bridge structures and crossings in the model:

- The geometry of the weirs representing the bridge decks should be updated to extend the geometry vertically to facilitate a more accurate calculation of flow overtopping the bridge deck
- The geometry of the weirs representing the bridge deck for Weston Road and Rockcliffe Boulevard should be updated to better represent the elevated concrete barriers on each side of the bridges

- The overtopping of the concrete barrier on the upstream side of the Weston Road bridge should be coupled to the street surface (using a Standard Link) and the overflow from the street to the downstream side of the Weston Road bridge should be coupled to the creek (using a Standard Link)

3.2.1 MIKE Hydraulic Model Updates

The proposed model updates were implemented in the model and are described in more detail in this section. A comparison of the TRCA model and the updated model for the Regional Storm Unsteady event was also prepared to evaluate the difference in results between the two versions of the model.

Widening the 1D model channel

Figure 3.1 Error! Reference source not found. compares the 1D channel boundaries between the TRCA model and the updated model. In the TRCA MIKE FLOOD model, the 1D model only represents the concrete channel that is approximately 25 to 30 m in width. In the updated MIKE FLOOD model the channel cross-sections represented in the 1D model are extended by 20 to 40 m on each side. When berms or local high points are encountered, the cross-section extent is set to the local high point along the cross-section. This is done to avoid an early 'spill' from the 1D model to the 2D model at cross-sections where the elevation at the extent of the cross-section is not the highest point on that side of the cross-section. Since the lateral links between 1D and 2D models are created at the extents of the 1D channel cross-sections, and lateral flow occurs as soon as water level in 1D channel reaches the elevation at each extent, setting the extent of the cross-section at the high points ensures the occurrence of lateral flow (spilling) to the 2D model only occurs when the water level exceeds the highest bank elevation.

The road crossing between Lawrence Avenue West and Trethewey Drive is also modified in the updated model. The lateral links in the TRCA model had sharp turns away from the channel to accommodate the expanded cross-sections at the bridge. In the updated model, several cross-sections upstream and downstream from the bridge are gradually extended (ref. Figure 3.2), to alleviate the sudden change in the length of the cross-sections and, thus, eliminate the sharp angles in the lateral links.

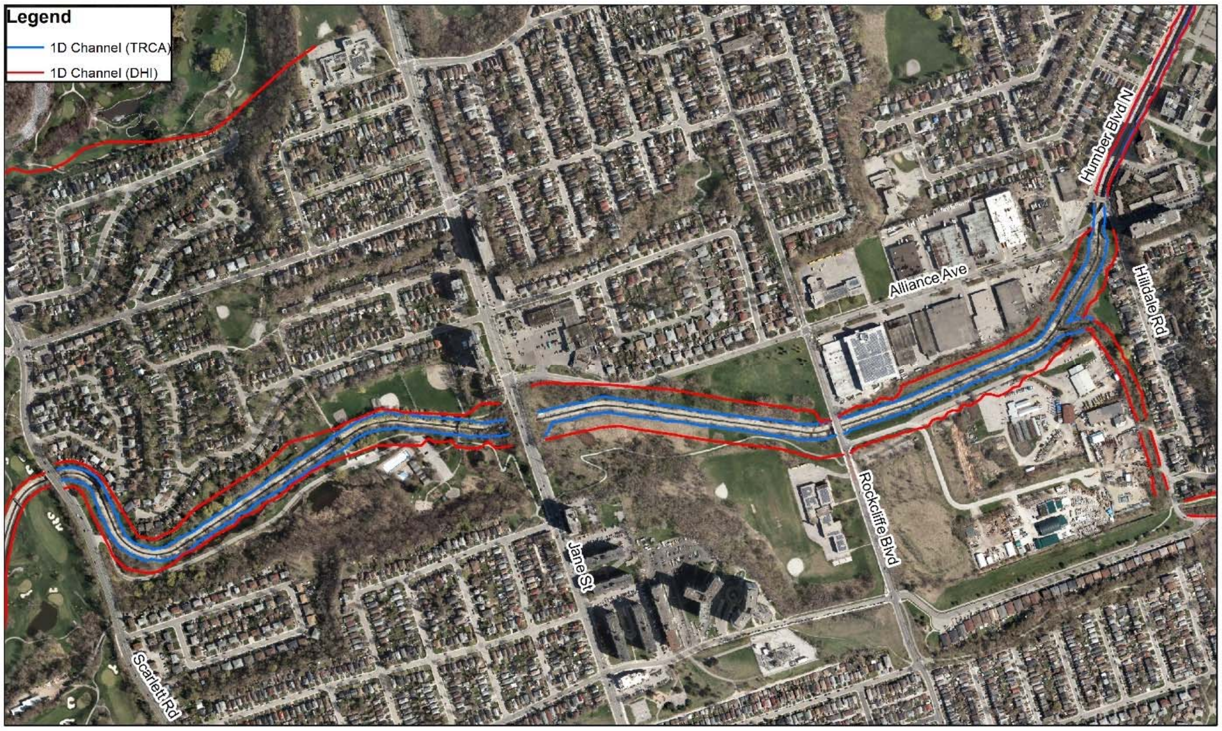

Figure 3.1. Channel Expansion between Alliance Avenue and Scarlett Rd.

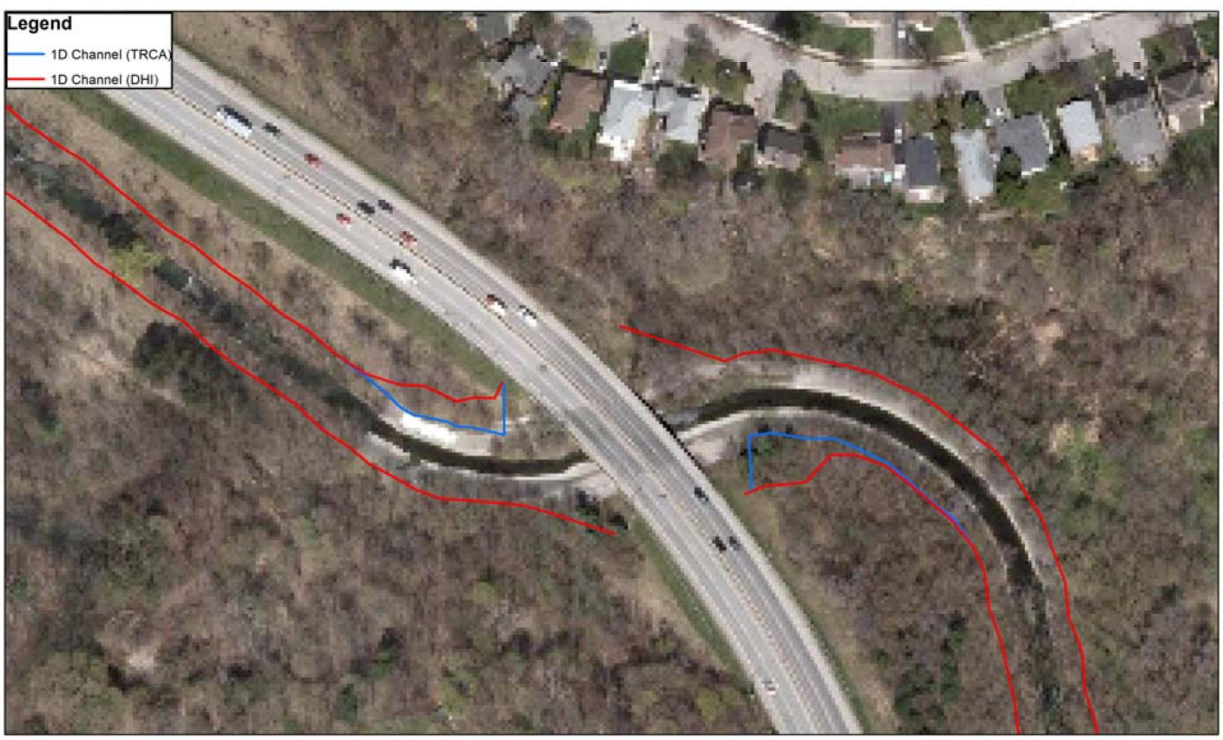

Figure 3.2. Channel Expansion at Road Crossing between Lawrence Ave. W. and Trethewey Dr.

In the updated model the cross-sectional geometry and roughness values from the TRCA model are preserved. The bathymetry data and the roughness map were utilized to extract the geometry of each extended cross-section and to assign roughness values for the extended segments of the cross-sections. Figure 3.3. shows a comparison of the 1D model cross-section geometry and roughness values between the original TRCA model ('Before') and the update model ('After').

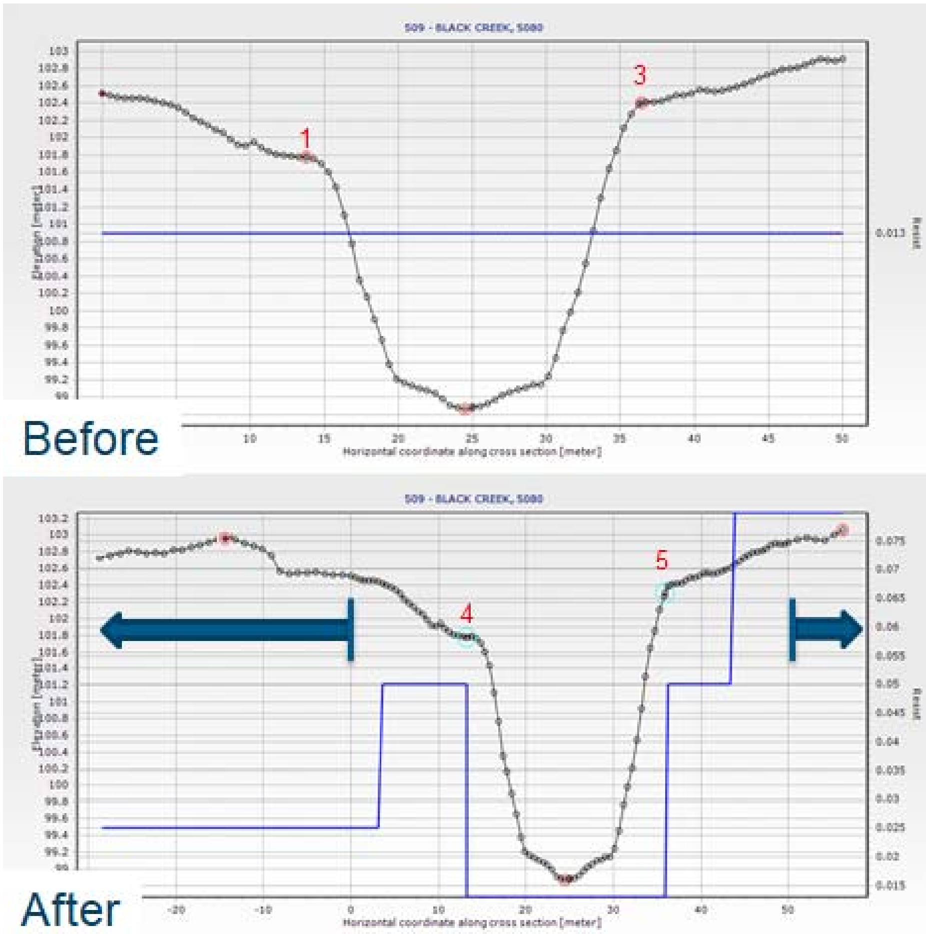

Figure 3.3. 'Before' and 'After' Comparison of 1D Model Cross-Section Geometry and Roughness Values

Updating Bridge and Road Crossing Structures

The TRCA model used composite culvert and weir structures to represent the bridges and road crossings in the model. The culvert structures represented the opening under the bridge/crossing while the weir represented the deck of the bridge/crossing. In most cases, the weir geometry was defined using a cross-section geometry extracted from the top of the roadway. While this provided an accurate description of the elevation of the roadway, the Q-H curve used by the model to calculate the flow over the weir did not extend above the highest elevation of the roadway. Therefore, if the water level spilling over the roadway was higher than the highest elevation of the roadway, then the overtopping flow was fixed at the maximum Q value from the Q-H curve. Consequently, the water level upstream from the structures was over-estimated. In the updated model, the geometries of the weirs are modified by adding vertical walls on each side to expand the range of flow in the Q-H relationship. This modification is made to all bridges/crossings in the model except for Jane Street because the water level never exceeds the highest elevation of the roadway.

At the Rockcliffe Boulevard bridge, the weir geometry was also updated by adding 0.5 m to the height of the cross-section where it crosses the road. This was done to better reflect the concrete barrier on the upstream and downstream sides of the bridge where it crosses over the creek. The 0.5 m was an estimate of the height of the barrier because it was not surveyed.

At the Weston Road bridge, the weir geometry was also updated by adding 0.5 m to a segment of the weir geometry corresponding to the approximate location of the concrete barrier where the roadway crosses over the creek. In addition, the coupling between the 1D model and the 2D model was customized at Weston Road, to better represent the complex flow at this location when the bridge overtops. In a typical bridge crossing the flow overtopping the bridge deck is transferred to the downstream side of the channel. However, at Weston Road, the flow overtopping the upstream side of the bridge will flow down Humber Boulevard North and Humber Boulevard South, until the water level on Weston Road is higher than the concrete barrier on the downstream side of the bridge.

To directly model the interaction between the flow that overtops the bridge and the cross flow on top of the deck, the updated model represented the Weston Road bridge deck as part of the 2D model surface. Two standard links are used to connect 1D model channel flow with 2D overland flow - one link for the upstream and one link for the downstream. The standard links are created at the end of short branches that extend from the main channel a short distance downstream from the upstream side of the bridge, and a short distance upstream from the downstream side of the bridge. Each short branch consists of a cross-section at the confluence with the main channel, a weir representing bridge deck and barriers, and another cross-section on top of the bridge for the standard link connection with 2D model (ref. Figure **3.4.**).

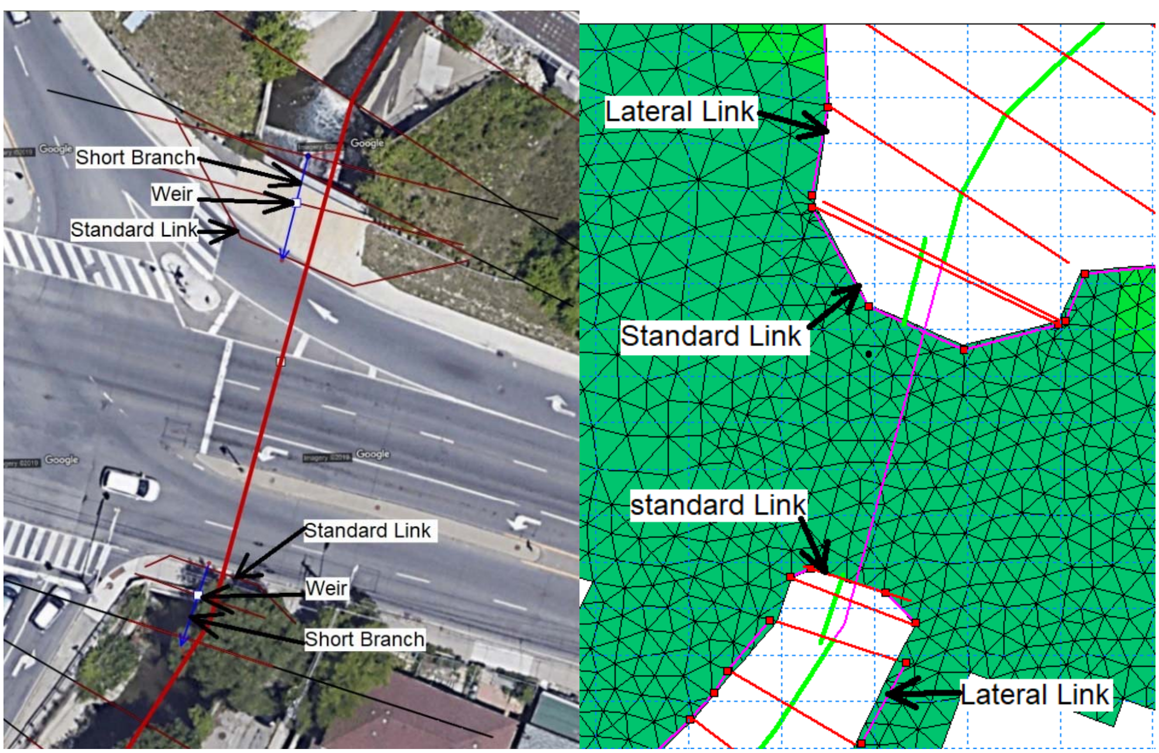

Figure 3.4. 1D-2D Model Coupling at Weston Road Bridge

3.2.2 Comparison of results between the TRCA model and updated model

The updated model was run for the Regional Storm event under unsteady flow conditions and the results were compared with the original TRCA model to evaluate the differences. The results were primarily compared for the 1D model at the Weston Road bridge, Rockcliffe Boulevard bridge and Jane Street crossing. In addition, the maximum depth, water surface elevation, and velocity from the 2D model results were also compared.

Weston Road Bridge

Figure 3.5 compares the flows and water levels at Weston Road bridge for the updated (DHI) model and the TRCA model. The upstream maximum water level in the updated model is 0.63 m higher, and the downstream maximum water level is 0.05 m lower than in TRCA model. This can be explained by the higher deck elevation on the bridge due to representation of the concrete barrier in the updated model.

The total discharge through the culvert structure in the updated model is 85 m^3/s lower than through the combined weir and culvert structure in the TRCA model, but that is compensated by the 1D-2D model exchange on the upstream side of the channel where the peak flow overtopping the bridge onto Weston Road is 90 m^3/s, and the maximum discharge overtopping the downstream side of the bridge and into the 1D channel is 4 m^3/s (ref. Figure 3.6.)

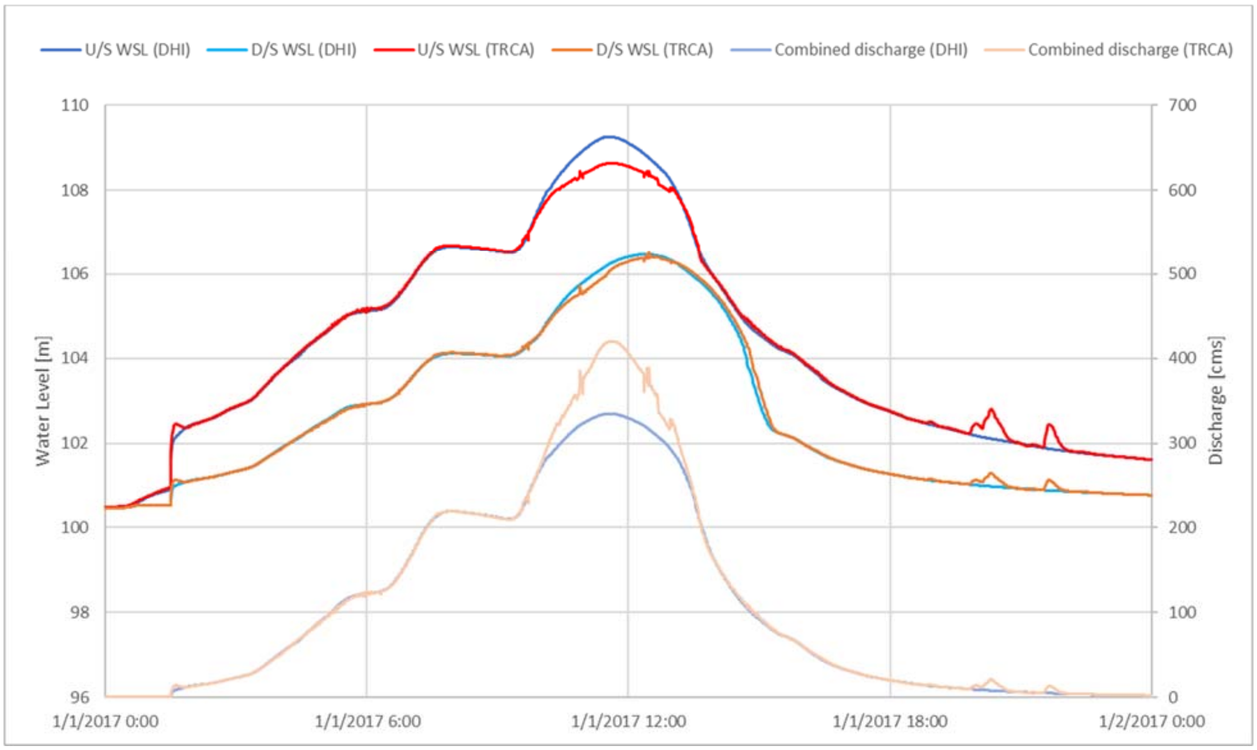

Figure 3.5. Comparison of Flow and Water Level at Weston Road Bridge

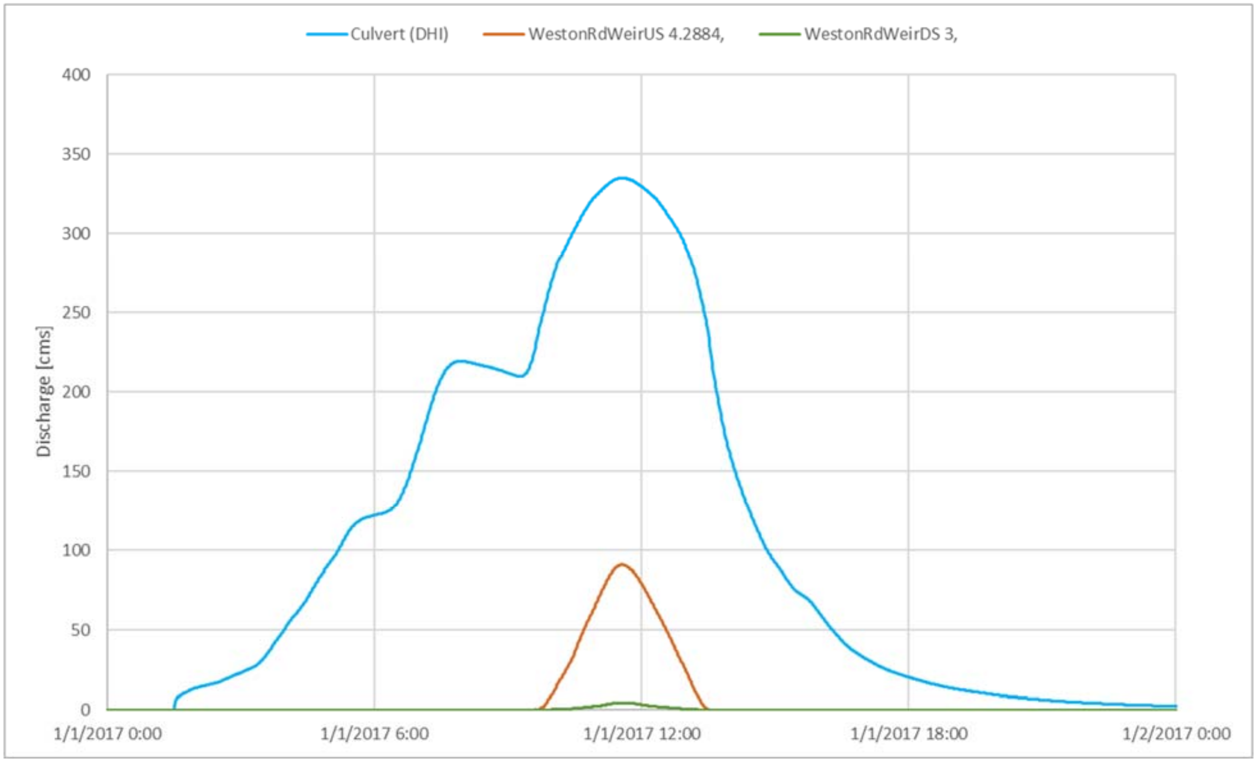

Figure 3.6. Total Discharge Under and Overtopping Weston Road Bridge

Rockcliffe Boulevard Bridge

Figure 3.7. shows a comparison of the flow and water level at Rockcliffe Boulevard bridge for the updated (DHI) model and the TRCA model. At Rockcliffe Boulevard bridge, the upstream maximum water level is 0.19 m lower, and the downstream is 0.11 m higher in the updated model than in TRCA model. While this result may be somewhat unexpected considering the bridge deck elevation was increased to account for the concrete barrier, the update to the weir Q-H curve also played a role in allowing more flow to pass over the top of the bridge.

The total discharge through the combined structure is also very different between the two models (ref. Figure 3.8.). The updated model allows significantly more combined discharge through the structure and the majority of that is attributed to the increased flow overtopping the bridge (compared to the TRCA model). The additional flow over the bridge deck is attributed to the updated Q-H curve for the weir (as noted herein). The flow conveyed through the culvert is initially less in the updated model than in the TRCA model, but the flow regime transitions at peak flow where the flow overtopping the bridge suddenly decreases and the flow conveyed through the culvert increases. The abrupt changes in discharge through the culvert, may be due to the control scheme changing from inlet control to full pipe for the culverts. When using full pipe control, it assumes free discharge at culvert outlet.

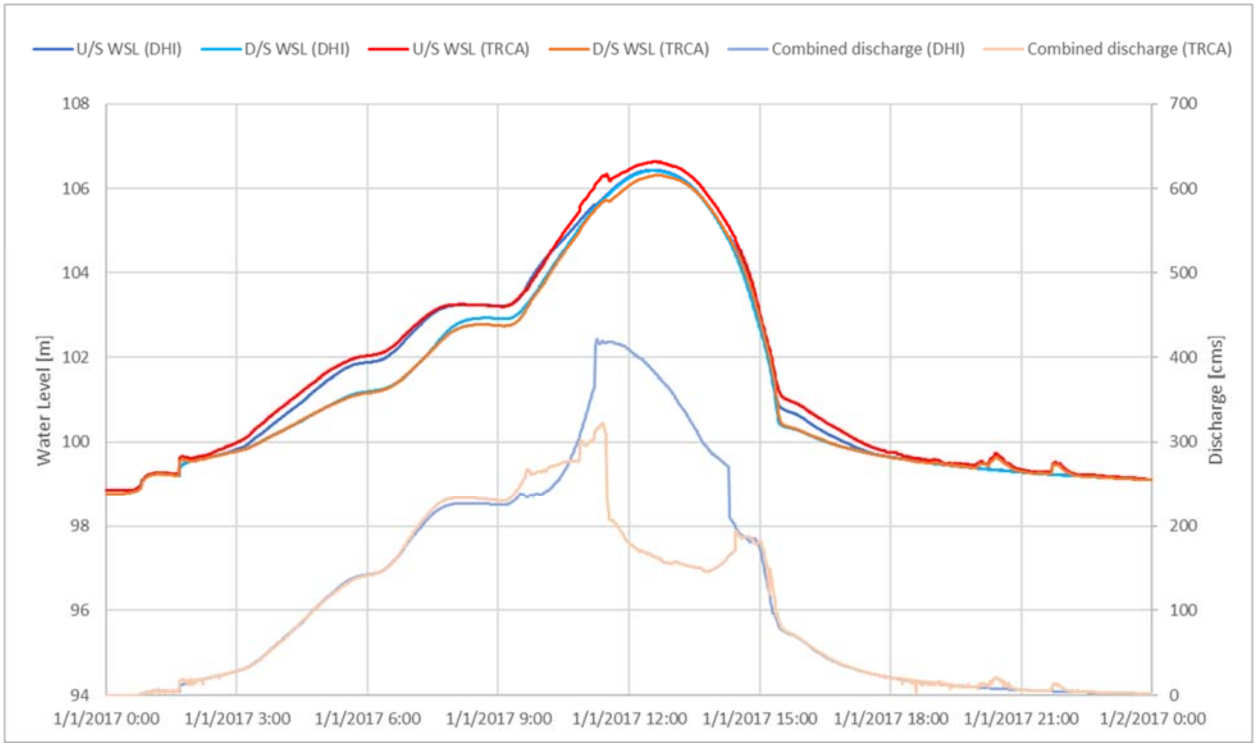

Figure 3.7. Comparison of Flow and Water Level at Rockcliffe Boulevard Bridge

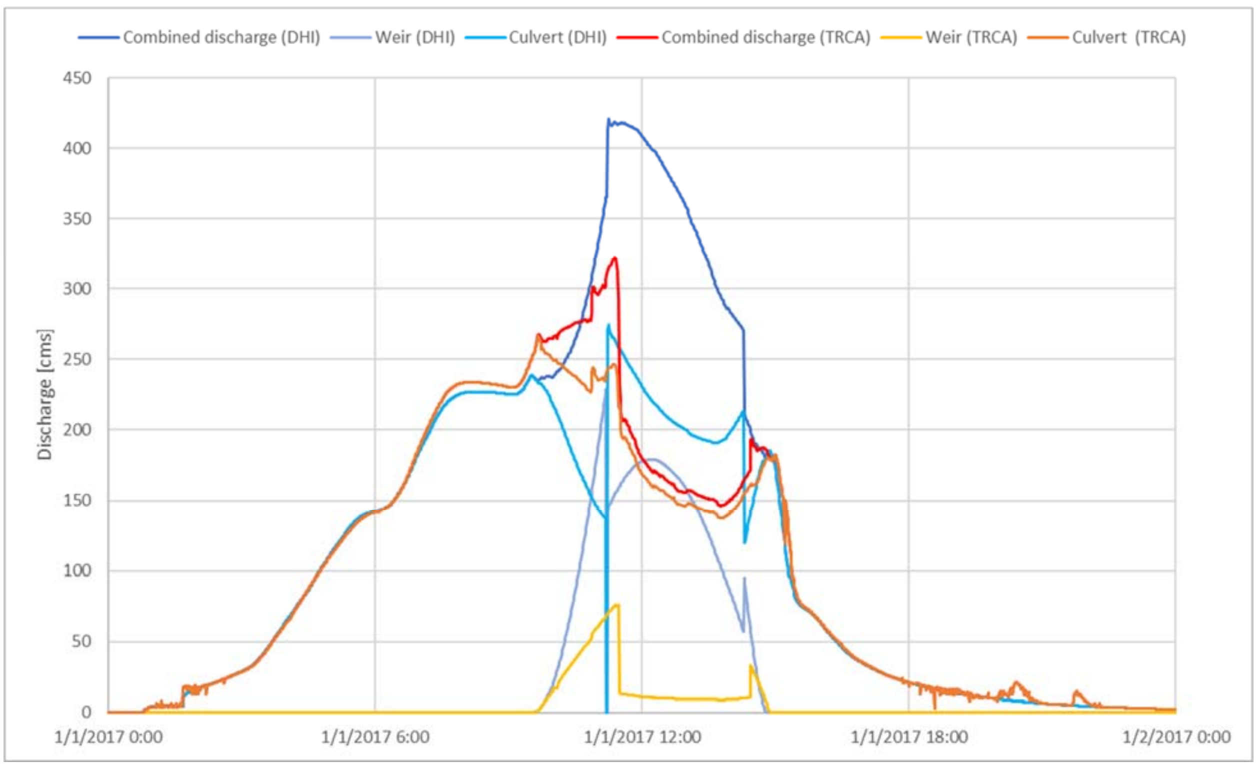

Figure 3.8. Comparison of Culvert and Weir Flow at Rockcliffe Boulevard Bridge

Jane Street Crossing

Figure 3.9. provides a comparison of the flows and water levels at the Jane Street crossing for the updated (DHI) model and the TRCA model. The results as expected are very similar with a maximum water level for the updated model being 0.44 m higher on the upstream and 0.12 m lower on the downstream side than the TRCA model.

The total discharges through the combined structure are also very similar between the two models.

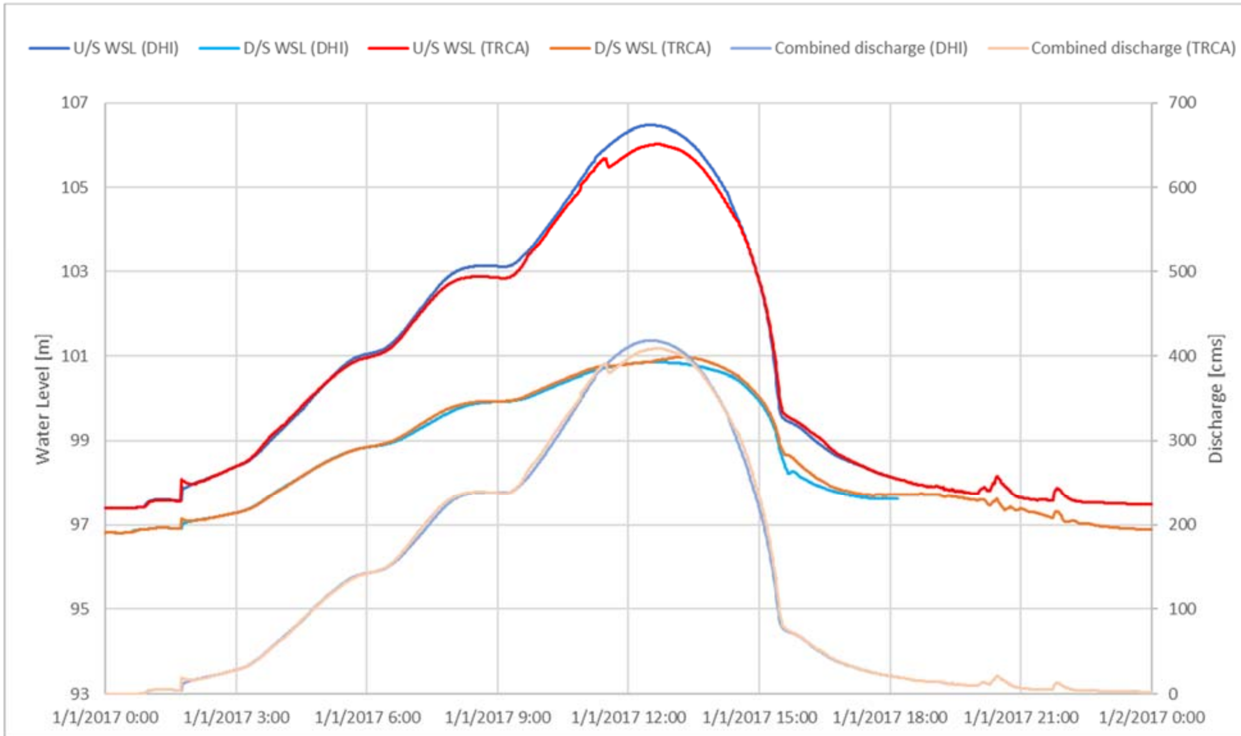

Figure 3.9. Comparison of Flow and Water Level at Jane Street Crossing

2D Maximum Water Surface Level and Depth

The maximum water surface level (WSL) and maximum depth have been determined for both the TRCA model and the updated model. The difference in maximum WSL and Depth (updated model minus TRCA model) is indicated in Figure 3.10. and Figure 3.11. , respectively, where yellow to red colors indicate the updated model has higher values, while green to blue colors indicate the updated model has lower values. In general, the updated model has:

- Slightly lower maximum WSL (and Depth) upstream of the CNR railway bridge. This is attributed to the increased flow overtopping the structures due to the adjustment of the Q-H curve for the weirs representing the bridge decks.
- Moderately higher maximum WSL (and Depth) immediately upstream of Weston Road. This is attributed to the modification of the Weston Road weir structure and 1D-2D model coupling at this location
- Slightly higher maximum WSL (and Depth) between Rockcliffe Road and Scarlett Road. This is attributed to higher peak flows passing through Rockcliffe Boulevard bridge.

- Significantly lower maximum WSL (and Depth) downstream of Scarlett Road. This is attributed to the increased flow overtopping the structures due to the adjustment of the Q-H curve for the weirs representing the bridge decks.

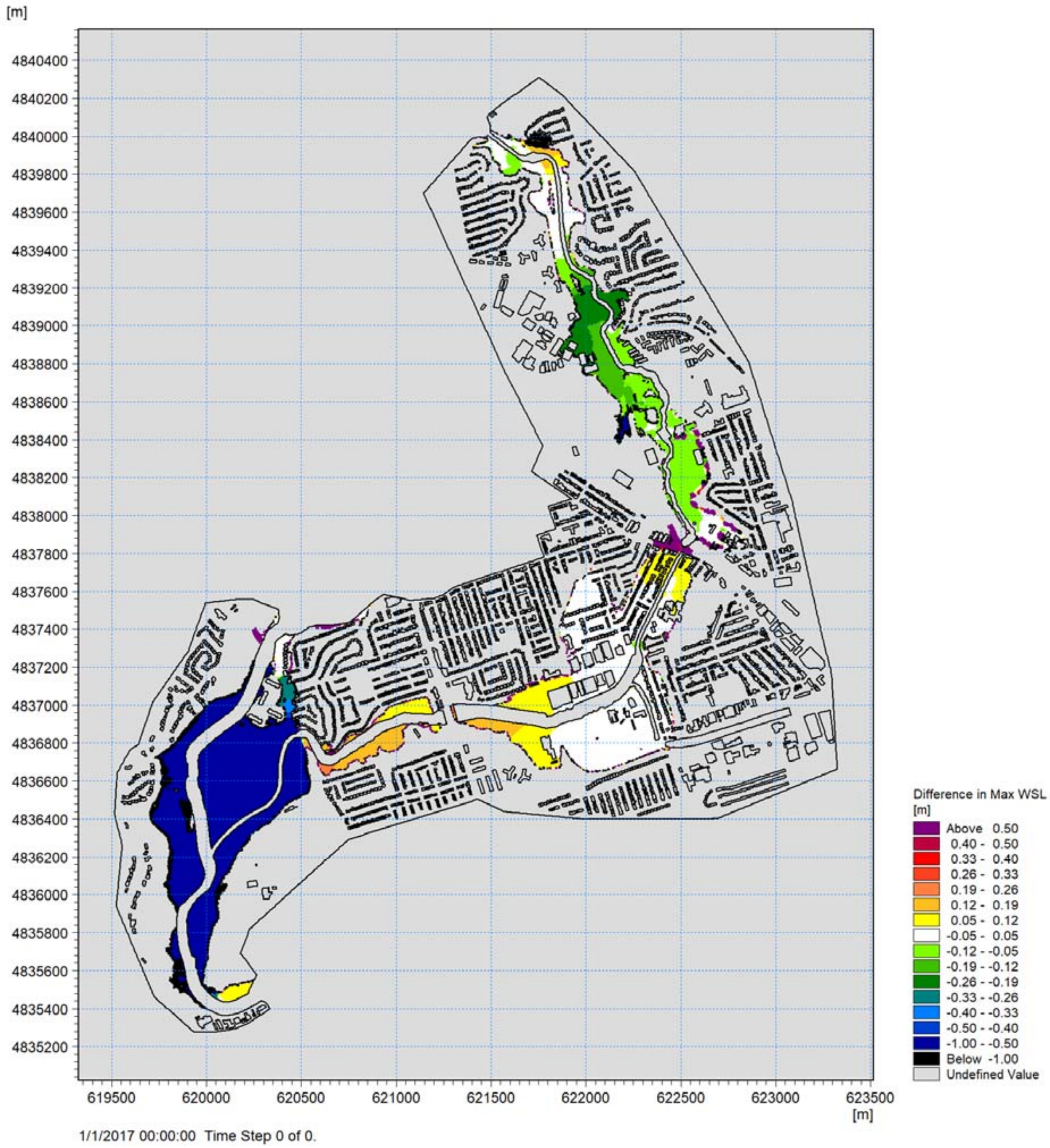

Figure 3.10. Difference in Maximum Water Level (Updated Model Minus TRCA Model)

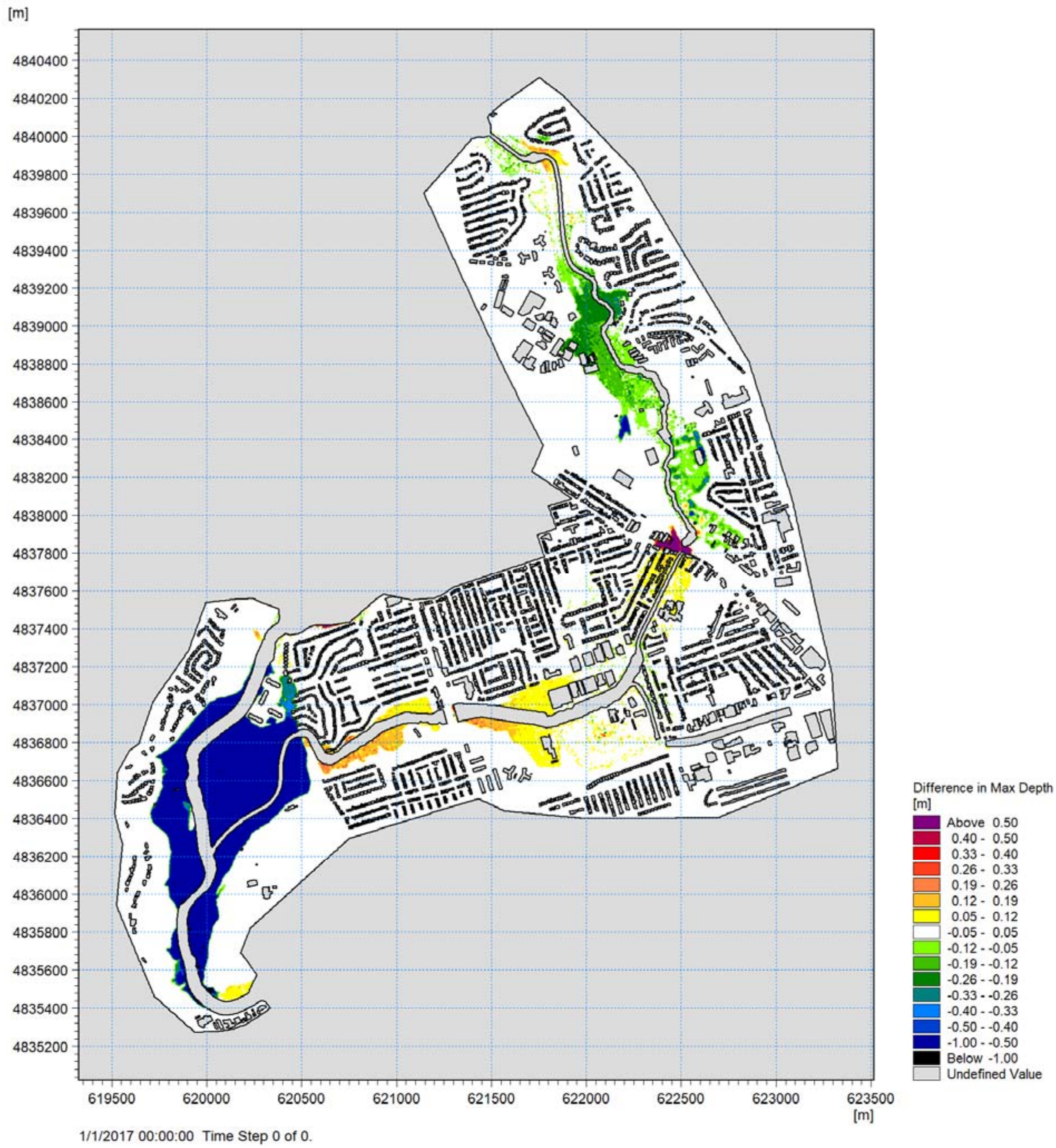

Figure 3.11. Difference in Maximum Depth (Updated Model Minus TRCA Model)

2D Maximum Velocity

The maximum flow velocity was calculated for both the TRCA model and the updated model. The difference in maximum velocity (updated model minus TRCA model) is shown in Figure 3.12. where yellow to red colors indicate the updated model has higher values, while green to blue colors indicate the updated model has lower values. In general, the flow velocities do not significantly change between the two models with a relatively narrow range of $^{+}/_{-}$ 0.5 m/s.

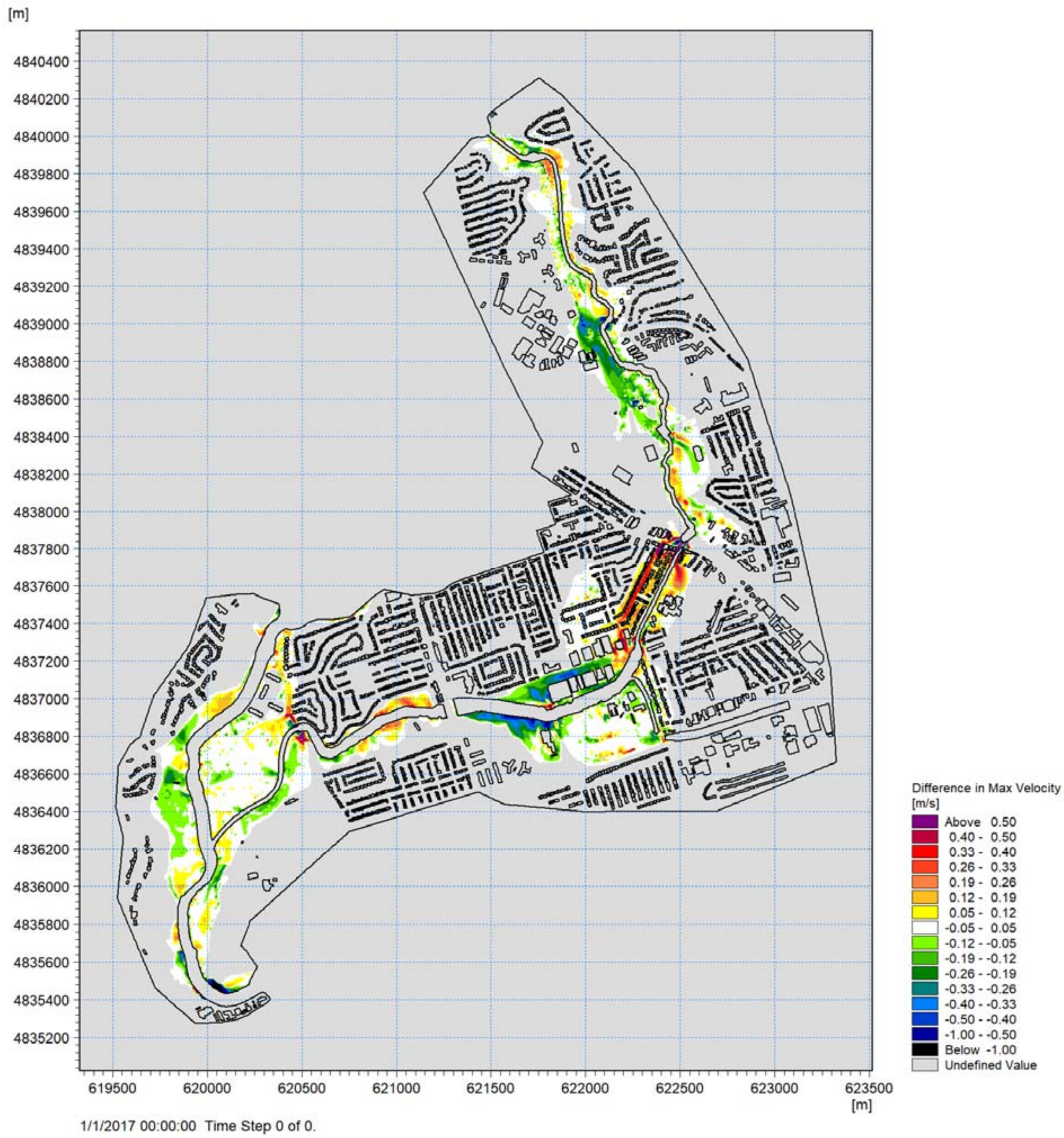

Figure 3.12. Difference in Maximum Velocity (Updated Model Minus TRCA Model)

3.3 Existing Flood Conditions

Maps showing the extent of flooding and maximum surface water elevations are provide in Appendix G.

- The existing conditions model shows extensive flooding of properties adjacent to Black Creek between Weston Road and Rockcliffe Boulevard, and adjacent to Lavender Creek from immediately upstream of Symes Road to the confluence with Black Creek. The main origins of flooding are: Overtopping of Weston Road during the 350 year and Regional Storm events (caused by backwater from Weston Road crossing).
- Overtopping of Black Creek along Humber Boulevard North during the 50 year, 100 year, 350 year, and Regional Storm events (caused by backwater from Rockcliffe Boulevard bridge and Jane Street crossing).
- Overtopping of Black Creek upstream of Rockcliffe Boulevard adjacent to Rockcliffe Court during the 10 year to 350 year and Regional Storm events (caused by backwater from Rockcliffe Boulevard bridge and Jane Street crossing).
- Overtopping of Black Creek upstream of Rockcliffe Boulevard adjacent to Alliance Avenue during the 10 year to 350 year and Regional Storm events (caused by backwater from Rockcliffe Boulevard bridge and Jane Street crossing).
- Overtopping of Lavender Creek at Symes Road during the 2 year to 350 year and Regional Storm events (caused by backwater from the Symes Road crossing).
- Overtopping of Lavender Creek at the Upstream Private Crossing during the 10 year to 350 year and Regional Storm events (caused by backwater from the Upstream Private Crossing).
- Overtopping of Lavender Creek at the Downstream Private Crossing during the 5 year to 350 year and Regional e Storm vents (caused by backwater from the Downstream Private Crossing).
- Overtopping of Lavender Creek at the confluence of Black Creek during the 10 year to 350 year and Regional Storm events (caused by high water levels in Black Creek).

The number of impacted buildings for each event, based upon the current existing conditions simulation, is summarized in Table 3.1.

Table 3.1. Number of Impacted Buildings under Existing Conditions per Storm Event

Event	Impacted Buildings
Regional Storm	366
350 year	215
100 year	113
50 year	57
25 year	47
10 year	33
5 year	26
2 year	15

4.0 Updated Assessment of 2014 Class EA Alternatives

4.1 Description of 2014 Class EA Alternatives

The 2014 Class Environmental Assessment, was initiated in response to major riverine flooding across TRCA's watershed, as part of TRCA's overall Flood Control Program. The Rockcliffe Area was ranked fifth (5^{th}) out of thirty-one (31) flood damage centres in terms of overall priority within TRCA's jurisdictional area. The study used the Conservation Ontario Class EA process (reference 2002, updated 2009) as the basis to assess the problem of riverine flooding along the Black Creek.

The riverine flood risk for the Rockcliffe Area was assessed using HEC-RAS one dimensional (1D) hydraulic modelling (i.e. to determine flood depths, elevations and velocities along and within the Black Creek floodplain). The 2002 Humber River study (ref. Humber River Watershed Hydrology Update, Aquafor Beech Limited, 2002) provided the peak flow rates for the Rockcliffe Area, which were used in the hydraulic model to determine the level of flood risk. The Rockcliffe Area was divided into four (4) distinct reaches for the flood risk assessment that have different hydraulic characteristics. For each reach, the level of risk and the number of properties at risk were determined, with a total of 226 properties at risk for the 100 year storm event and 413 properties at risk for the Regional Storm (Hurricane Hazel).

The study determined that flood risk can be reduced by lowering flood levels, decreasing the frequency of flooding and thereby removing some of the properties from flood risk by flood proofing properties and/or buildings. Further, by increasing the conveyance capacity including hydraulic crossing sizes (e.g. Jane Street Crossing), channel widths and floodplain geometry, flow conveyance can be increased in this area. Flood proofing measures included earthen berms, flood walls and improvements to buildings. The preferred solutions (Ref. Figure 4.1) included:

- Jane Street 200 m span Bridge and Valley Wall Reshaping
- Flood Protection (barrier) along:
  - Black Creek Blvd. and Scarlett Road
  - Rockcliffe Blvd.
  - Hilldale Road and Symes Road
- Creek naturalization and channel widening between Rockcliffe Blvd. and Alliance Avenue

The change in flood risk and the flood risk resulting from implementing the 2014 flood alternatives are indicated in Figure 4.2 and Figure 4.3 respectively.

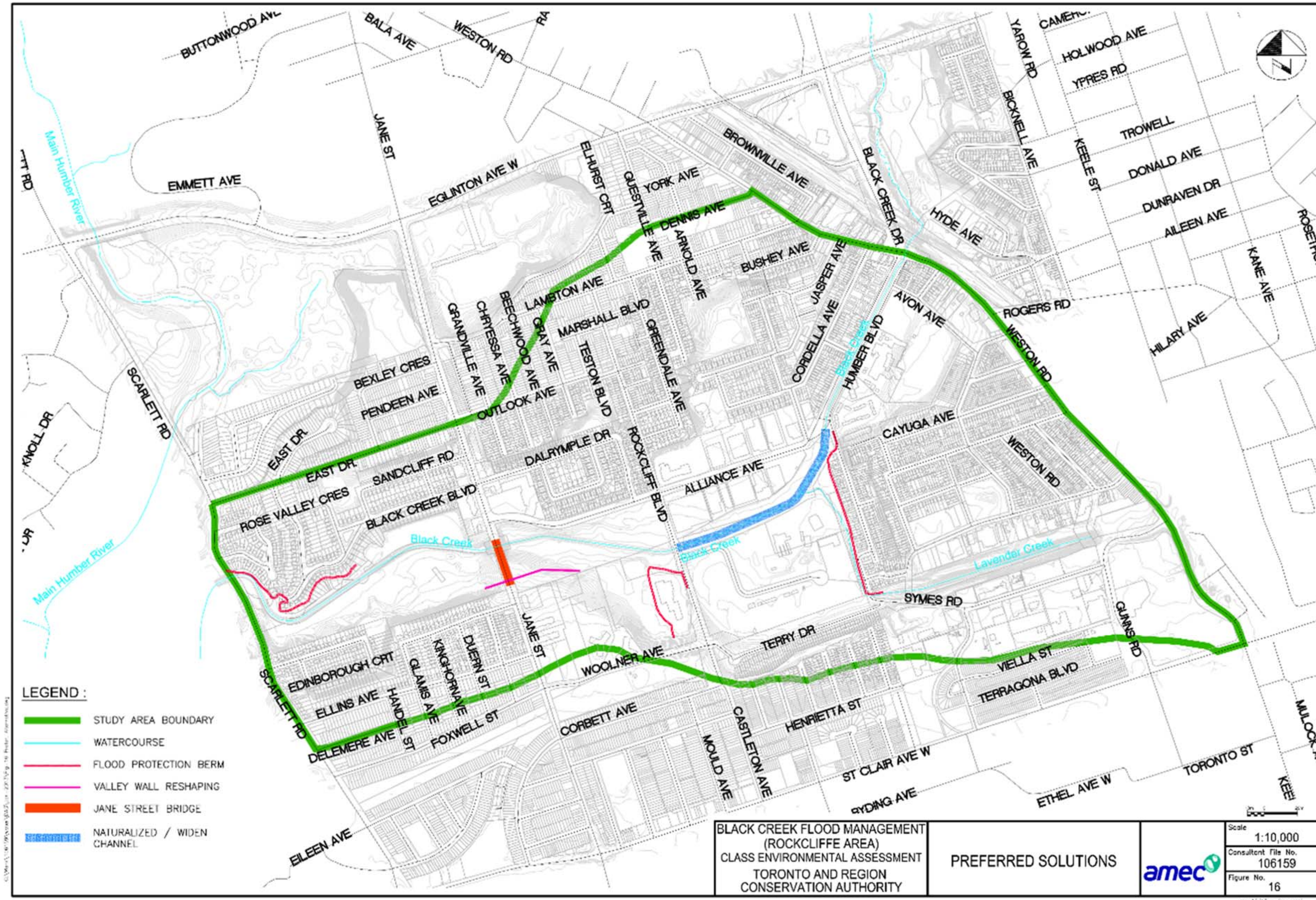

Figure 4.1. 2014 Class EA Preferred Solutions

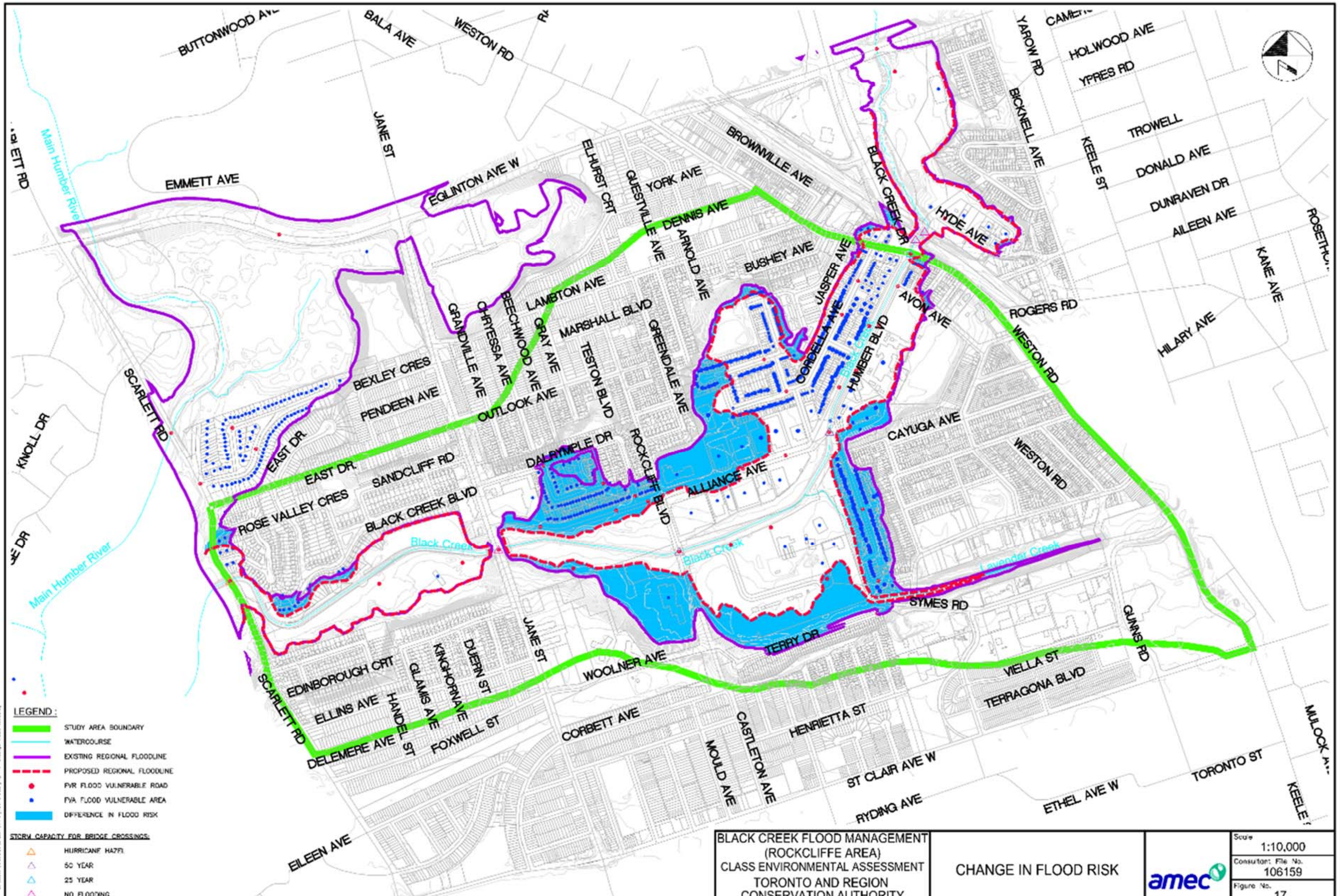

Figure 4.2. Change in Flood Risk (Class EA)

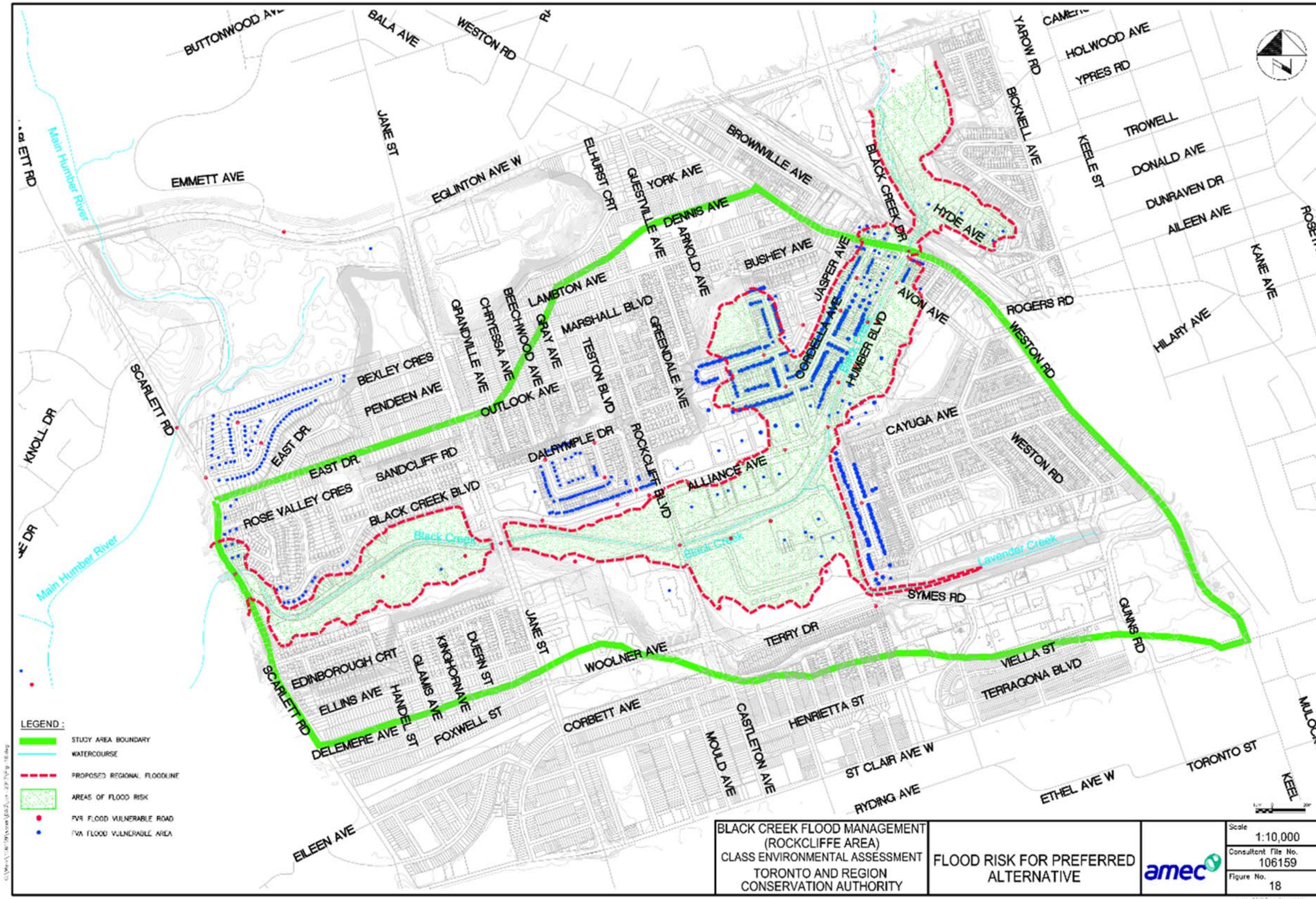

Figure 4.3. Flood Risk for Preferred Alternatives (Class EA)

4.2 Alternative Scenarios

The updated existing conditions MIKE FLOOD model has been modified to reflect the proposed flood remediation measures from the 2014 Class EA. As per discussions with TRCA, and as per the project Terms of Reference, there were to be a total of 4 separate alternative scenarios to be evaluated using the MIKE FLOOD model, whereby each of the flood remediation measures would be implemented in the model individually to assess the benefits derived from each measure in isolation, and an additional model to be prepared with all three measures combined , as per the following:

- ***Scenario 1*****:** Jane Street crossing upgrade and valley wall reshaping: This is primarily reflected in updated structure geometry in the 1D model and updated upstream and downstream cross-sections in the 1D model. The 1D model was an initial approach to obtain preliminary results, with 1D/2D modelling conducted to obtain updated and final results for this assessment
- ***Scenario 2***: Flood protection berms for Rockcliffe Middle School, Hilldale Road, and Black Creek Drive: The berms are represented in the 2D model using linear dike structures
- ***Scenario 3*****:** Channel widening and naturalization from Rockcliffe Blvd. to Alliance Ave.: This is represented using updates to the 1D model cross-sections and tying them into the 2D model topography.
- ***Scenario 4*****:** Scenario 1, Scenario 2 and Scenario 3 combined.

To execute the MIKE model in steady state with an 8 hour flow hydrograph, takes approximately 2 days of runtime, while a 24 hour flow hydrograph would take 4 days of runtime. Based on the foregoing, to reduce the number of modelling runs, it was agreed by TRCA, to only model Scenario 4, but to assess different level of services for the Jane Street crossing. To produce the most realistic hydraulic results and reduce the modelling time, it was determined by TRCA to execute the MIKE model only in unsteady state. The following summarizes the components of the Scenario 4 hydraulic assessment:

- Jane Street Upgrade (Scenario 1),
- Flood Protection Berms as per Scenario 2, and

Channel Widening as per the Class EA (Scenario 3) The various levels of service for Jane Street to be assessed included the following:

- **Alternative 1**: 200 m span and valley shaping as per the Class EA,
- **Alternative 2**: 100 Year Level of Service with lowered invert (1.5m +/-) : based on the 100 year flooding levels resulting from the 2018 MIKE 1D/2D hydraulic model,
- **Alternative 3**: 350 year Level of Service: Initial structure geometry to be determined using HEC-RAS, and
- **Alternative 4**: Relief Culvert(s), sizing to be based on Wood's perspective on what can be reasonably constructed in the floodplain areas.

4.3 Hydraulic Assessment of Alternatives

4.3.1 Jane Street Alternative 1: *200 m Span Bridge*

The Jane Street Culvert over Black Creek is a 57.25m long cast-in-place concrete arch structure with a 10.7m span and is located on Jane Street approximately 70m south of the Alliance Avenue intersection. The culvert carries four lanes of traffic (two in each direction.). There is approximately 6.0m of earth fill on top of the culvert and the watercourse flows from east to west through the culvert. It is suspected that there may be embedded utility ducts within each sidewalk. The existing culvert results in significant backwater effect and is considered hydraulically undersized.

4.3.1.1 Proposed Crossing Design

The 200m long structure could be constructed as a 3-span structure with spans of 60 m-80 m-60 m utilizing haunched steel I-girders. The bridge could also be constructed as a 4-span structure with spans of 45-55-55-45 meters and prismatic steel I-girders. To reduce the number of piers, spans of 60 m-80 m-60 m would be preferred. Two (2) piers would be required, each a minimum of 1.5 m in width.

The construction of the 200 m bridge could be conducted in stages. The current configuration of Jane Street carries two lanes of traffic in each direction. Roadway protection will be required down the middle of the roadway reducing the number of lanes to one in each direction. Using sheet piling, shoring and potential bracing to support half of the road, half the road and existing crossing would be removed. Subsequently, half of the proposed bridge would be constructed. Upon completion of half of the proposed bridge, the remaining half of the road and crossing would be removed to clear space for construction of the second half of the proposed bridge and piers.

4.3.1.2 Alternative 1 Hydraulic Results

Flood Protection Berms

The flood protection berms at Hilldale Road, Rockcliffe Middle School, and Black Creek Boulevard were represented in the model for each of the flood remediation alternatives. The berms were represented as impermeable vertical walls for the purpose of determining crest elevation (and height) required to prevent flooding. The proposed alignment of the Hilldale Road and Black Creek Boulevard flood protection berms cross through portions of both the 1D model channel and the 2D model. In cases where the berm alignment falls within the 1D model channel, the cross-sections were trimmed at the location of the berm and the 2D model domain was adjusted to fill the gap where the channel was trimmed. In addition, the lateral links between the 1D and 2D models were removed along the berm location to prevent the exchange of water at these sections (i.e. the edge of the channel acts like a vertical wall). In cases where the berm alignment is within the 2D model domain, a linear dike structure was added to the 2D model, with crest levels more than 10 m above the ground surface (see Figure 4.4. **Representation of Flood Protection Berms in the MIKE FLOOD Model**
). It should be noted that the flood protection berm adjacent to Lavender Creek and upstream of Symes Road was extended upstream a short distance compared to the original alignment proposed in the Class EA (AMEC, 2014). The extension of the berm was necessary to contain the flooding from Lavender Creek at this location. The Rockcliffe Middle School flood protection berm is totally within the 2D model domain and was modelled using a linear dike structure with crest level more than 10 m above the ground surface.

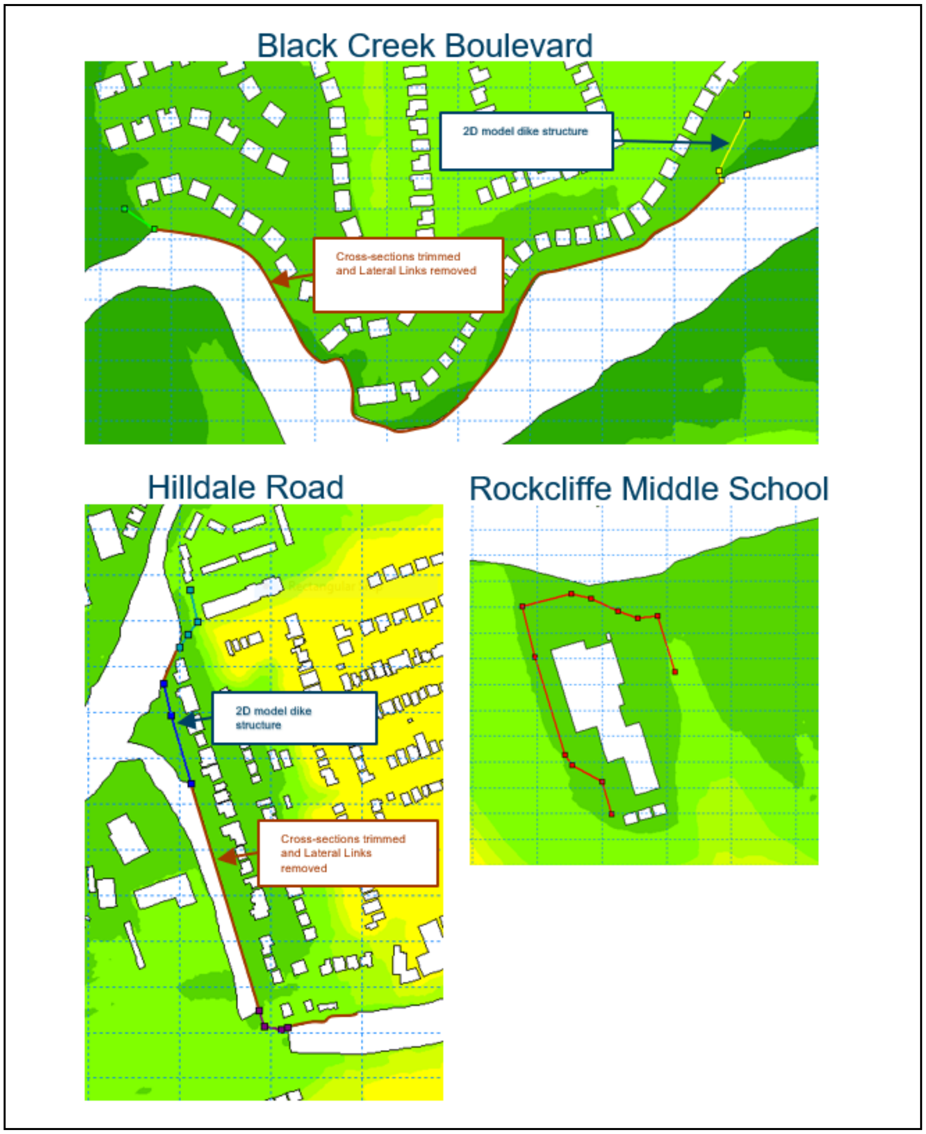

Figure 4.4. Representation of Flood Protection Berms in the MIKE FLOOD Model

Channel Widening and Naturalization from Alliance Avenue to Rockcliffe Boulevard

The 1D model representing Black Creek was widened for the segment from Alliance Avenue to Rockcliffe Boulevard for each of the flood remediation alternatives. The Class EA report (AMEC, 2014) did not provide specific dimensions for widening the creek, however, the drawings and text in the report indicated the proposed channel should be twice as wide as the existing channel. This flood mitigation option was represented in the MIKE FLOOD model developed as part of the previous Rockcliffe SPA study (DHI, 2014). As such, the 1D model cross-sections from Alliance Avenue to Rockcliffe Boulevard were copied from the previous MIKE FLOOD model and used in the MIKE FLOOD model developed for this project.

In addition to widening the channel, it was also proposed to naturalize the channel so the roughness for the engineered portion of the channel was set to a Manning's n value of 0.03 while the roughness outside of the widened channel remained consistent with the 2D surface roughness map. The side slope for the channel was set to approximately 2:1. Figure 4.5 provides a comparison of a typical Black Creek channel cross-section before and after the channel widening (the blue line indicates the channel roughness value corresponding to the right axis).

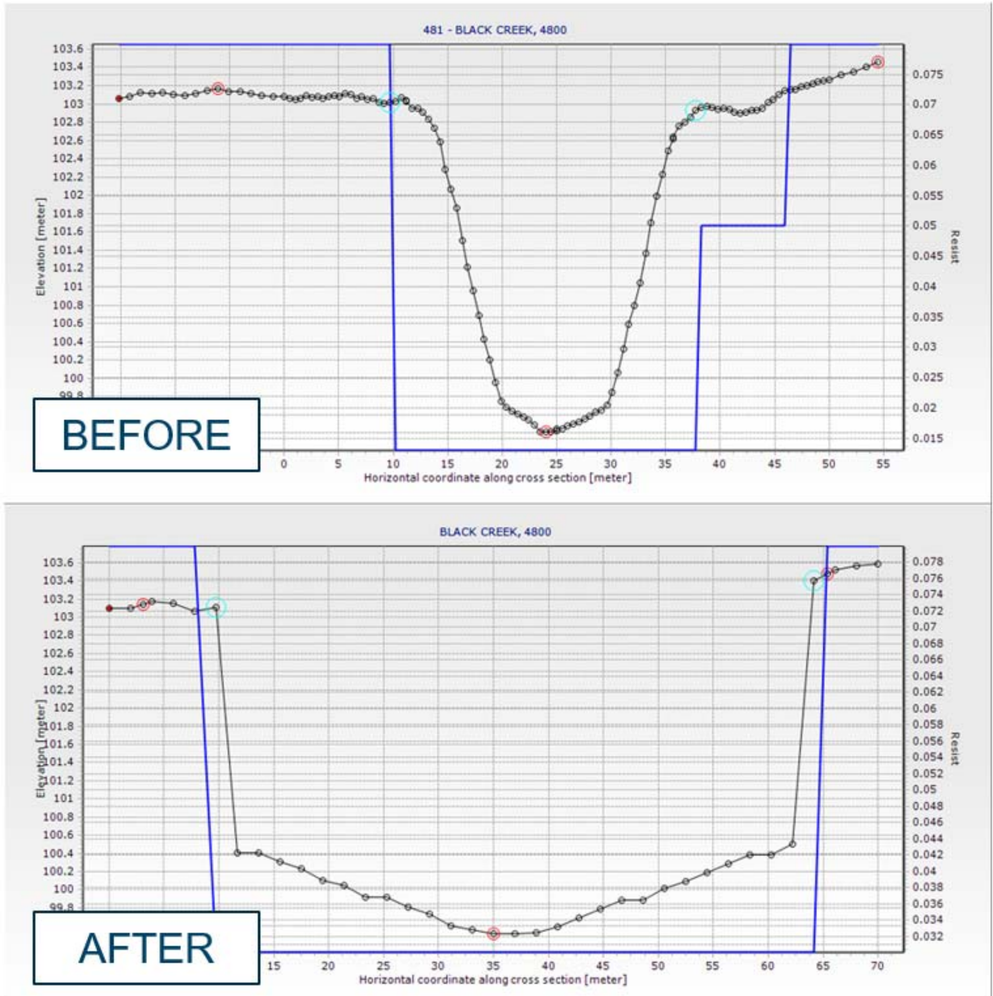

Figure 4.5. Comparison of Black Creek Channel Cross Sections 'Before' and 'After' the Channel Widening

Jane Street Crossing

For Alternative 1 the 1D model was updated to reflect the proposed geometry of the 200 m span bridge. The geometry of the culvert representing the Jane Street crossing was updated according to the dimensions provided in the MIKE FLOOD model from the previous Rockcliffe SPA study (DHI, 2018). The shape of the channel opening under the bridge was represented using a Level-Width curve corresponding to the dimension of the proposed 200 m span bridge. Figure 4.6 provides the updated geometry of the culvert while the upstream and downstream culvert invert levels were updated to 98 m and 97.5 m, respectively.

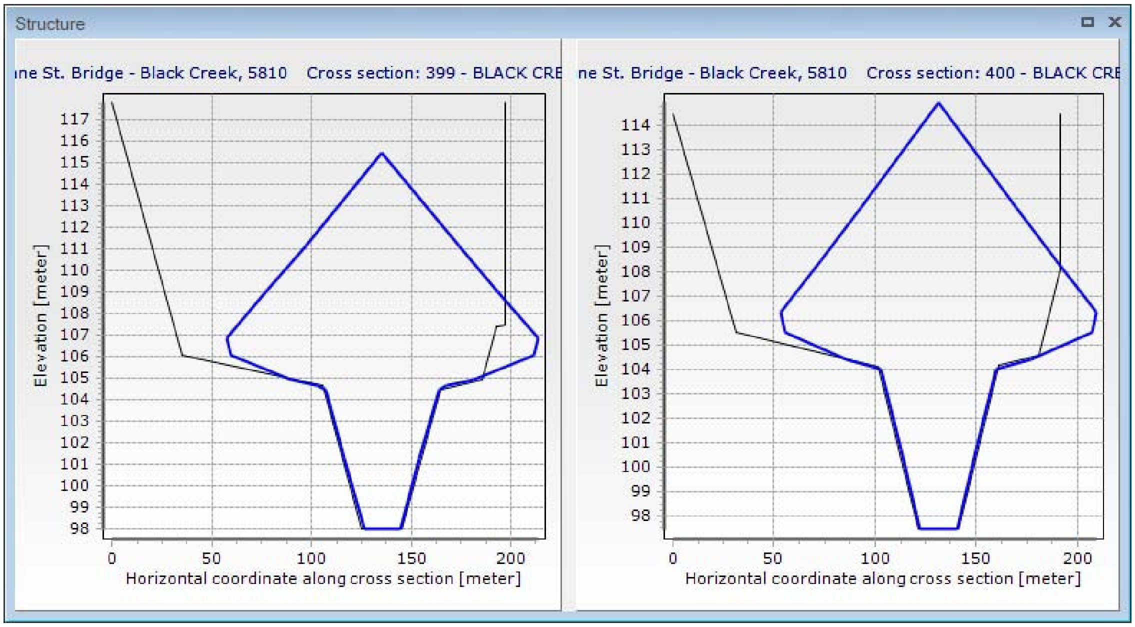

Figure 4.6. Jane Street Bridge Culvert Geometry Updated for Alternative 1

4.3.2 Jane Street Alternative 2: *Lower Channel Invert*

As discussed with TRCA, there is an opportunity to lower the channel invert through the Jane Street crossing, based on the drop structure located on the downstream side of the crossing; this has been assessed as Alternative 2.

4.3.2.1 Crossing Design

The concrete trapezoidal channel within the existing Jane Street structure, is located between the structure footings. A minimum of 1 m offset is required from the footing, before the channel can be lowered. The channel would retain the existing base width dimension of approximately 1m.

4.3.2.2 Alternative 2 Hydraulic Model Updates

For Alternative 2, the upstream and downstream invert levels for the Jane Street culvert were updated to 96.9 m and 96.3 m, respectively. The downstream invert elevation of the culvert was set 0.05 m above the cross-section immediately downstream of the culvert, while the upstream invert of the culvert was set to maintain the existing slope of the culvert (e.g. a drop of 0.6 m), as indicated in the as-built drawings. In addition, the flat bottom of the culvert (as represented in the TRCA model) was updated to include the low flow channel in the center (Ref. Figure 4.7). Finally, the bottom of the cross-sections immediately upstream of the culvert were adjusted to provide a smooth transition from the existing channel elevation to the proposed lowered invert elevation.

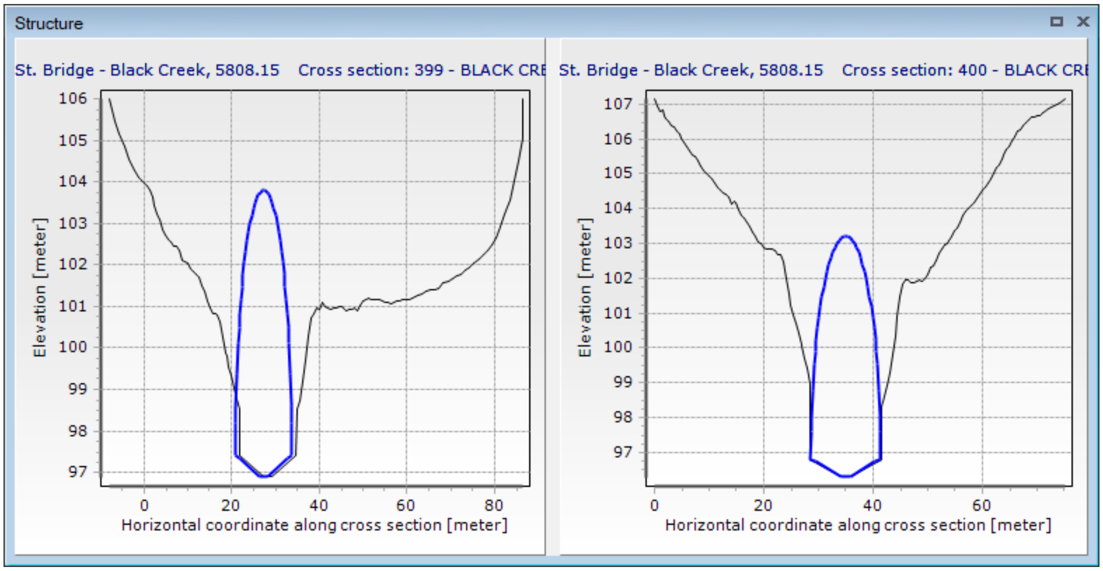

Figure 4.7. Jane St. Bridge Culvert Geometry Updated for Alternative 2

4.3.3 Jane Street Alternative 3: *350 Year Level of Service (72m span)*

Using HEC-RAS, a 72 m structure was established to result in a 350 year storm event Level of Service.

4.3.3.1 Crossing Design

The 72 m structure can be constructed as either a 72 m single span structure with temporary supports required in the valley during erection or a 2-span structure with spans of 36-36 meters. Both options are feasible utilizing steel I-girders and the second option is also feasible using CPCI or NU precast and prestressed girders. Based on constructability, a 2-span structure would be preferred over a 72 m single span structure. The bridge would require a single pier, that would be approximately 1.8 m in width.

The construction of the 72 m span could be conducted in stages. The current configuration of Jane Street carries two lanes of traffic in each direction. Roadway protection will be required down the middle of the roadway reducing the number of lanes to one in each direction. Using sheet piling, shoring and potential bracing to support half of the road, half the road and existing crossing would be removed. Subsequently, half of the proposed bridge would be constructed. Upon completion of half of the proposed bridge, the remaining half of the road and crossing would be removed to clear space for construction of the second half of the proposed bridge and pier.

Alternative 3 Hydraulic Model Updates

For Alternative 3, the 1D model was updated to reflect the proposed geometry of a 72 m span bridge. The geometry of the culvert representing the Jane Street crossing was updated using the same level-width curve as Alternative 1, except the maximum width was limited to 72 m. Figure 4.8 indicates the updated geometry of the culvert while the upstream and downstream culvert invert levels were updated to 98 m and 97.5 m, respectively.

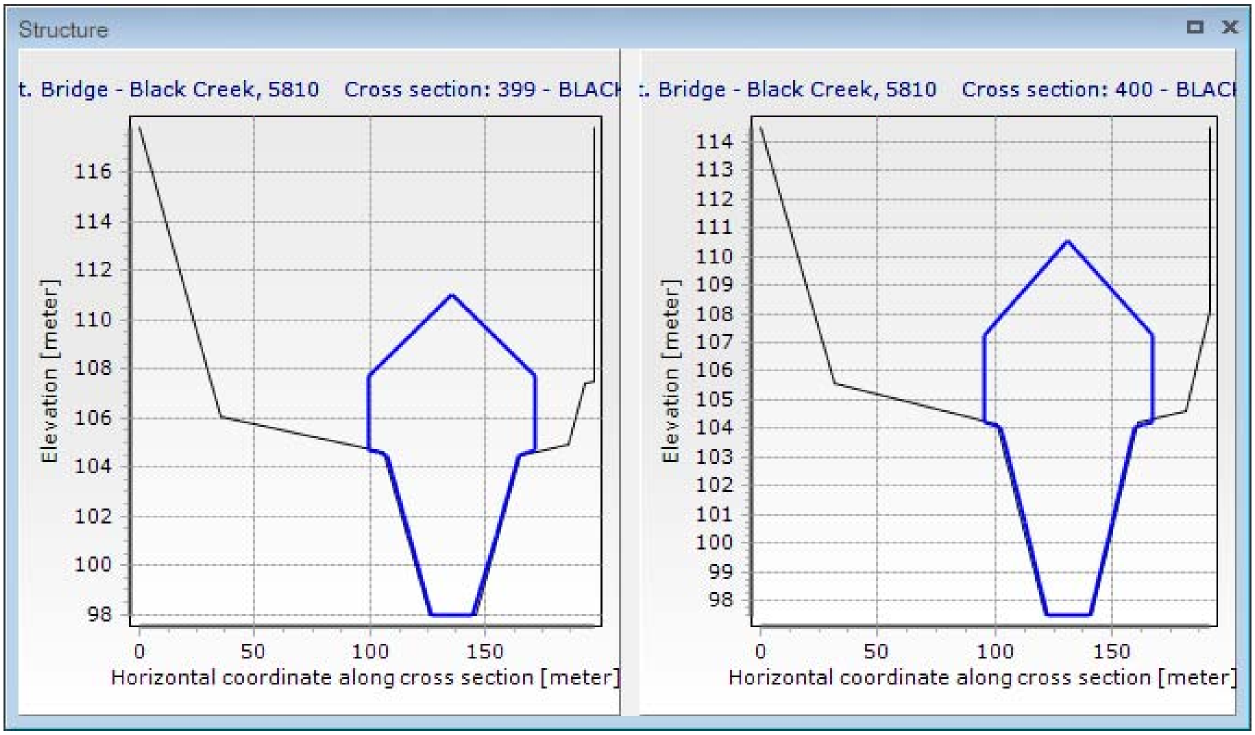

Figure 4.8. Jane St. Crossing Culvert Geometry Updated for Alternative 3

4.3.4 Jane Street Alternative 4: *Relief Culverts*

Relief culverts, located within the overbank areas could provide supplemental flow capacity for the less frequent storm events and reduce flooding depths and extents upstream of the Jane Street crossing. The relief culverts, would have to avoid or relocate existing utilities and infrastructure.

4.3.4.1 Crossing Design

Two (2) 5.4 m diameter supplemental culverts have been added to the existing Jane Street crossing, with a culvert located either side of the existing crossing. The sizing of the culverts has been established to avoid existing infrastructure while fitting within the overbank areas and to be feasible using the New Austrian Tunnel methodology. The tunneling methodology staging consists of excavation, bracing the tunnel, then final concrete forming, before moving ahead with further tunnel excavation.

4.3.4.2 Alternative 4 Hydraulic Model Updates

For Alternative 4, the two relief culverts were added as an additional structure with two identical culverts at the same location as the original culvert. The unusual geometry of the relief culverts (5.4 m diameter with bottom 1.4 m filled) was represented using a Level-Width curve with the upstream and downstream inverts set equal to 100 m (ref. Figure 4.9).

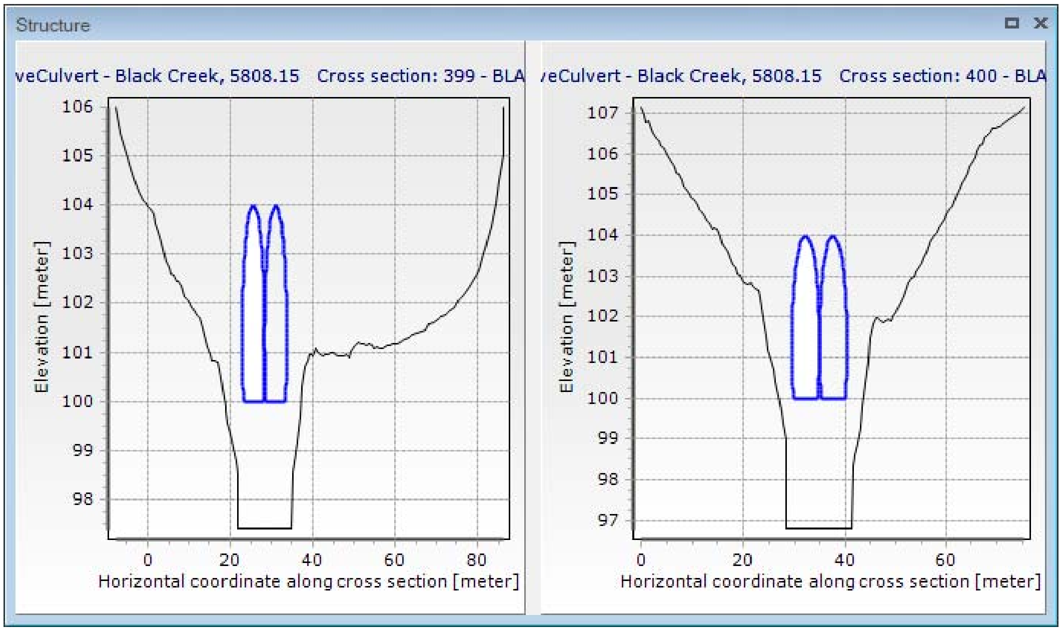

Figure 4.9. Jane St. Crossing Relief Culverts for Alternative 4

4.3.5 Hydraulic Modelling Results

The existing condition model and the 4 Alternatives were run for the 2, 5, 10, 25, 50, 100 and 350 year design storm events as well as the Regional Storm event for unsteady flow conditions. Flood maps of maximum water surface elevation, maximum flood depth and maximum velocity are provided as follows:

- Appendix G-B- Existing Conditions
- Appendix G-C – Alternative 1 – 200 m Span Bridge
- Appendix G-D – Alternative 2 – Lowered Channel Invert
- Appendix G-E – Alternative 3 – 72 m Span Bridge
- Appendix G-F – Alternative 4 – Relief Culverts

The following sections present the results of the simulations and provide a comparison of the relative benefits of each Alternative.

4.3.5.1 Properties and Buildings Affected

One of the primary objectives of evaluating the flood remediation alternatives is to determine the most feasible option to minimize the number of properties and buildings being impacted by flooding. The building footprints shapefile for the study area was provided by TRCA and was used to estimate the number of buildings impacted for each event, for each Alternative. The building footprints were intersected with the flood extents to identify the buildings that are affected by the respective flood. In each case the flood depth threshold and the buffer distance were each set to 0.0 m – thus, any building that gets wet anywhere around the building will count as being impacted. A summary of the count of affected buildings for each event and for each alternative is provided in Table 4.1.

The results indicate that all of the Alternatives have some benefit to the affected buildings for events with return periods equal or less than 350 years. For the Regional Storm event, Alternatives 1 and 3 provide the most benefit with 84 buildings protected from flooding. Alternative 4 is the next most effective with 76 buildings protected from flooding, while Alternative 2 would result in the least benefit with 65 buildings being protected from flooding.

Given the similar performance of the Alternatives for events with return periods equal or less than 350 years, and the fact that the majority of buildings impacted by flooding are upstream of Rockcliffe Boulevard, it is clear that the existing bottleneck at the Jane Street crossing is not the only factor influencing the flooding of buildings.

Table 4.1. Summary of Buildings Impacted by Flooding for Each Alternative

	Regional	350 yr	100 yr	50 yr	25 yr	10 yr	5 yr	2 yr
Existing	366	215	113	57	47	33	26	15
Alternative 1 200 m Span Bridge	282 (84)	173 (42)	82 (31)	18 (39)	11 (36)	5 (28)	1 (25)	0 (15)
Alternative 2 Lowering Channel	301 (65)	173 (42)	82 (31)	18 (39)	11 (36)	5 (28)	1 (25)	0 (15)
Alternative 3 72 m Span Bridge	282 (84)	173 (42)	82 (31)	18 (39)	11 (36)	5 (28)	1 (25)	0 (15)
Alternative 4 Relief Culverts	290 (76)	173 (42)	82 (31)	18 (39)	11 (36)	5 (28)	1 (25)	0 (15)

*Values shown in parenthesis indicate numbers of properties or buildings benefiting from alternatives, in comparison with the existing scenario.

4.3.5.2 Extent of Flooding

The mapping provided in Appendix G shows that the flood extents for all events are very similar for the areas upstream of Alliance Avenue and downstream of Jane Street, while the most notable differences in flood extents occurs between Alliance Avenue and Jane Street. An example of these differences is provided in , which indicates the extents of flooding for the Regional Storm event for the Existing Condition and for each alternative for the area from Weston Road to Jane Street, including Lavender Creek.

The following is a summary of the notable differences in the extent of flooding between Alliance Avenue and Jane Street:

- Both the Hilldale Road and the Black Creek Blvd Flood Protection Berm alignments are effective in protecting the buildings behind the berms from overland flooding for all events, but the Rockcliffe Middle School Flood Protection Berm fails for Alternatives 2 and 4 for the Regional Storm event.
- Alternatives 1 and 3 significantly reduce the extent of flooding on the south side of Alliance Avenue immediately upstream of Rockcliffe Boulevard bridge, for the Regional Storm and 350 year storm events, but the buildings are still impacted.
- Alternatives 1 and 3 show a significant reduction in flooding between Rockcliffe Boulevard and Jane Street for the Regional Storm, as well as the 350, 100, 50 and 25 year storm events.

The Hilldale Road Flood Protection Berm causes Lavender Creek to spill at Symes Road for all events and causes flooding throughout the area south of Black Creek between Hilldale Road and Rockcliffe Boulevard. The Lavender Creek alternatives will further assess and consider this issue.

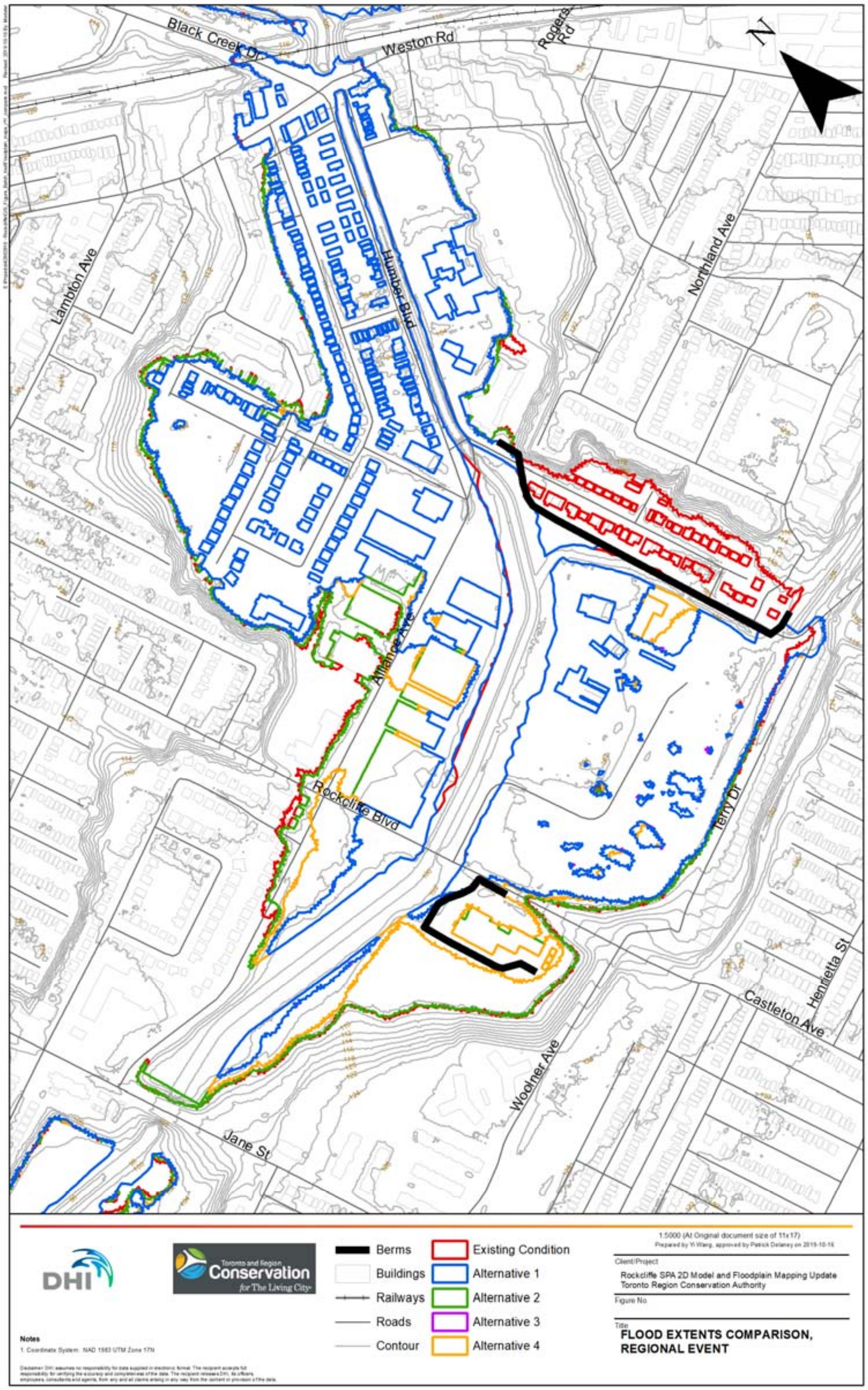

Figure 4.10. Flood Extents in Regional Storm Event

4.3.5.3 Jane Street Crossing

Table 4.2 provides a summary of the maximum water elevations on the upstream and downstream side of the Jane Street crossing for each Alternative and for each event.

Alternatives 1 and 3 provide significant benefits in lowering the upstream water elevations at the Jane Street crossing by approximately 4 m for the Regional Storm event, approximately 2.5 m for the 350 year storm event, by 2.2 m for the 100 Year storm event, by approximately 1.85 m for the 50 Year storm event, by approximately 1.6 m for the 25 year storm event, by approximately 1.2 m for the 10 Year storm event, and by less than 1 m for the 5 and 2 year storm events.

Alternative 4 is effective in lowering the peak water elevations upstream of the Jane Street crossing by approximately 1.45 m for the Regional Storm event, by approximately 1 m for the 350 Year storm event, and by less than 1 m for the remaining events.

Alternative 2 has negligible impact for the Regional Storm event and the 350 storm event, and only lowers the peak water elevations upstream of the Jane Street crossing by approximately 0.3 m for the remaining events.

Table 4.2. Summary of Peak Water Elevations at Jane Street Crossing

	Peak Water Elevations (masl)							
	Regional		350 yr		100 yr		50 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	106.47	100.85	103.84	100.18	103.23	99.92	102.72	99.67
Alternative 1 200 m Span Bridge	102.45	101.36	101.29	100.31	101.04	99.98	100.86	99.72
Alternative 2 Lowering Channel	106.27	100.97	103.63	100.19	102.98	99.89	102.44	99.65
Alternative 3 72 m Span Bridge	102.46	101.36	101.30	100.31	101.03	99.98	100.83	99.72
Alternative 4 Relief Culverts	105.03	101.21	102.88	100.34	102.39	100.02	102.04	99.77
	25 yr		10 yr		5 yr		2 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	102.20	99.42	101.58	99.09	100.26	98.45	99.51	98.02
Alternative 1 200 m Span Bridge	100.63	99.46	100.38	99.14	99.85	98.49	99.50	98.13
Alternative 2 Lowering Channel	101.86	99.40	101.18	99.09	99.88	98.44	99.19	98.00
Alternative 3 72 m Span Bridge	100.63	99.46	100.39	99.14	99.84	98.49	99.49	98.13
Alternative 4 Relief Culverts	101.65	99.49	101.20	99.13	100.23	98.45	99.51	98.02

4.3.5.4 Rockcliffe Blvd Bridge

Table 4.3 provides a summary of the maximum water elevations on the upstream and downstream side of the Rockcliffe Boulevard bridge for each Alternative and for each event.

Alternatives 1 and 3 provide significant benefits in lowering the peak upstream water elevations at the Rockcliffe Boulevard bridge by approximately 1.7 m for the Regional Storm event, by approximately 0.5 m for the 350 Year storm event, and by 0.3 m or less for all remaining events. The reduction in peak water elevations on the downstream side of the bridge is commensurate with the reductions in peak water elevations on the upstream side of the Jane Street crossing.

Alternative 4 is effective in lowering the peak water elevations upstream of the Rockcliffe Boulevard bridge by approximately 1.1 m for the Regional Storm event, by approximately 0.5 m for the 350 Year storm event, and by less than 0.1 m for the remaining events.

Alternative 2 lowers the peak water elevations upstream of the Rockcliffe Boulevard bridge by less than 0.2 m for all events.

Table 4.3. Summary of Peak Water Elevations at Rockcliffe Boulevard Bridge

	Peak Water Elevations (masl)							
	Regional		350 yr		100 yr		50 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	106.45	106.43	104.16	103.74	103.35	103.03	103.08	102.50
Alternative 1 200 m Span Bridge	104.72	102.93	103.65	101.94	103.29	101.73	103.04	101.57
Alternative 2 Lowering Channel	106.26	106.25	103.99	103.50	103.29	102.77	103.04	102.24
Alternative 3 72 m Span Bridge	104.72	102.93	103.65	101.94	103.29	101.72	103.04	101.56
Alternative 4 Relief Culverts	105.32	105.05	103.65	102.73	103.29	102.26	103.04	101.95
	25 yr		10 yr		5 yr		2 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	102.72	102.01	102.26	101.51	101.35	100.76	100.77	100.38
Alternative 1 200 m Span Bridge	102.73	101.38	102.28	101.16	101.35	100.69	100.77	100.38
Alternative 2 Lowering Channel	102.73	101.75	102.28	101.34	101.35	100.66	100.77	100.34
Alternative 3 72 m Span Bridge	102.73	101.37	102.28	101.16	101.35	100.69	100.77	100.38
Alternative 4 Relief Culverts	102.73	101.65	102.28	101.36	101.35	100.76	100.77	100.38

4.3.5.5 Alliance Ave Bridge

For the Regional Storm event, Alternatives 1 and 3 would result in the lowest peak water elevations at both the upstream and downstream side of the Alliance Ave. Bridge. Alternative 4 would provide lower peak water elevations than Alternative 2.

For the 350-yr event, upstream peak water elevations are same for all four alternatives. Alternative 2 shows higher downstream peak water than the existing condition model.

The alternatives show no difference in peak upstream or downstream water elevations for events smaller than the 100-yr return period. The difference at downstream, comparing to existing condition, is due to channel widening.

Table 4.4 provides a summary of the maximum water elevations on the upstream and downstream side of the Alliance Ave. bridge for each Alternative and for each event.

Alternatives 1, 3 and 4 provide significant benefits in lowering the peak upstream water elevations at the Alliance Ave. bridge by approximately 1.1 m for the Regional Storm event, and by less than 0.3 m or less for all remaining events. The reduction in peak water elevations on the downstream side of the bridge is commensurate with the reductions in peak water elevations on the upstream side of the Rockcliffe Boulevard bridge.

Alternative 2 lowers the peak water elevations upstream of the Alliance Avenue bridge by less than 0.1 m for all events.

Table 4.4. Summary of Peak Water Elevations at Alliance Avenue Bridge

	Peak Water Elevations (masl)							
	Regional		350 yr		100 yr		50 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	106.71	106.41	104.62	103.81	104.00	103.26	103.69	103.03
Alternative 1 200 m Span Bridge	105.63	104.73	104.45	103.75	104.00	103.44	103.70	103.22
Alternative 2 Lowering Channel	106.63	106.29	104.45	103.89	104.00	103.44	103.70	103.22
Alternative 3 72 m Span Bridge	105.63	104.74	104.45	103.75	104.00	103.44	103.70	103.22
Alternative 4 Relief Culverts	105.63	105.24	104.45	103.75	104.00	103.44	103.70	103.22
	25 yr		10 yr		5 yr		2 yr	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Existing	103.34	102.76	102.93	102.39	102.09	101.70	101.59	101.30
Alternative 1 200 m Span Bridge	103.34	102.93	102.92	102.49	102.09	101.65	101.59	101.21
Alternative 2 Lowering Channel	103.34	102.93	102.92	102.49	102.09	101.65	101.59	101.21
Alternative 3 72 m Span Bridge	103.34	102.93	102.92	102.49	102.09	101.65	101.59	101.21
Alternative 4 Relief Culverts	103.34	102.93	102.92	102.49	102.09	101.65	101.59	101.21

4.3.5.6 Flood Protection Berms

The Black Creek Boulevard flood protection berm successfully protects the buildings located along the south side of the street and, in particular at the west end of the street, from flooding during the Regional Storm event as well as the 350, 100, 50 and 25 year storm events. No buildings are impacted during the remaining events. The peak water depths (or minimum flood berm height) adjacent to the berm at the west end of Black Creek Boulevard are summarized in Table 4.5.

Table 4.5. Summary of Peak Depths Adjacent to Black Creek Blvd. Flood Protection Berm

Alternatives	Regional	350 yr	100 yr	50 yr	25 yr
Alternative 1 200 m Span Bridge	>2.5	>2.0	>1.5	NA	NA
Alternative 2 Lowering Channel	>2.5	>2.0	>1.5	NA	NA
Alternative 3 72 m Span Bridge	>2.5	>2.0	>1.5	NA	NA
Alternative 4 Relief Culverts	>2.5	>2.0	>1.5	NA	NA

The Rockcliffe Middle School flood protection berm is not required for Alternatives 1 and 3 because the peak water elevations downstream of Rockcliffe Boulevard bridge are significantly reduced. For Alternatives 2 and 4, the berm fails to protect the school from flooding for the Regional Storm event and it is not required for the 350 year event because the peak water elevations do not reach the berm location. It may be possible to extend the berm to the south to provide protection from flooding during the Regional Storm event for Alternatives 2 and 4 but these options were not evaluated in this phase of the project.

The Hilldale Road flood protection berm provided the adjacent buildings protection from flooding for all events and for each Alternative. The peak water depths (or minimum flood berm height)adjacent to the berm along Lavender Creek are summarized in Table 4.6. The maximum depth varies along the length of the berm, but the values presented in are generally occurring at the far upstream side of the berm (adjacent to the Symes Road crossing on Lavender Creek) and at the far downstream side adjacent to Black Creek.

Table 4.6. Summary of Peak Depths Adjacent to Hilldale Flood Protection Berm

Alternatives	Regional	350 yr	100 yr	50 yr	25 yr	10 yr	5 yr	2 yr
Alternative 1 200 m Span Bridge	>2	>2	>2	2	1.8	1.6	1.1	0.5
Alternative 2 Lowering Channel	>2	>2	>2	2	1.8	1.6	1.1	0.5
Alternative 3 72 m Span Bridge	>2	>2	>2	2	1.8	1.6	1.1	0.5
Alternative 4 Relief Culverts	>2	>2	>2	2	1.8	1.6	1.1	0.5

4.3.5.7 Channel Widening and Naturalization

The benefits of the channel widening (double channel width) and naturalization from Alliance Avenue to Rockcliffe Boulevard is very minimal due mainly to the additional flow in the channel being constricted at the Rockcliffe Boulevard bridge. There will be very little flood reduction benefit from widening and naturalizing the channel, should the opening under the Rockcliffe Boulevard bridge not be expanded.

4.3.6 Additional Assessment of Jane Street Alternatives

The assessment of the Jane Street Alternatives revealed that the flooding problems upstream of Rockcliffe Boulevard were caused by flow restrictions at both Jane Street and Rockcliffe Boulevard. As a result, many of the flooding problems upstream of Rockcliffe Boulevard persisted even after the Jane Street crossing was widened. In addition, the effectiveness of the Jane Street Alternatives could not be properly assessed because the peak flow reaching the Jane Street crossing was being attenuated at Rockcliffe Boulevard.

In order to directly assess the effectiveness of the design alternatives for Jane Street, it was decided to model the flow in Black Creek assuming there are no upstream structures between Jane Street and Weston Road (i.e. the structures at Rockcliffe Boulevard, Alliance Avenue and Humber Boulevard were removed). This allowed the proposed Jane Street alternatives to be comparatively assessed under the most probable worst-case conditions where peak flow is not being attenuated by any upstream structures in accordance with MNRF protocols.

The proposed Jane Street Alternatives were modelled for the 10 year to 350 year and Regional Storm events and the results comparing water levels upstream of Jane Street are presented in Table 4.7.

Table 4.7. Comparison of Maximum Water Level Upstream of Jane Street for Proposed Jane Street Alternatives

Alternative	Maximum Water Level Upstream of Jane Street (m)					
	Regional	350 yr	100 yr	50 yr	25 yr	10 yr
Existing Conditions	107.3	104.9	104.2	103.7	103.3	102.8
Alternative 1 200 m span bridge	102.5	102.0	101.7	101.5	101.2	101.0
Alternative 2 Lowering channel	107.0	104.3	103.3	102.8	102.3	101.6
Alternative 3 72 m span bridge	102.5	101.8	101.5	101.3	101.2	100.9
Alternative 4 Relief Culverts	105.8	103.9	103.2	102.9	102.5	102.1

These results demonstrate that the proposed Alternatives 1 and 3 are significantly more effective in reducing peak water levels upstream of Jane Street than Alternatives 2 and 4. As a result, Alternative 3 has been selected as the preferred alternative over Alternative 1, as it has a shorter span and is equally as effective in lowering peak water levels upstream of Jane Street during flood events.

As an additional level of verification of the selection of Alternative 3, five (5) target water surface elevations upstream of Jane Street have been established (ref. Figure 4.11) and compared to flood elevations for each storm event (ref. Table 4.8) resulting from Alternative 3. The following target flood elevations have been established:

1. Humber Blvd North: max WSE of 101.30 m (Black Creek)
2. Cordella Ave at Cliff St: max WSE of 101.50 m (Black Creek)
3. Hilldale Blvd: max WSE of 101.30 m (Lavender Creek)
4. Alliance Blvd at Rockcliffe Blvd: Basement driveway elevation of 100.45 m
5. Rockcliffe Blvd bridge soffit 102.57 m

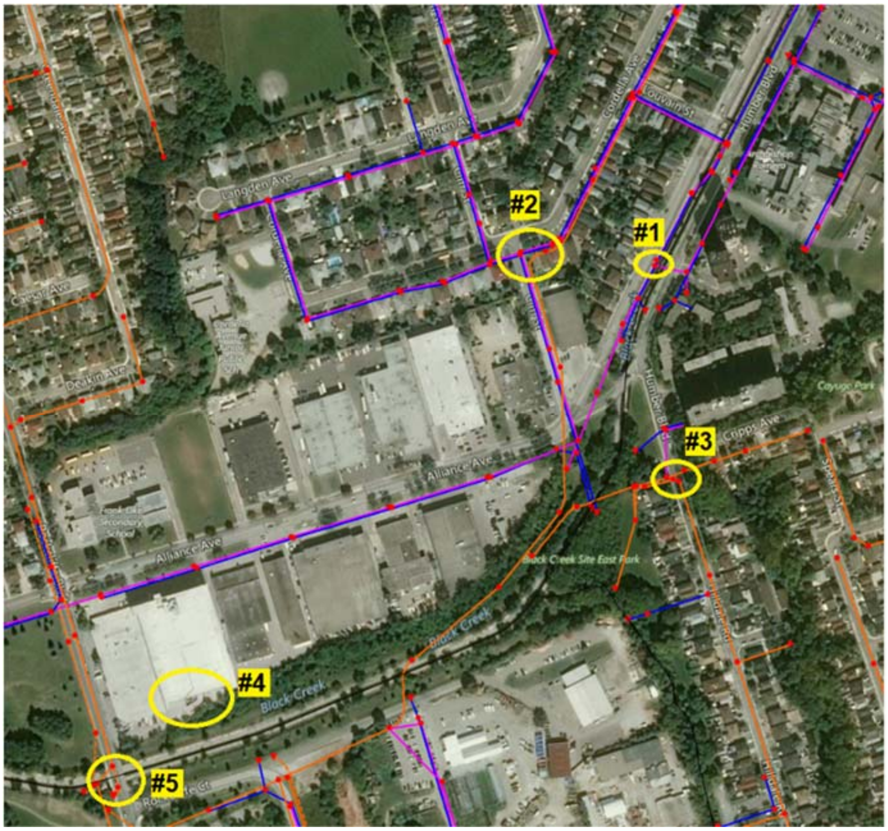

Figure 4.11. Locations of Target Flood Elevations

Target elevations one (1) to four (4) represent basement elevations at each of the locations, while the fifth target elevation is the Rockcliffe Avenue bridge soffit. The locations were selected to determine at what storm return period would basement flooding occur or reach the Rockcliffe Avenue bridge. Italicized numbers in Table 4.8 indicate that target flood elevations have been exceeded in certain locations. Based on the flood elevations, Alternative 3, 72m span Jane Street Bridge has been selected as the preferred alternative, however it is worth noting that basement flooding would still likely occur upstream depending on the storm return periods, thus it is recommended that the City of Toronto consider the riverine hydraulics in identifying the need for storm and combined sewer backflow prevention to prevent local basement flooding. The Jane Street Level of Service slides in Appendix N and Figure 4.12 illustrate how Alternative 3 is the best alternative in meeting the target elevations.

Table 4.8. Comparison of Maximum Water Levels Upstream of Jane Street to Target Elevations

Location	Target Elevations	Maximum Water Level Upstream of Jane Street (m)						
		5 yr	10 yr	25 yr	50 yr	100 yr	350 yr	Regional
1	101.30	101.30	*101.75*	*102.00*	*102.20*	*102.40*	*102.70*	*103.65*
2	101.50	100.65	101.05	101.30	101.5	*101.75*	*102.00*	*103.00*
3	101.30	100.75	101.30	*101.5*	*101.7*	*101.90*	*102.20*	*103.25*
4	100.45	99.70	100.25	*100.65*	*100.85*	*101.15*	*101.50*	*102.5*
5	103.30	99.70	100.25	100.65	100.85	101.15	101.50	102.50

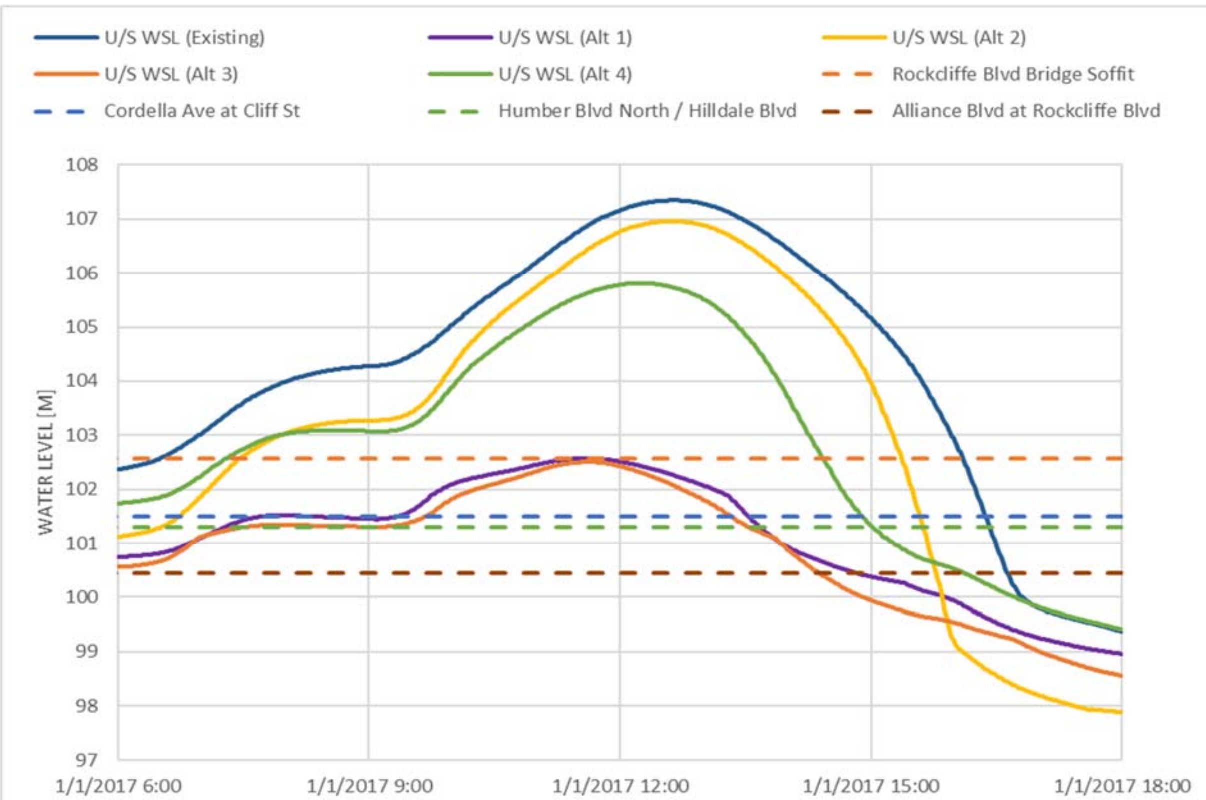

Figure 4.12. Regional Storm Flood Elevations vs. Target Elevations

5.0 Assessment of Lavender Creek Alternatives

5.1 Alternative Scenarios

The Jane Street Alternative 3 – 72 m span bridge MIKE FLOOD model has been used as the base to assess the flood mitigation scenarios for Lavender Creek. As per discussions with TRCA, and as per the project Terms of Reference, there were to be a total of six (6) separate alternative scenarios to be evaluated using the MIKE model for the Lavender Creek area, whereby the first five (5) alternative scenarios leadup to the preferred alternative Scenario No. 6, as per the following:

- ***Scenario 1*:**
  - Jane Street 72 m span upgrade;
  - Black Creek channel widening upstream of Jane Street to Rockcliffe Blvd. to Alliance Ave. as per Phase 2A (50-55m);
  - Rockcliffe Blvd. bridge upgraded to a 52 m span by 4.9 m rise structure; currently 15.2 m span by 4.6 m;
  - Channel widening upstream of Rockcliffe Blvd. to Alliance Ave. as per Phase 2A (50-55m);
  - Symes Road crossing upgrade to 15 m span by 1.97 m rise (currently 3.66 m by 0.90 m rise, 40.2 m long);
  - Eliminate upstream private crossing – as it is not being used;
  - Downstream private crossing upgraded to 15 m span by 3.87 m rise (4.8 m by 3 m now); and
  - Widen Lavender Creek channel from Symes Road to Black Creek: 15m wide concrete rectangular channel – rise would vary depending on adjacent grades. Channel slope of 0.5%.
    - ***Scenario 1A*:**
      - As per Scenario 1, but Lavender Creek channel revised from a 15 m wide concrete channel to a 30 m wide natural channel with 2:1 side slopes.
    - ***Scenario 1B*:**
      - As per Scenario 1A, but private northern crossing revised to a 20 m span.
- ***Scenario 2***:
  - As per Scenario 1 but with Symes Road crossing eliminated. Invert at Symes Road maintained. Channel slope of 0.7%
    - ***Scenario 2A*:**
      - As per Scenario 2, but channel revised from a 15 m wide concrete channel to a 30 m wide natural channel with 2:1 side slopes.
    - ***Scenario 2B*:**
      - As per Scenario 2a, but private northern crossing revised to a 20 m span.
- ***Scenario 3***:
  - As per Scenario 2 but with the 2nd southern private crossing eliminated
- ***Scenario 4*:**
  - Jane Street 72 m span upgrade;
  - Rockcliffe Road upgraded to a 52 m span by 4.9 m rise bridge; currently 15.2 m span by 4.6 m
  - Channel widening upstream of Rockcliffe Blvd to Alliance Avenue as per Phase 2A (50-55m)
  - Realign Lavender Creek downstream of Symes Road to Black Creek – through properties north and east of Rockcliffe Court

- ***Scenario 5*:**
  - As per Scenario 1, but with Humber Blvd and Alliance Ave bridges eliminated on Black Creek in the model, to avoid calculating hydraulic losses through these structures;
  - Symes Road crossing upgraded to two culverts of 5.486 m span by 1.829 m rise;
  - Lavender Creek channel revised from a 15 m wide concrete channel to a 22.5 m wide natural channel with 2:1 side slope; and
  - Flood Protection Berm along Lavender Creek removed but Flood Protection Berms around Rockcliffe School and along Black Creek Drive remain in place.
- ***Scenario 6*:**
  - One (1) of Scenarios 1-5 selected with flood protection berm/ wall in place to address residual flooding (if necessary)

The various alternatives evaluated as part of the assessment of the Lavender Creek system have been summarized in Table 5.1.

Table 5.1. Lavender Creek Alternative Scenario Summary

Alternatives	Scenarios									
	1	1A	1B	2	2A	2B	3	4	5	6
Black Creek Alternatives / Updates										
Jane St 72 m Span Upgrade	X	X	X	X	X	X	X	X	X	
Black Creek Channel Widening (Jane St to Alliance Ave as per Phase 2A)	X	X	X	X	X	X	X	X	X	
Rockcliffe Blvd 52 m Span Upgrade	X	X	X	X	X	X	X	X	X	
Remove Humber Blvd & Alliance Ave from Model (avoid hydraulic losses)									X	
Lavender Creek Alternatives / Updates										
Eliminate Upstream Private Crossing	X	X	X	X	X	X	X		X	
Downstream Private Crossing Options:										
Upgrade to 15 m span x 3.87 m rise	X	X		X	X				X	
Upgrade to 20 m span x 3.87 m rise			X			X				
Remove Crossing							X			
Symes Road Crossing Options:										
Upgrade to 15 m span x 1.97 m rise (dropping invert)	X	X	X							
Remove Crossing (invert maintained)				X	X	X	X			
Upgrade to Dual Culverts - Dropping Invert (5.486 m span x 1.829 m rise)									X	
Lavender Creek Channel Options:										
Widen to 15 m wide – rectangular concrete with 0.5% slope	X									
Widen to 15 m wide – rectangular concrete with 0.7% slope				X			X			
Widen to 30 m wide with 2:1 side slopes – naturalized with 0.5% slope		X	X							
Widen to 30 m wide with 2:1 side slopes – naturalized with 0.7% slope					X	X				
Re-align Lavender Creek Downstream of Symes Rd (North and East of Rockcliffe Court)								X		
Widen to 22.5 m wide with 2:1 side slopes – naturalized with 0.5% slope									X	
One of Scenarios 1-5 with flood protection berm/wall if necessary										X

5.2 Hydraulic Assessment of Alternatives.

5.2.1 Scenario 1

Scenario 1 as outlined in Section 4 includes the following:

- Jane Street 72 m span upgrade;
- Black Creek channel widening upstream of Jane Street to Rockcliffe Blvd. to Alliance Ave. as per Phase 2A (50-55m);
- Rockcliffe Blvd. bridge upgraded to a 52 m span by 4.9 m rise structure; currently 15.2 m span by 4.6 m;
- Black Creek channel widening upstream of Rockcliffe Blvd. to Alliance Ave. as per Phase 2A (50-55m);
- Symes Road crossing upgrade to 15 m span by 1.97 m rise (currently 3.66 m by 0.90 m rise, 40.2 m long);
- Eliminate upstream private crossing – it is not being used;
- Downstream private crossing upgraded to 15 m span by 3.87 m rise (4.8 m by 3 m now); and
- Widen Lavender Creek channel from Symes Road to Black Creek: 15m wide concrete rectangular channel – rise would vary depending on adjacent grades. Channel slope of 0.5%.

The following sections provide a summary of the hydraulic modelling results, based on the foregoing improvements being applied.

5.2.1.1 Black Creek Channel and Crossing Upgrades

Black Creek Channel Widening

The Black Creek channel was widened to a width between 50 to 55 m from the downstream side of Alliance Avenue to the upstream side of Jane Street. Similar to the channel widening evaluated for the Rockcliffe area, the widened channel maintained a 2:1 side slope and a 0.5% bottom slope and it was modelled as a natural channel with a Manning's n roughness of 0.03. Between Rockcliffe Boulevard and Jane Street, the centerline of the channel was shifted slightly south to maintain a safe distance from Alliance Avenue on the north side of the channel (ref. Figure 5.1).

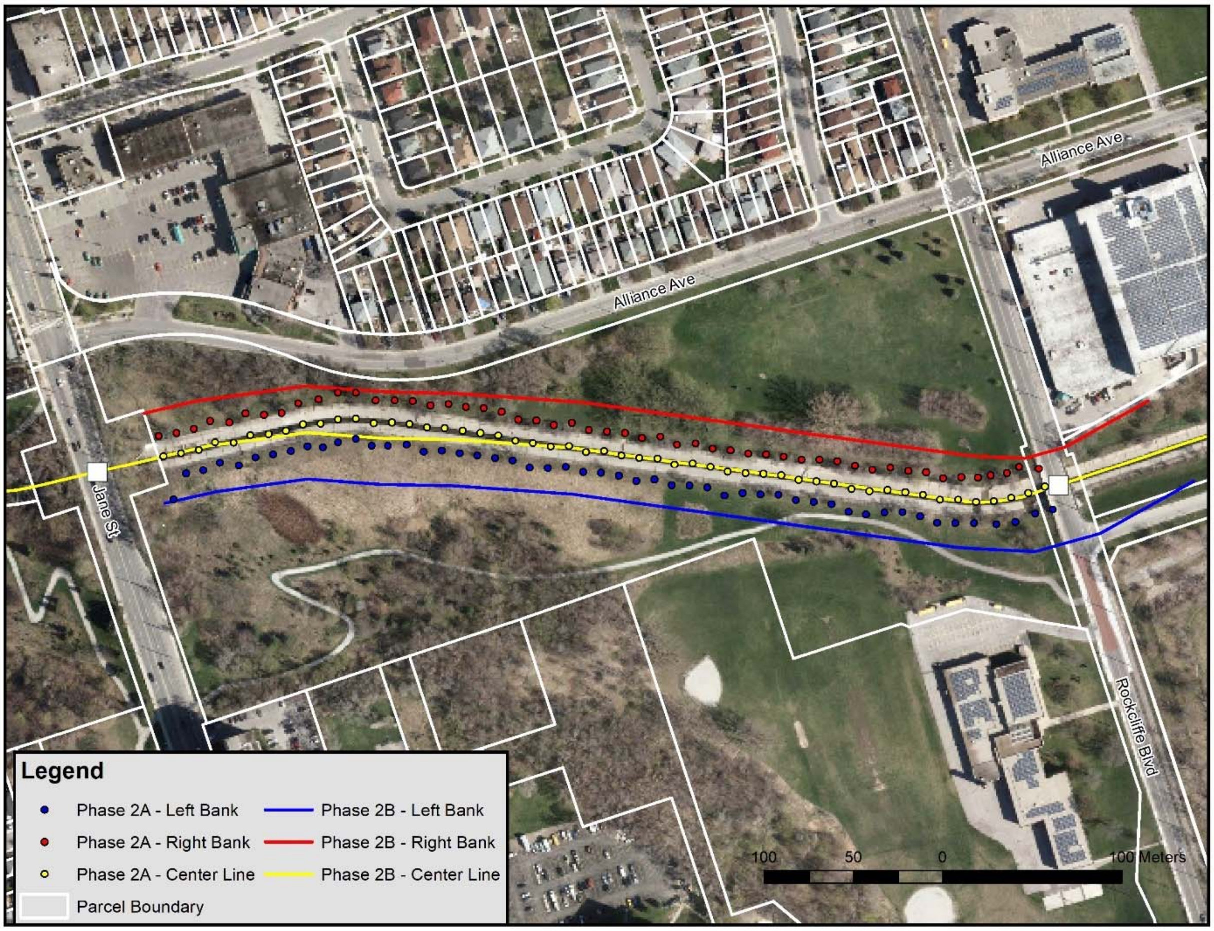

Figure 5.1. Black Creek Channel Widened from Rockcliffe Blvd to Jane St

Rockcliffe Boulevard Bridge Upgrade

Modelling results from the earlier assessment suggested the bridge at Rockcliffe Boulevard was restricting flow and creating backwater conditions and upstream flooding. In order to address this finding, the Rockcliffe Boulevard bridge crossing was upgraded to a 52 m span by 4.9 m rise with pier in the middle. The bridge structure was simulated as two rectangular culvert structures, each with a width of 26 m and a height of 4.9 m. The invert level was lowered from 98.85 m to 98.4 m and the soffit level was raised from 102.57 m to 103.30 m (ref. Figure 5.2).

The deck of the bridge was assumed to have concrete barriers approximately 1.5 m in height installed on the upstream and downstream sides of the bridge and extending 6 m on the left and right side of the bridge beyond the opening. The deck and barrier were represented in the model using a weir structure with a geometry as indicated in Figure 5.3.

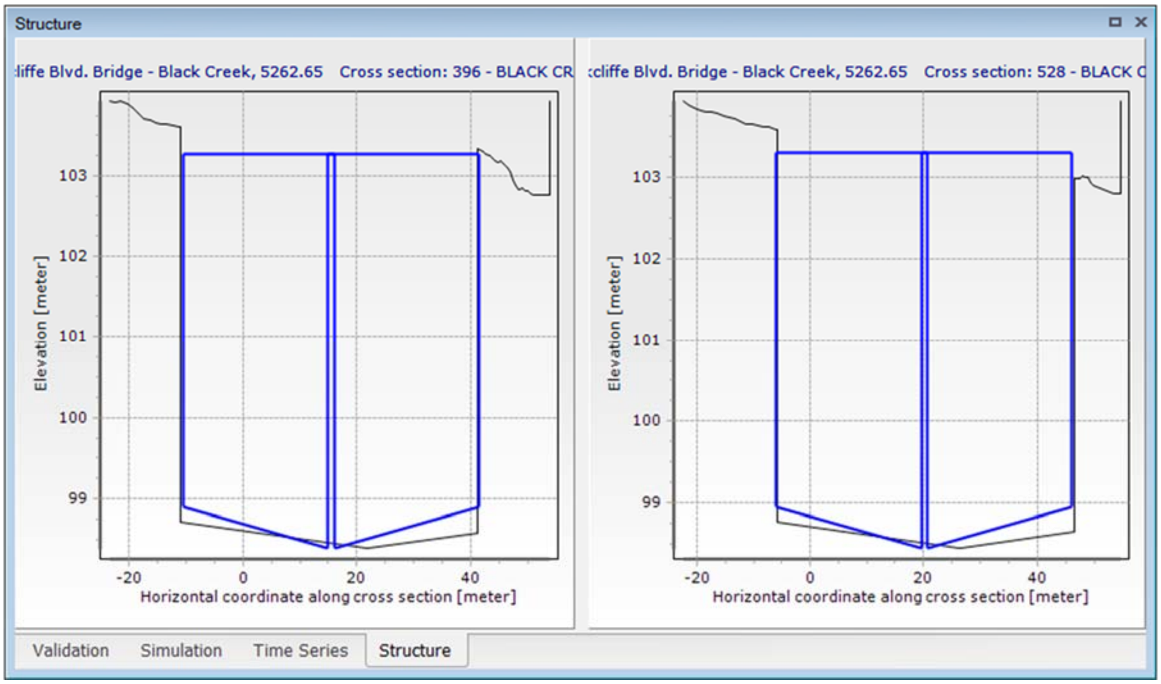

Figure 5.2. Upgraded Rockcliffe Boulevard Bridge Opening

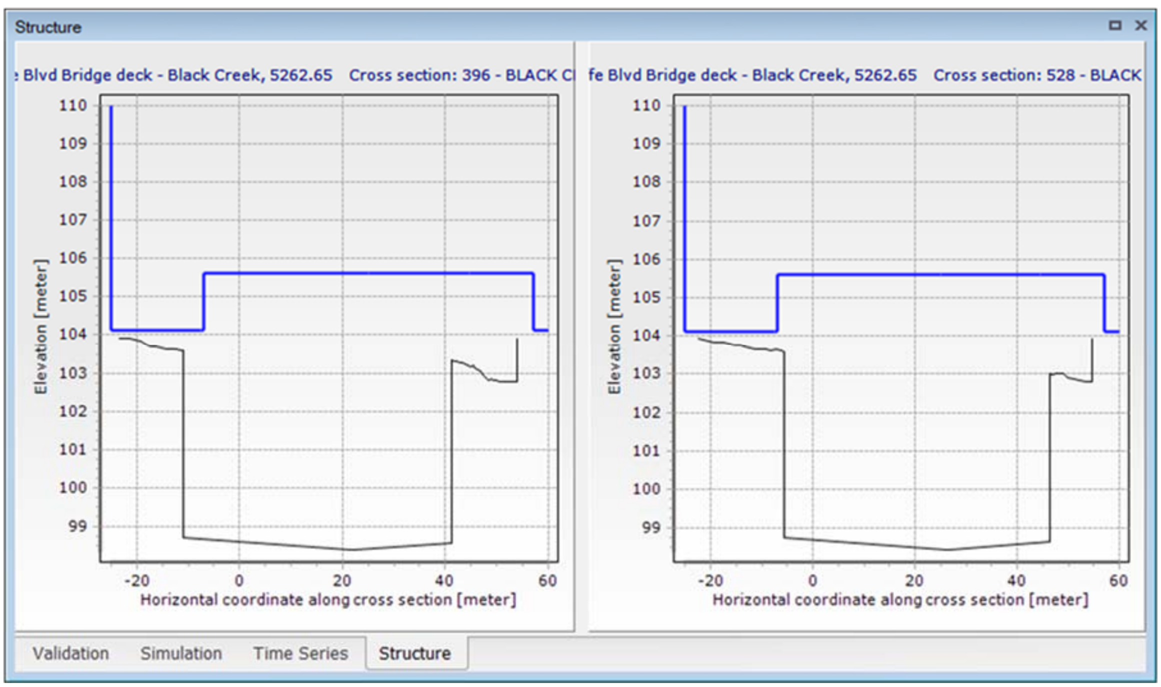

Figure 5.3. Upgraded Rockcliffe Boulevard Bridge Deck

Jane Street Bridge Upgrade

In the preferred alternative reported earlier, the Jane Street bridge opening was represented using the same geometry as the existing upstream channel geometry. However, when the channel upstream of Jane Street was widened, the geometry of the lower section of the bridge opening represented an unnecessary restriction to the flow in the widened channel. In order to mitigate this effect, the opening of the upgraded Jane Street bridge was modified to reflect the same shape as the downstream channel geometry, which is consistent with the recommendation of valley wall reshaping from the 2014 Class EA (ref. Figure 5.4). The modified opening is still not as wide as the widened channel geometry upstream of the bridge, but widening of the channel downstream of Jane Street was not an option that was considered for this study.

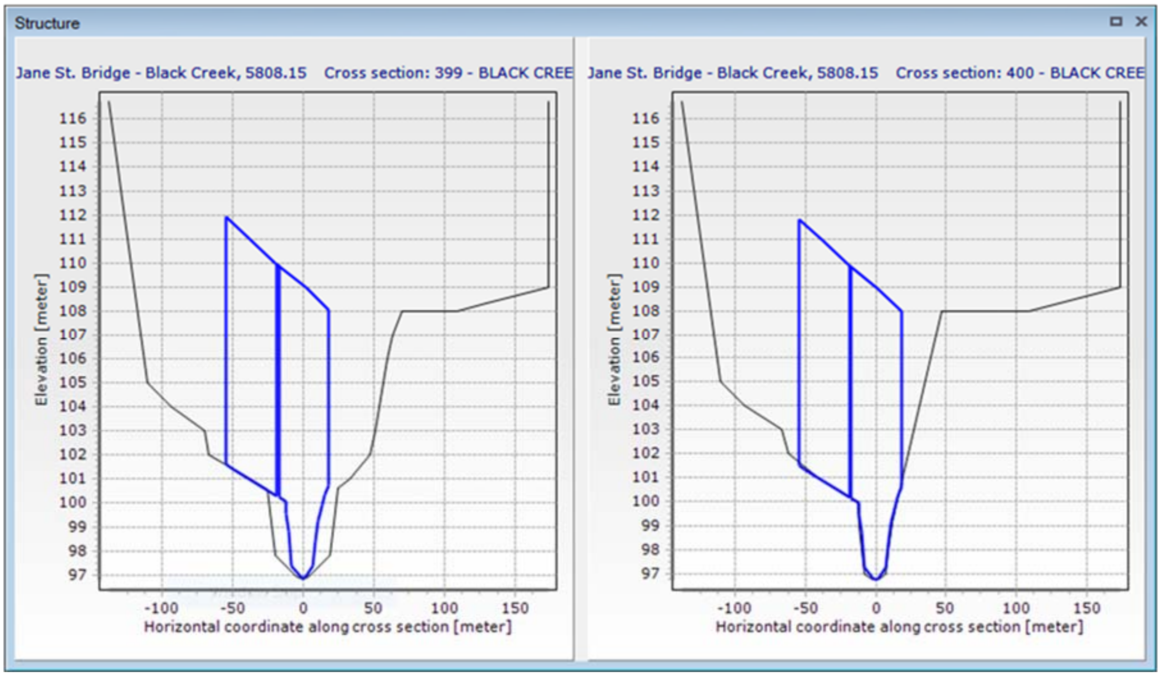

Figure 5.4. Upgraded Jane Street Bridge Opening

5.2.1.2 Lavender Creek Channel and Crossing(s) Upgrades

Lavender Creek Channel Widening

The Lavender Creek was upgraded to a 15 m wide concrete rectangular channel from the downstream side of Symes Road to the confluence with Black Creek. The channel centerline was realigned to avoid encroaching on private properties or existing roads. Figure 5.5 indicates the modelled alignment and extent of the widened Lavender Creek channel.

The Lavender Creek channel invert at the confluence was lowered from an elevation of 100.54 m to 99.8 m to be level with the invert of the Black Creek channel. Based on area topography, an average (constant) 0.5 % channel slope was applied from the confluence at Black Creek to the Symes Road crossing and the inverts for the creek cross-sections and crossings were calculated accordingly.

The cross-sections on Lavender Creek from Symes Road Crossing to the confluence with Black Creek were extended on both sides to include the widened channel and adjacent natural ground surface (ref. Figure **5.11** and Figure 5.28).

Figure 5.5. Lavender Creek Widened from Symes Road Crossing to Black Creek, 15 m Wide Concrete Channel

Symes Road Crossing Upgrade

The Symes Road Crossing culvert was upgraded from a 3.66 m span by 0.96 m rise to a 15 m span by 1.97m rise. For this scenario the obvert of the culvert needed to remain unchanged to accommodate the overlying sewers that it was supporting. As such, the potential rise of the culvert was determined by calculating the invert according to a designed channel slope of 0.5 % and the distance from the crossing to the confluence. Figure 5.6 indicates the geometry of the culvert structure. The cross-sections upstream from the crossing were widened to fit the culvert and provide a smooth transition from the existing channel invert to the lowered channel invert.

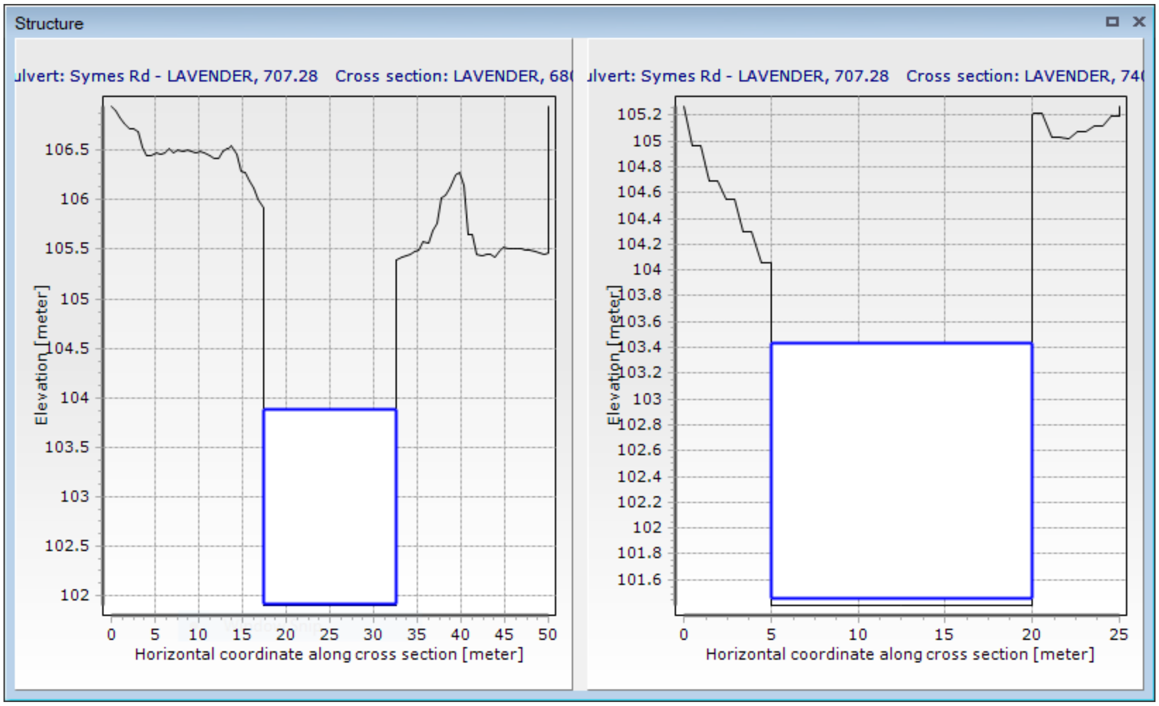

Figure 5.6. Upgraded Symes Road Crossing

Private Crossing Upgrade

The downstream private crossing was widened to 15 m span and 3.9 m rise and the obvert elevation was unchanged (ref. Figure 5.7). The invert level of the crossing was calculated according to channel slope and distance to the confluence with Black Creek.

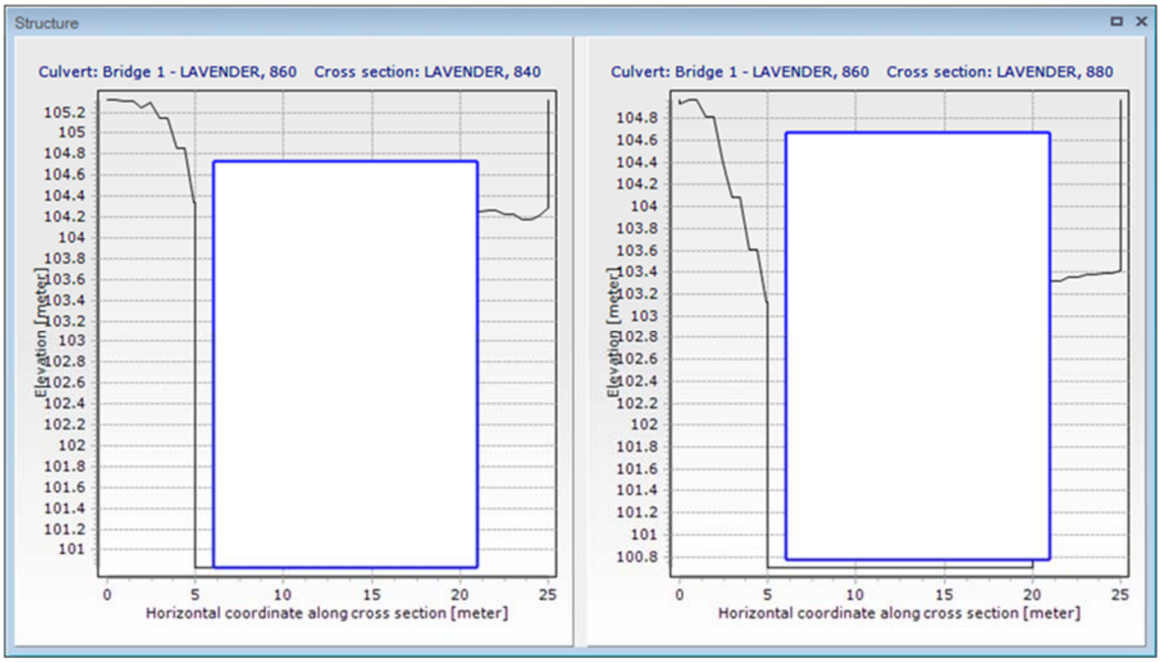

Figure 5.7. Upgraded Downstream Private Crossing

Hydraulic Modelling Results

Scenario 1 was run for the Regional Storm and 350 Year storm events and the results are discussed in reference to the flooding that occurs adjacent to Lavender Creek. The results of the modelling are presented in Figure 5.8 and Figure 5.9 as maximum water level profiles along Lavender Creek. The results for the Regional Storm event show that the proposed improvements to Lavender Creek completely eliminate the flooding upstream of the Downstream Private Crossing and the flow is mostly contained within the Lavender Creek except at chainage 920 m where the right bank is flooded, and at the confluence with Black Creek where it floods both sides of the creek. The flooding that occurs at chainage 920 m appears to be caused by backwater conditions from high tailwater levels in Black Creek.

The results for the 350 Year storm event show that flow is entirely contained in the channel except at the confluence with Black Creek where it also appears to be caused by high tailwater levels in Black Creek.

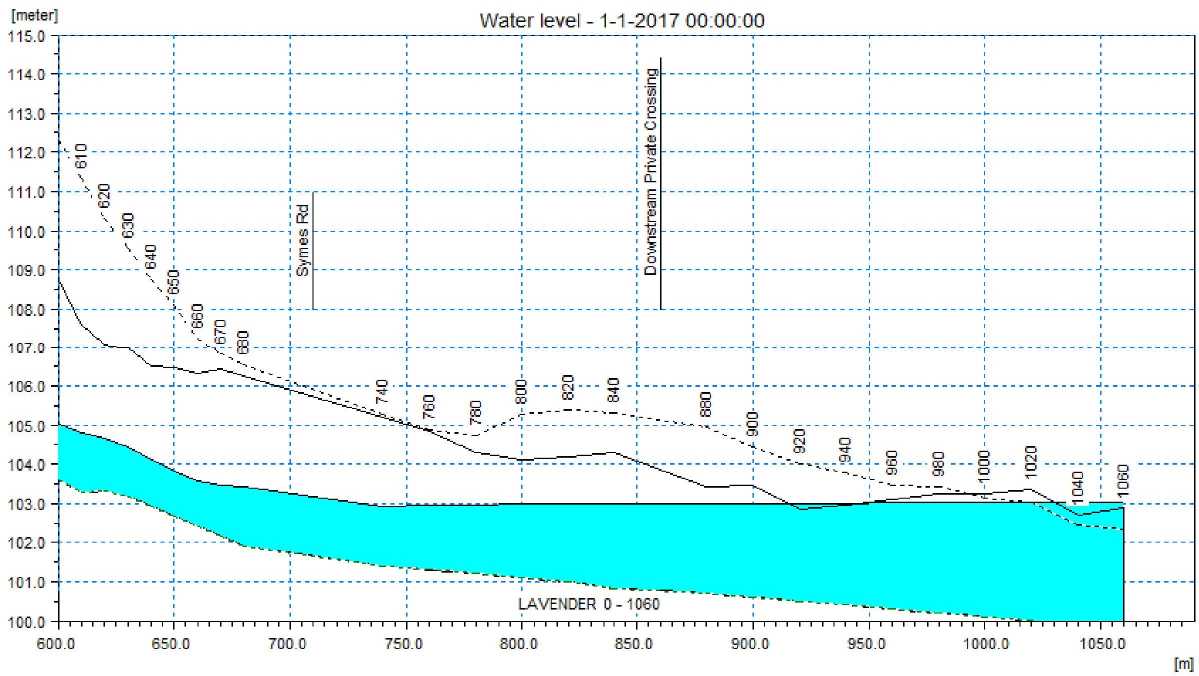

Figure 5.8. Max Profile on Lavender Creek from Chainage 600 m to Confluence with Black Creek, Regional Storm Event

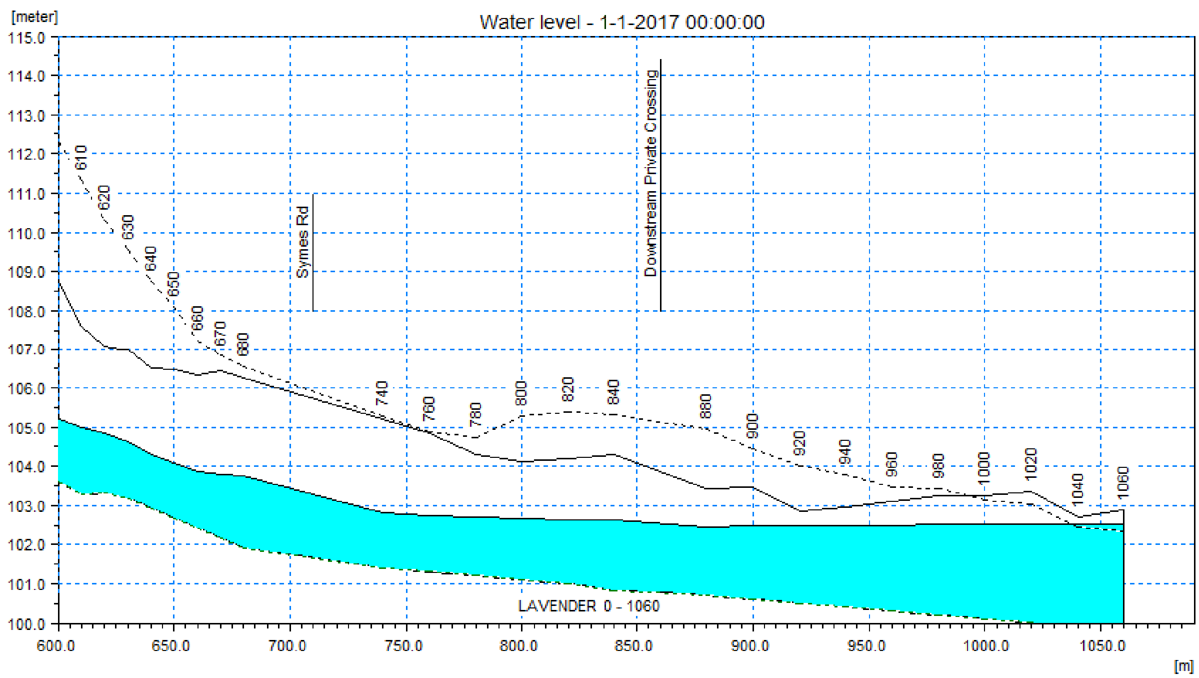

Figure 5.9. Max Profile on Lavender Creek from Chainage 600 m to Confluence with Black Creek, 350-Year Event

5.2.2 Scenario 1A

Scenario 1A is as per Scenario 1, but the Lavender Creek channel has been revised from a 15 m wide concrete channel to a 30 m wide natural channel with 2:1 side slopes. The following section provides a summary of the hydraulic modelling results, for Scenario 1A.

5.2.2.1 Lavender Creek Channel and Crossing(s) Upgrades

The widened channel was realigned to maintain a minimum distance to private properties on the right bank, and to minimize encroachment to Symes Road and to the industrial area on the left bank (ref. Figure 5.10). The realignment extended the channel length by 10 m and the locations and distances between cross sections were slightly changed. The bottom of the channel maintained a 0.5 % slope from the Symes Road Crossing to the confluence with Black Creek and the sides of the channel rises at 2:1 slope and connect to the existing ground surface (ref. Figure 5.11). The Manning's n roughness value for the channel was set to 0.03. The widths of the structures remain the same as in Scenario 1 but the invert levels were slightly modified to account for the additional length of the channel caused by the re-alignment.

Figure 5.10. Lavender Creek Widened from Symes Road Crossing to Black Creek, 30 m Wide Natural Channel

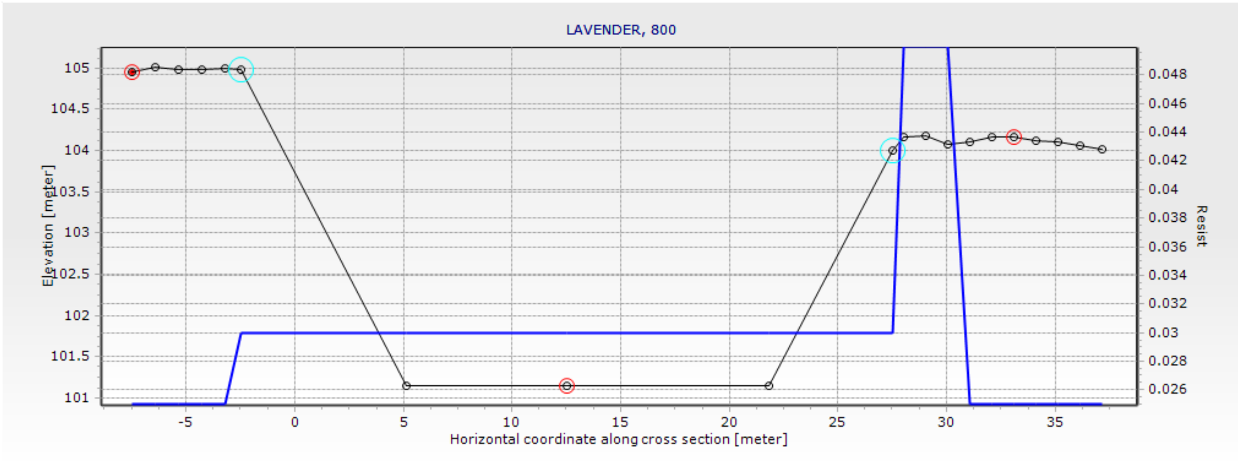

Figure 5.11. Natural Channel Cross Section (30 m Wide) and Roughness Values at Chainage 800 on Lavender Creek.

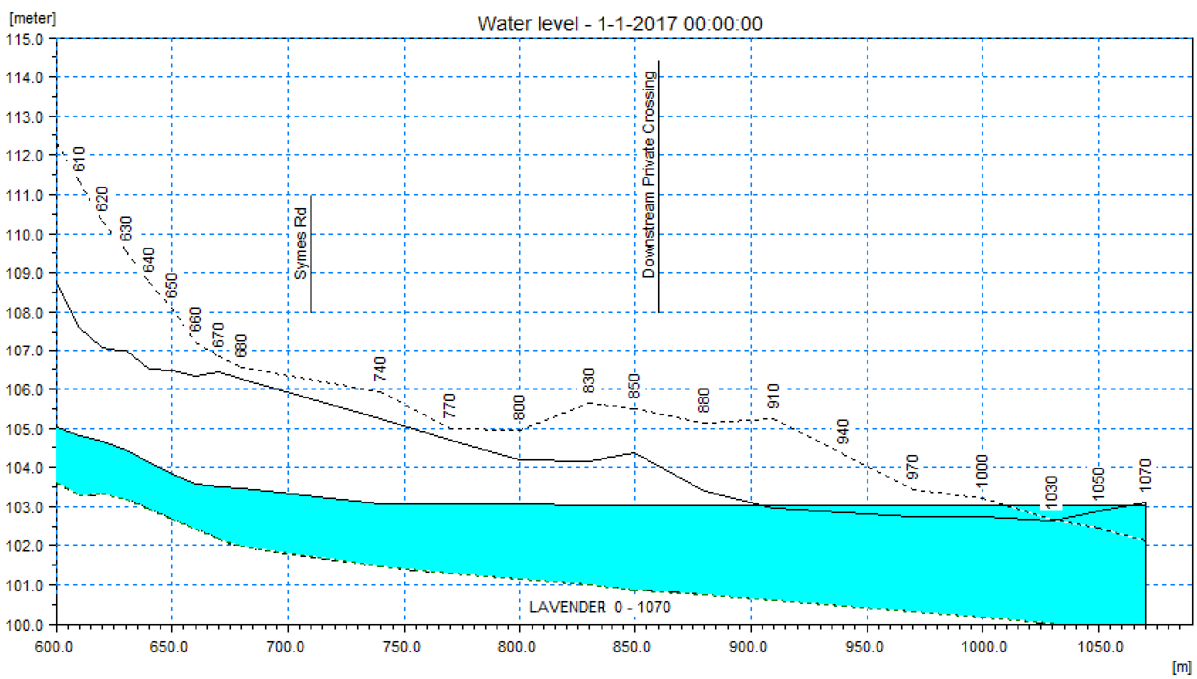

Figure 5.12. Scenario 1A – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

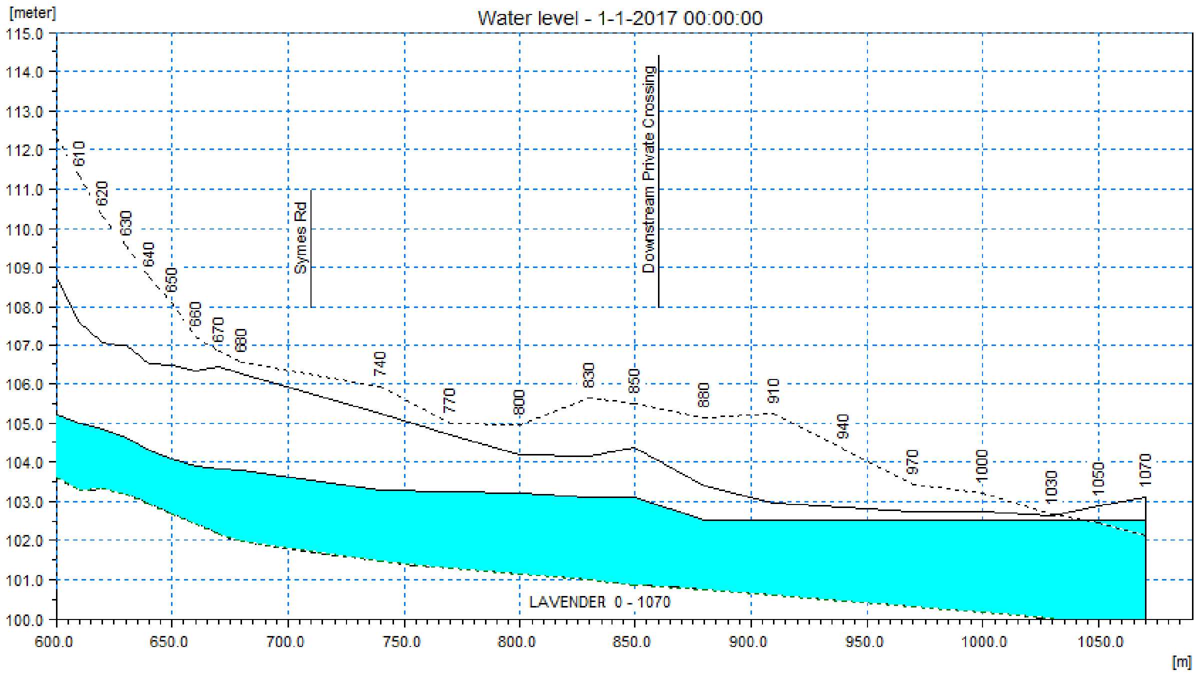

Figure 5.13. Scenario 1A – 350 Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

5.2.3 Scenario 1B

Scenario 1B is as per Scenario 1A, but the private northern crossing has been revised from a 15 m span crossing to a 20 m span crossing. The following section provides a summary of the hydraulic modelling results, for Scenario 1B.

5.2.3.1 Lavender Creek Channel and Crossing(s) Upgrades

In the hydraulic model, the geometry of the Downstream Private Crossing was expanded from a 15 m span to a 20 m span to determine if it would reduce the head loss across the structure. The upstream and downstream cross sections were also widened as necessary to avoid blocking the culvert.

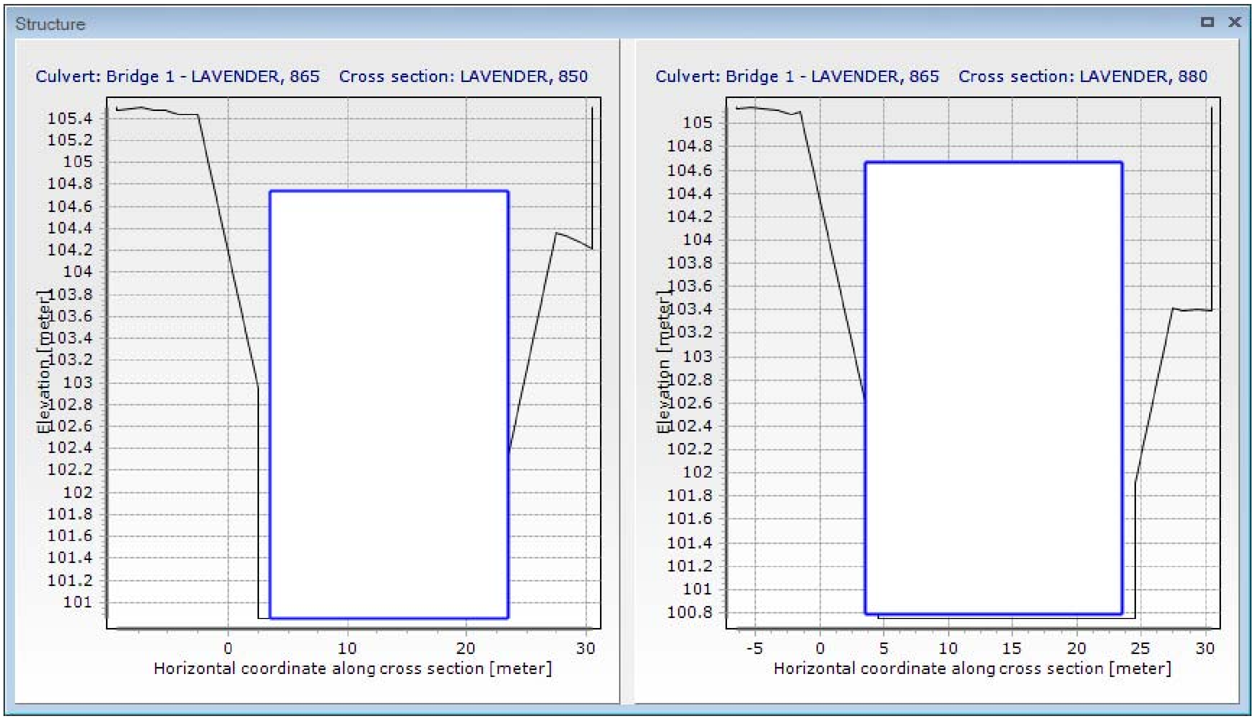

Figure 5.14. Updated Downstream Private Crossing

Hydraulic Modelling Results

Scenario 1B was run for the Regional Storm and 350 Year storm events and the results are discussed in reference to the flooding that occurs adjacent to Lavender Creek. The results of the modelling are presented in Figure 5.15 and Figure 5.16 as maximum water level profiles along Lavender Creek. The results for the Regional Storm event indicate that the proposed widening of the Downstream Private Crossing would have no impact on the flooding compared to Scenario 1A because the backwater condition from Black Creek extends upstream of the crossing.

The results for the 350 Year storm event show that the widening of the Downstream Private Crossing eliminates the head loss across the structure that was observed in Scenario 1A.

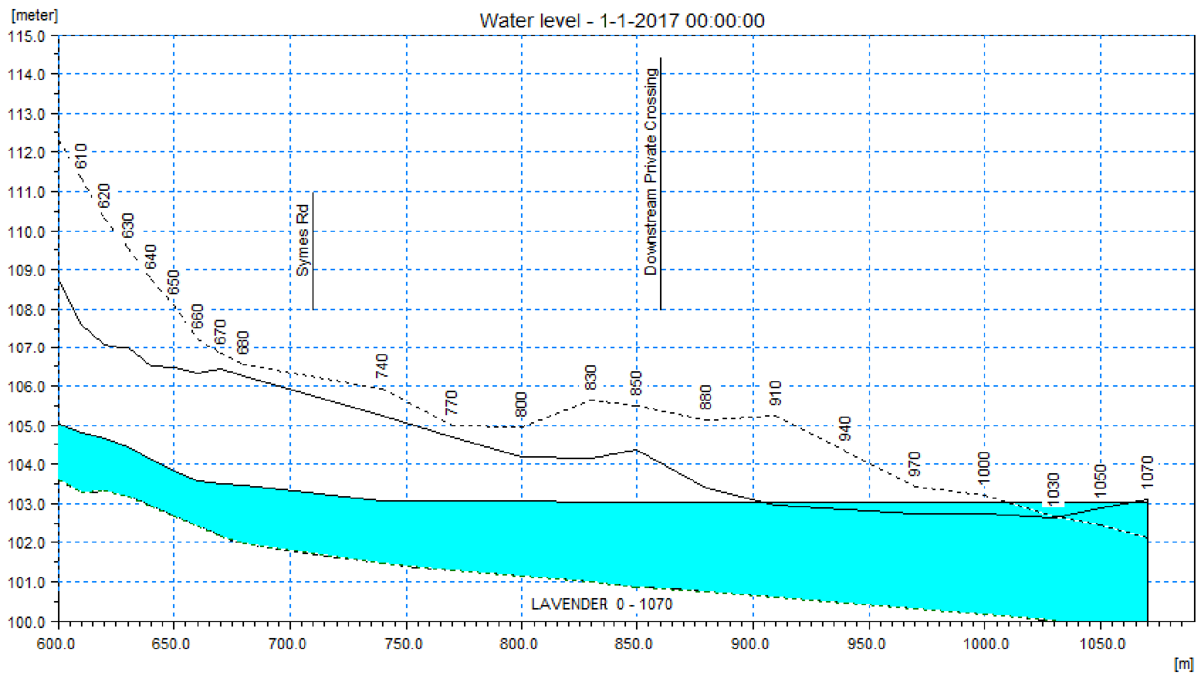

Figure 5.15. Scenario 1B – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

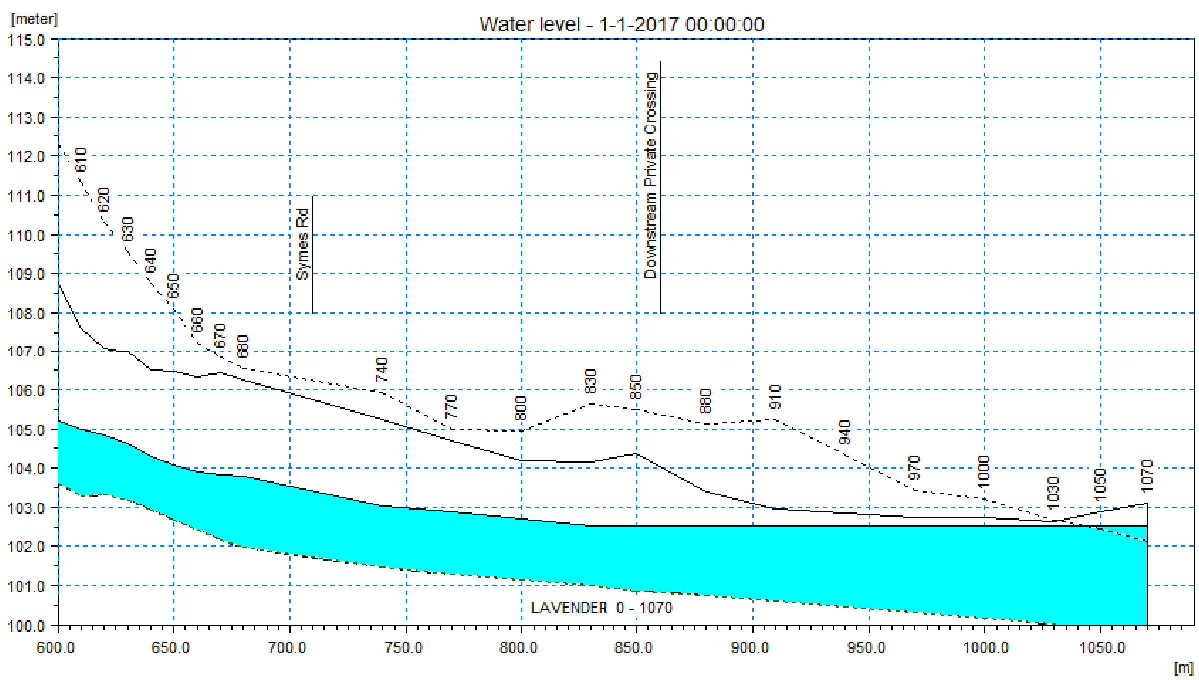

Figure 5.16. Scenario 1B – 35o Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

5.2.4 Scenario 2

Scenario 2 is the same as per Scenario 1, but the Symes Road crossing has been eliminated, as such the creek invert at Symes Road has been maintained due to lowering of a combined sewer below the channel, resulting in a channel slope of 0.7%. The following section provides a summary of the hydraulic modelling results, for Scenario 1B.

5.2.4.1 Lavender Creek Channel and Crossing(s) Upgrades

The culvert representing the Symes Road Crossing was replaced with two 15 m wide rectangular channel cross-sections in the hydraulic model. The invert of the two new cross sections (chainage 720 m and 700 m) were interpolated based on the two cross sections (chainage 680 m and 740 m) upstream and downstream of the Symes Road Crossing in the existing model. The channel was then assumed to have a constant slope from chainage 720 m to the confluence with Black Creek. Based on the length of the channel and the inverts at chainage 720 m and at the confluence with Black Creek, the channel slope was calculated as 0.71 % and the inverts of intermediate cross sections and structures were updated accordingly.

Since Lavender Creek bends 90° at Symes Road, there will naturally be some additional head loss due to the sudden change in direction of flow. In order to represent the expected head loss, the Manning's 'n' roughness values at the two new cross sections were increased from 0. 013 to 0.04. This roughness value was selected by comparing the increase of upstream water level with the velocity head calculated at the time of peak flow. This was considered to be a conservative estimate of the head loss at this location.

Hydraulic Modelling Results

Scenario 2 was run for the Regional Storm and 350 Year storm events and the results are discussed in reference to the flooding that occurs adjacent to Lavender Creek. The results of the modelling are presented in Figure 5.17 and Figure 5.18 as maximum water level profiles along Lavender Creek. The results for the Regional Storm event show that the proposed improvements to Lavender Creek completely eliminate the flooding upstream of the Downstream Private Crossing and the flow is mostly contained within the Lavender Creek except at chainage 920 m where the right bank is flooded, and at the confluence with Black Creek where it floods both sides of the creek. The flooding that does occur at chainage 920 m appears to be caused by backwater conditions from high water levels in Black Creek.

The results for the 350 Year storm event show that flow is entirely contained in the channel except at the confluence with Black Creek and it also appears to be caused by backwater conditions in Black Creek.

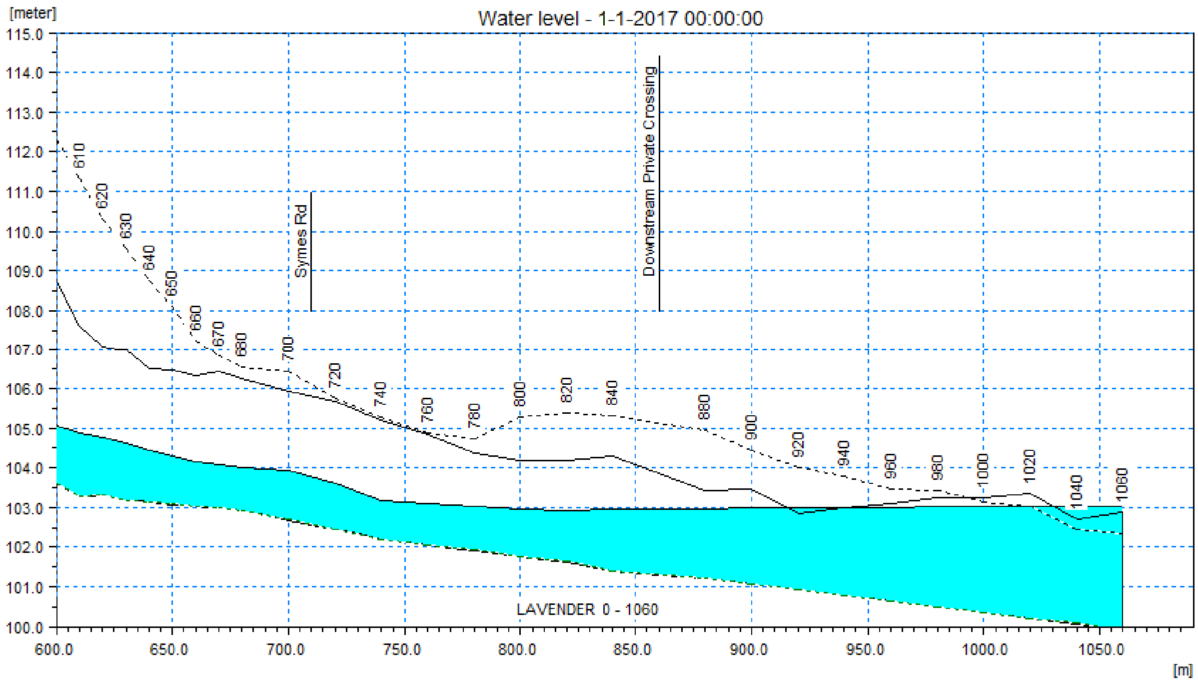

Figure 5.17. Scenario 2 – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

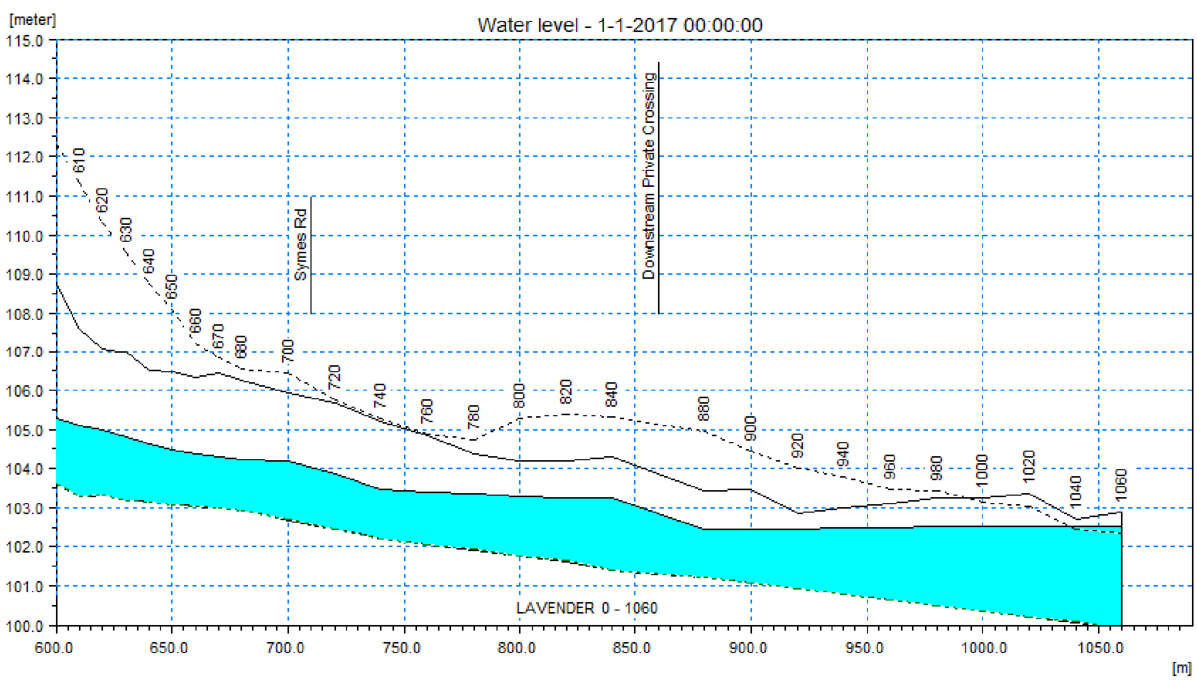

Figure 5.18. Scenario 2 – 350 Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

5.2.5 Scenario 2A

Scenario 2A is the same as Scenario 2 except the Lavender Creek channel has been revised from a 15 m wide rectangular concrete channel to a 30 m wide natural channel with 2:1 side slopes. The following section provides a summary of the hydraulic model setup and results for Scenario 2A.

5.2.5.1 Lavender Creek Channel and Crossing(s) Upgrades

The hydraulic model for Scenario 2A was modified in a similar manner as Scenario 1A except the Symes Road Crossing was removed and replaced with a 30 m wide open channel with 2:1 side slopes. A single cross-section was added to represent the bend in the channel at Symes Road. As with Scenario 2, the Manning's n roughness value for the cross-section at the bend was increased from 0.03 (natural channel) to 0.08 to account for the head loss due to the sudden change in direction of flow. The invert for the new cross-section was set equal to the downstream invert of the existing Symes Road culvert as required to re-route the sewer under the channel at this location.

Hydraulic Modelling Results

Scenario 2A was run for the Regional Storm and 350 Year storm events and the results are discussed in reference to the flooding that occurs adjacent to Lavender Creek. The results of the modelling are presented in Figure 5.19. and Figure 5.20. as maximum water level profiles along Lavender Creek. The results for the Regional Storm event show that the proposed improvements to Lavender Creek completely eliminate the flooding upstream of the Downstream Private Crossing and but there is overbank flooding downstream of chainage 900 m. This flooding appears to be caused by elevated water levels in Black Creek. It should also be noted that the channel widening has pushed the bank into an area where the existing ground level is lower, so the bank elevation is slightly lower.

The results for the 350 Year storm event show that flow is entirely contained in the channel except at the confluence with Black Creek and it also appears to be caused by backwater conditions in Black Creek.

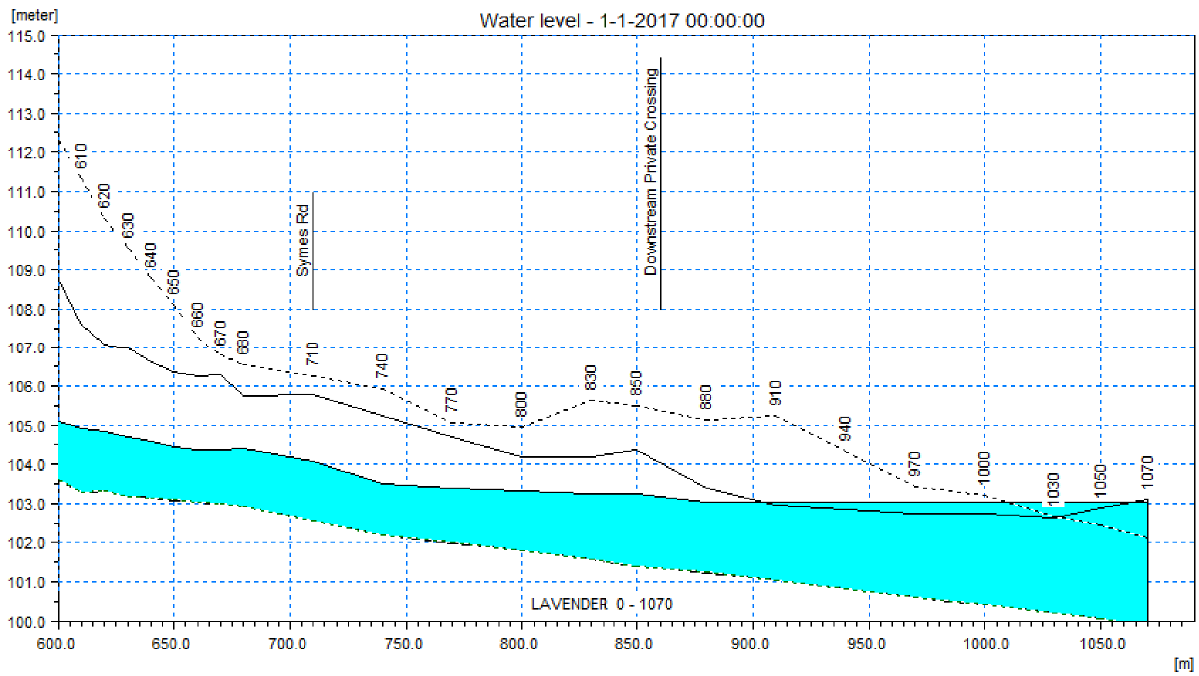

Figure 5.19. Scenario 2A – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

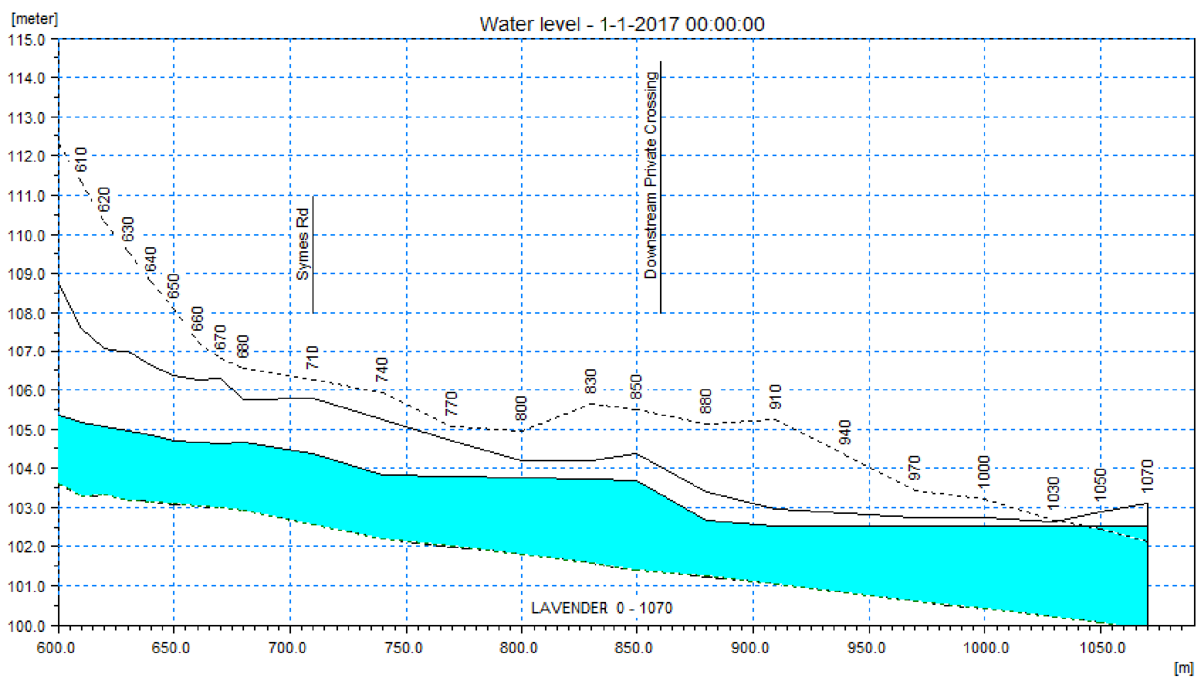

Figure 5.20. Scenario 2A – 350 Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

5.2.6 Scenario 2B

Scenario 2B is as per Scenario 2A, but the northern private crossing span has been upgraded to a 20 m wide span. The following section provides a summary of the hydraulic modelling results, for Scenario 2B.

5.2.6.1 Lavender Creek Channel and Crossing(s) Upgrades

In the hydraulic model, the geometry of the Downstream Private Crossing was expanded from a 15 m span to a 20 m span to see if it would reduce the head loss across the structure. The cross-sections immediately upstream and downstream of the crossing were also widened as necessary to avoid blocking the culvert.

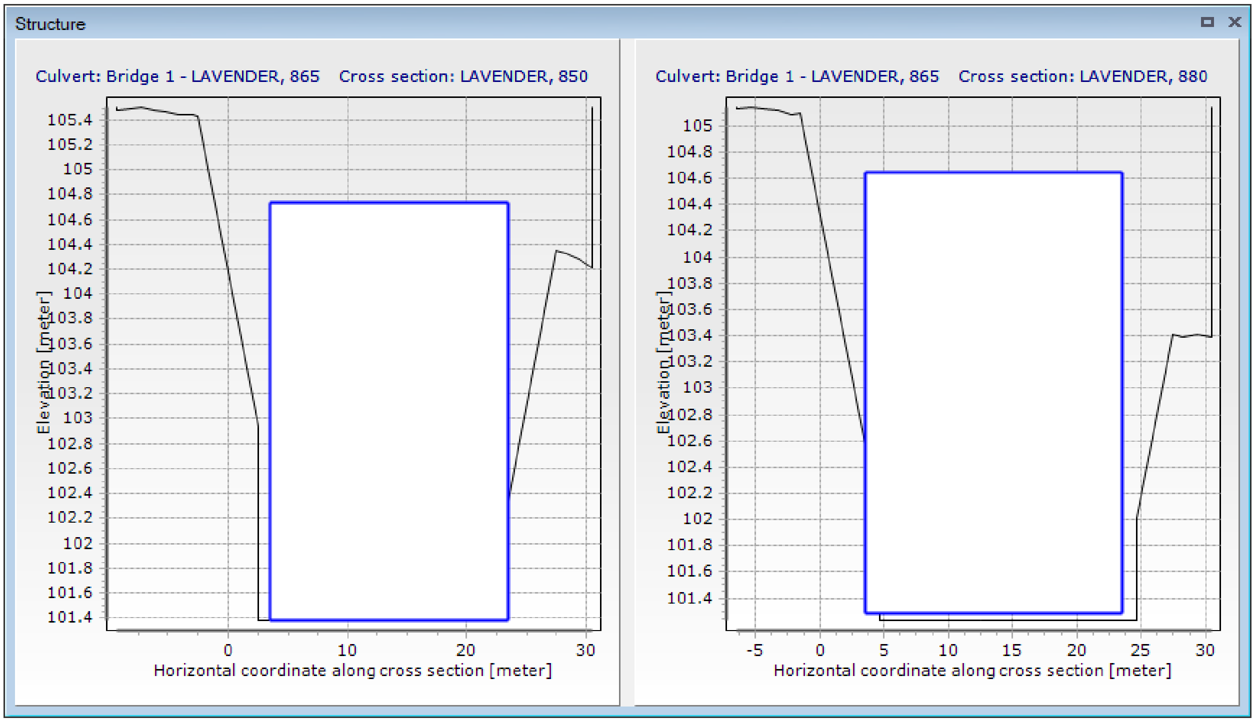

Figure 5.21. Updated Downstream Private Crossing

Hydraulic Modelling Results

Scenario 2B was run for the Regional Storm and 350 Year storm events and the results are discussed in reference to the flooding that occurs adjacent to Lavender Creek. The results of the modelling are presented in Figure 5.22. and Figure 5.23. as maximum water level profiles along Lavender Creek. The results for the Regional Storm event show that the proposed widening of the Downstream Private Crossing would have no impact on the flooding compared to Scenario 2A because the backwater condition from Black Creek extends upstream of the crossing.

The results for the 350 Year storm event show that the widening of the Downstream Private Crossing eliminates the majority of the head loss across the structure that was observed in Scenario 2A.

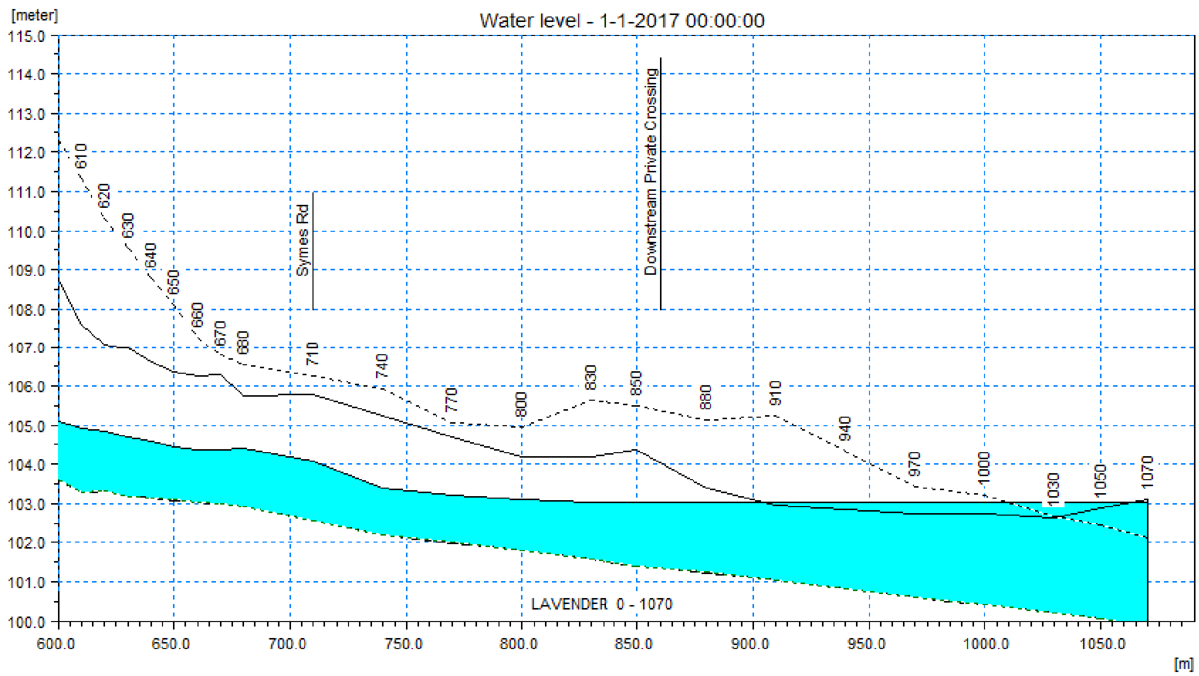

Figure 5.22. Scenario 2B – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

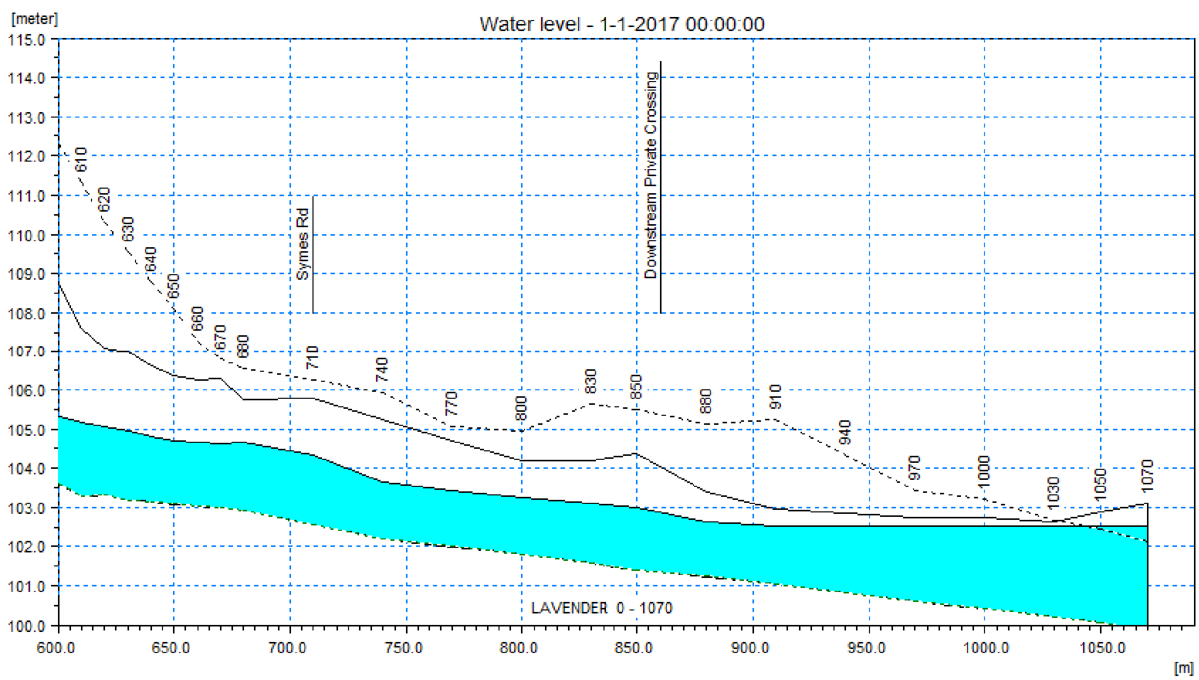

Figure 5.23. Scenario 2B – 350 Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to the Confluence with Black Creek

5.2.7 Analysis of Scenarios 1, 1A, 1B, 2, 2A and 2B Hydraulic Modelling Results

Prior to conducting hydraulic analyses of Alternative Scenarios 3-6, it was decided that a review of the combined effectiveness of Scenarios 1 and 2 and the Sub-Scenarios 1A, 1B, 2A and 2B be conducted, as the initial modelling results indicated that floodwaters were largely remaining within Lavender Creek and predominantly not overtopping the channel banks. A discussion was held with TRCA to review hydraulic results for both Scenarios 1 and 2 and to determine if supplemental analysis of Scenarios 3, 4 and 6 was warranted. The following summarizes the hydraulic results for Scenarios 1 and 2 and the Sub-Scenarios.

Figure 5.24. and Figure 5.25. present a comparison of the maximum water level profiles for all of the scenarios for the Regional Storm event and the 350 Year storm event, respectively. These results indicate that Scenario 1, 1A and 1B alternatives produce significantly lower maximum water levels at Symes Road than Scenario 2, 2A and 2B. In Scenario 1, 1A and 1B the invert of the Symes Road crossing culvert is lowered by more than 1 m and, hence, the bottom of the channel is also lowered, while, in Scenario 2, the invert of the channel remains unchanged from the existing condition. The effectiveness of all scenarios is very similar downstream of the Downstream Private Crossing because the water levels in the channel are controlled by backwater conditions from Black Creek. Although the scenarios using a 15 wide rectangular concrete channel produced lower maximum water levels than the 30 m wide natural channel, both options were effective in mitigating flooding upstream of the Downstream Private Crossing. In the scenarios with a 30 m wide natural channel, a 20 m wide culvert at the Downstream Private Crossing significantly reduced head loss through the structure compared to a 15 m wide culvert.

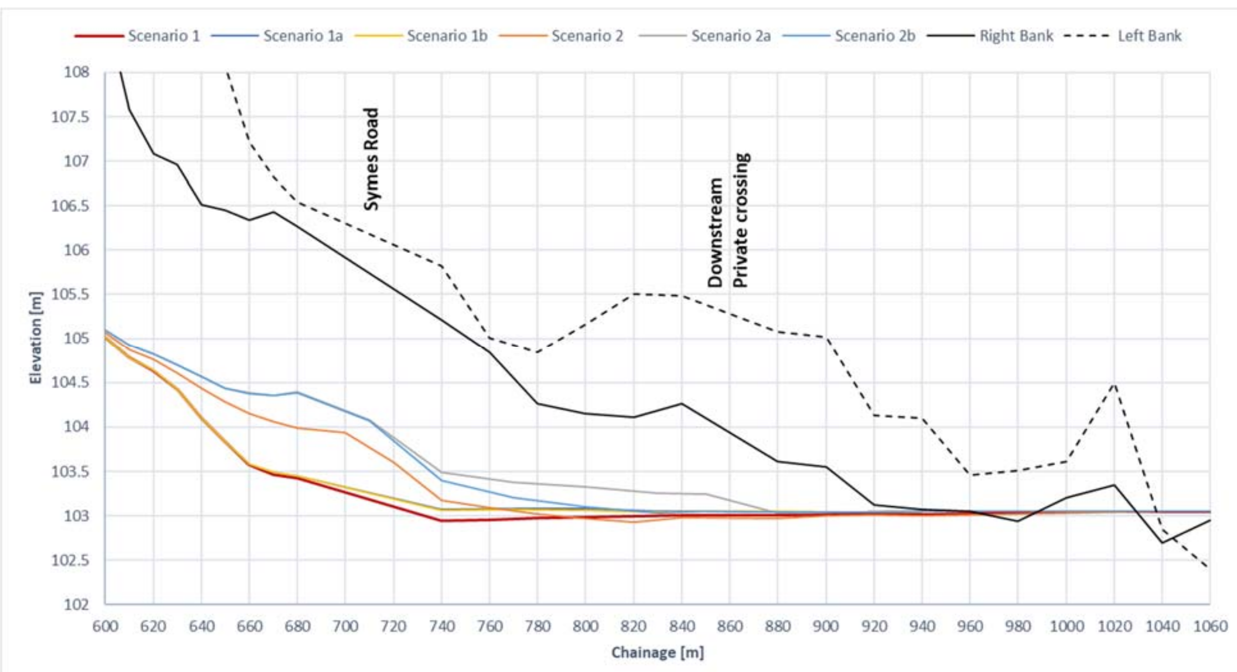

Figure 5.24. Comparison of Scenarios – Regional Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to Confluence with Black Creek

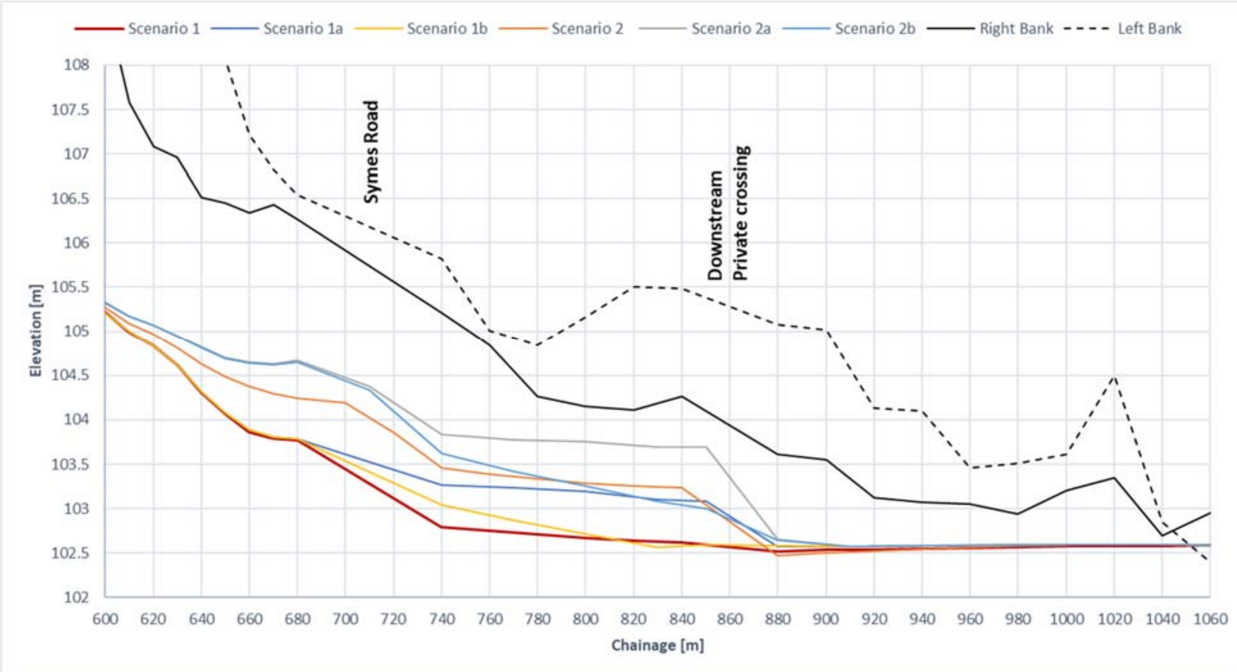

Figure 5.25. Comparison of Scenarios –350 Year Design Storm Event: Maximum Water Level Profile on Lavender Creek from Chainage 600 m to Confluence with Black Creek

5.2.8 Screening of Scenarios 3, 4 and 6

Through discussion with TRCA, Scenarios 3, 4 and 6 were screened out from further consideration, based on the positive hydraulic results from Scenarios 1 and 2. Alternative Scenarios 3, 4 and 6 consist of the following:

Scenario 3:

- As per Scenario 2 but with the 2nd downstream private crossing eliminated/removed

Scenario 3 was screened from further consideration as is it was determined through assessment of Scenario 2 that the downstream private crossing could be maintained and the Lavender Creek could convey the Regional Storm within the defined channel. The crossing is used by the land owner west of the creek block.

***Scenario 4*:**

- Jane Street 72 m span upgrade;
- Rockcliffe Road upgraded to a 52 m span by 4.9 m rise bridge; currently 15.2 m span by 4.6 m
- Channel widening upstream of Rockcliffe Blvd to Alliance Avenue as per Phase 2A (50-55m)
- Realign Lavender Creek downstream of Symes Road to Black Creek – through properties north and east of Rockcliffe Court

Realigning Lavender Creek away from the Hilldale neighbourhood has been determined not to be necessary based on the level of service that would be provided by Lavender Creek for Scenario 2. In addition, significant alterations to existing municipal infrastructure would be required to support this scenario. Furthermore, the existing 2,286 mm by 2,591 mm combined sewer would be required to be lowered by 6m +/- over its 640 m length.

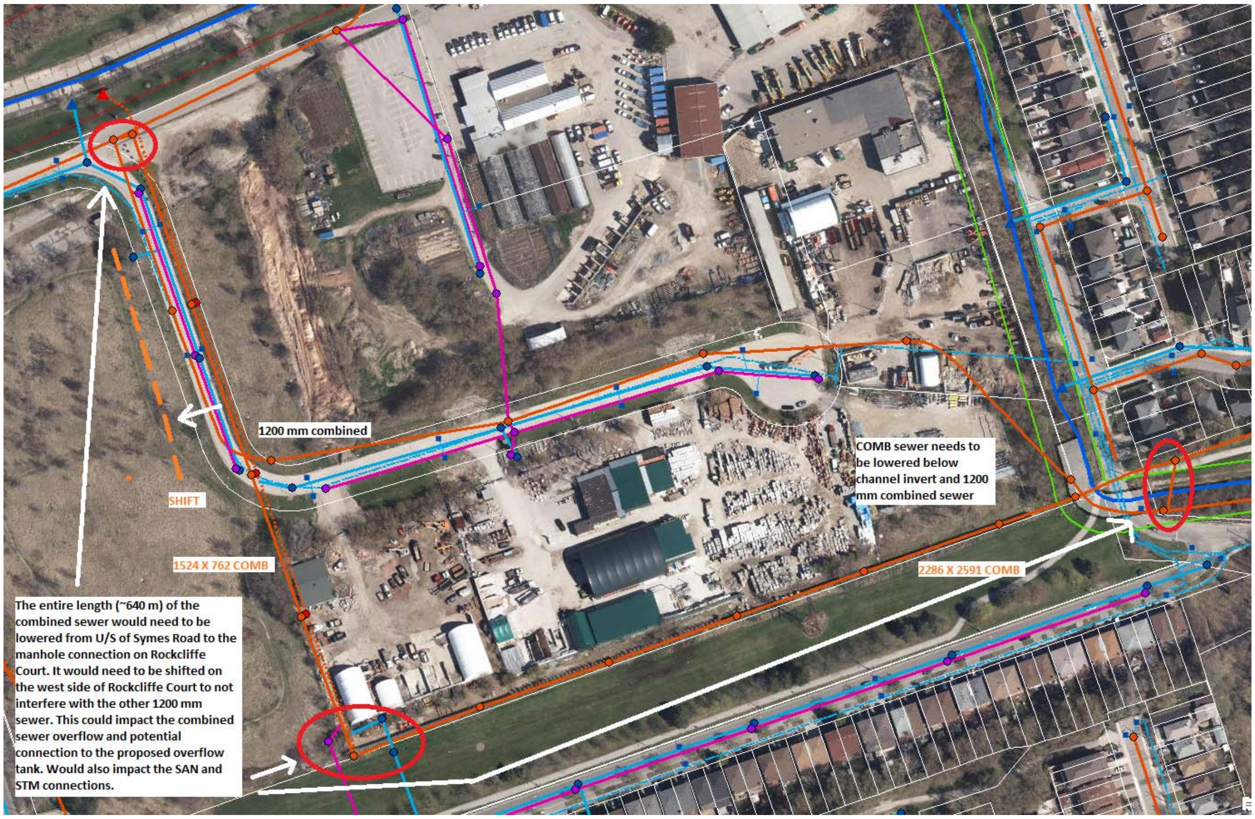

Figure 5.26. Scenario 4 – Lavender Creek Realignment and Municipal Infrastructure Adjustments

***Scenario 6*:**

- One (1) of Scenarios 1-5 selected with flood protection berm/ wall in place (if necessary)

Scenario 6 has been screened from further consideration as it has been determined that Scenario 5 would convey the Regional Storm within the channel based on the results from Scenarios 1 and 2, as such, combinations of alternative scenarios has not been further assessed. After discussion with TRCA resulting in the screening of Scenarios 3, 4 and 6, Scenario 5 was assessed.

5.2.9 Scenario 5

Scenario 5 was essentially the same as Scenario 1A except the Lavender Creek channel width was reduced from 30 m to 22.5 m and the crossing at Symes Road was changed to twin, side-by-side box culverts with a 5.486 m span and 1.829 m rise with 0.3 m wall thickness. The following section provides a summary of the hydraulic model setup and results for Scenario 5.

5.2.9.1 Black Creek Channel and Crossing Upgrades

All of the proposed changes made to the Black Creek channel and structures in Scenario 1 were maintained for Scenario 5. However, the model structures (weir and culvert) representing the Humber Boulevard and Alliance Avenue bridges were removed because the channel does not change dimensions under these bridges and the maximum water level during the Regional Storm event does not exceed the soffit elevation for each bridge when the bridges are removed. It was decided to remove these structures from the model because the model will still calculate some head loss through the structures even though the channel dimension does not change. The artificial head loss anomalously calculated by the model caused higher water levels upstream of the structures and eventually caused the soffit to become submerged.

It should be noted that any future use of the model should always evaluate the maximum water level at these structures to ensure it does not exceed the soffit elevation. If the water level in the channel exceeds the soffit elevation, then the hydraulic structures should be put back into the model to ensure the hydraulic effects of the bridge deck are represented.

5.2.9.2 Lavender Creek Channel and Crossing(s) Upgrades

Scenario 5 used the same model setup as Scenario 1B except the maximum channel width was reduced from 30 m to 22.5 m and the Symes Road Crossing was updated to reflect two, side-by-side culverts with a 5.486 m span, a 1.829 m rise, and a wall thickness of 0.3 m. Figure 5.27. indicates the alignment of the channel, the extent of channel banks, and the channel cross-sections. The channel realignment maintains a safe distance to the private properties on the right bank, keeps Symes Road on the right bank intact, and avoids encroaching into the parking lot of the industrial building on the left bank. Like the Scenario 1A model, the channel slope is set to 0.5 % from the Symes Road Crossing to the confluence with Black Creek. The inverts of the intermediate cross-sections and structures are updated accordingly. Figure 5.28. shows the 22.5 m wide natural channel at chainage 800 m. The Manning's n roughness value of the natural channel was set to 0.03 for the entire length of the channel.

For the Symes Road Crossing, it was important to maintain the elevation of the top of the culvert in order to maintain the slope of the combined sewer that is crossing over top of the culvert. With the level of the obvert unchanged from the existing model, the outlet invert was calculated to be 101.3 m and the inlet invert was calculated to be 101.75 m. The head loss coefficients for inflow and outflow were kept at default values of 0.5 and 1, respectively. Figure 5.29. presents the geometry of the upgraded Symes Road Crossing.

The 2D model mesh along Black Creek and Lavender Creek was adjusted to ensure a continuous connection between the 1D channel and 2D overland flow models and the MIKE FLOOD Lateral Links connecting the 1D and 2D models were updated as well.

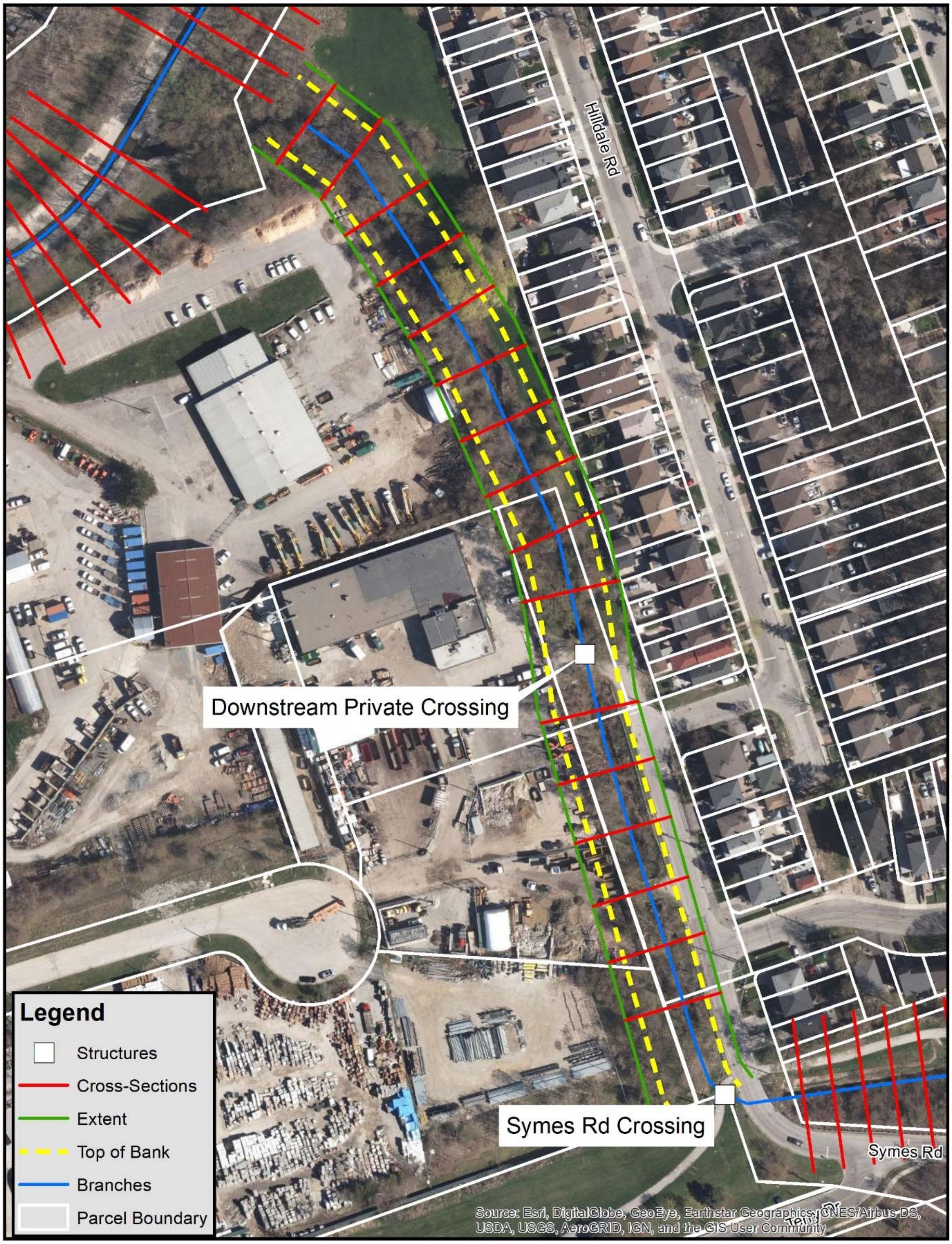

Figure 5.27. Lavender Creek Widened from Symes Road Crossing to Black Creek, 22.5 m Wide Natural Channel

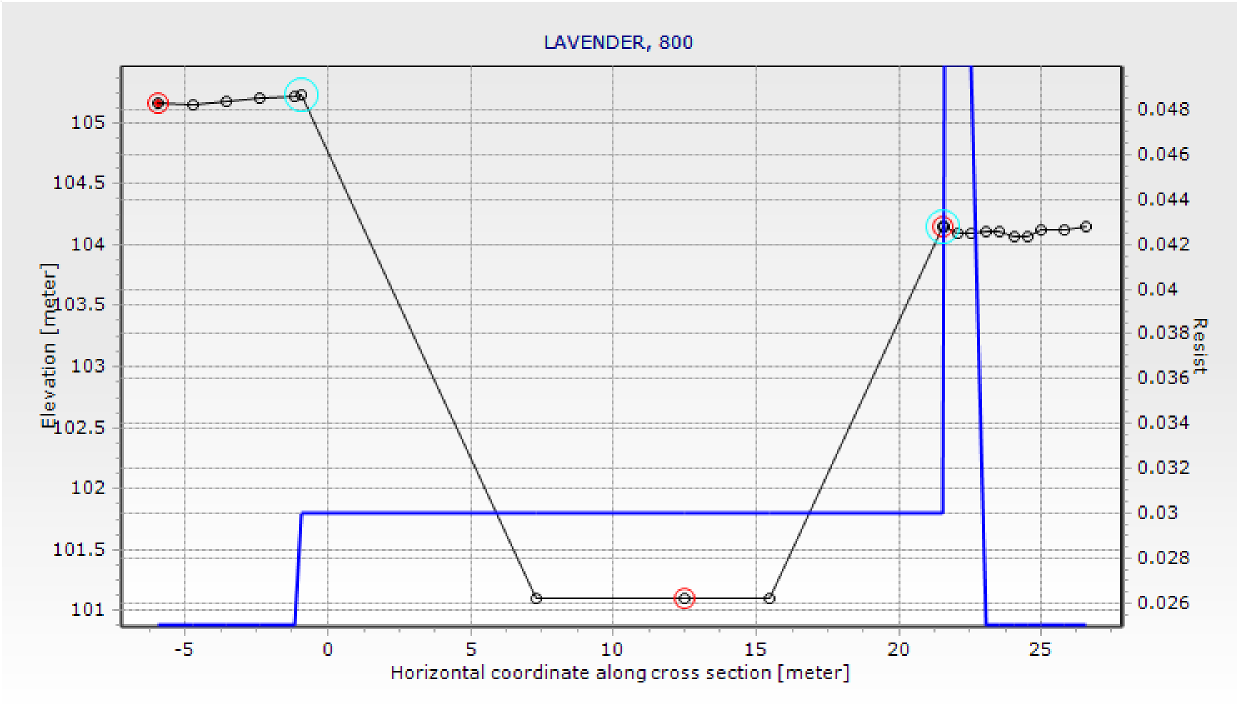

Figure 5.28. Natural Channel Cross Section (22.5 m Wide) and Roughness Values at Chainage 800 m on Lavender Creek

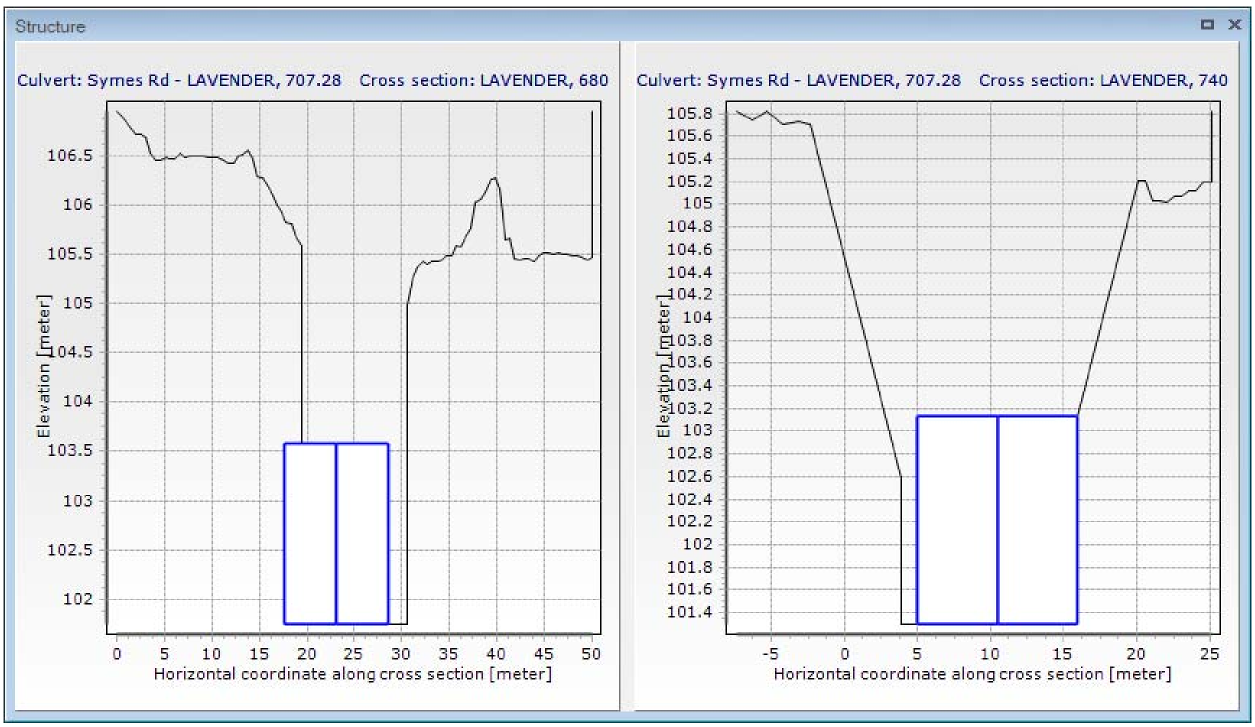

Figure 5.29. Upgraded Symes Road Crossing

Hydraulic Modelling Results

The Scenario 5 model was run for the full range of storm events including the 2, 5, 10, 25, 50, 100, and 350 Year storm events and the Regional Storm event (all events were run for the unsteady flow condition). The results are discussed in reference to the flooding adjacent to Lavender Creek, as well as flooding along Black Creek.

Figure 5.31. presents a comparison of the maximum water levels along Lavender Creek from upstream of Symes Road Crossing (chainage 600 m) to the confluence of Black Creek (chainage 1075 m) for each event. These results show that flooding along Lavender Creek has been completely eliminated for all events except the Regional Storm event where there is some overbank flooding on the left and right bank near the confluence with Black Creek. Figure 5.30. presents the lateral extent of flooding from the Lavender Creek channel in the 2D overland flow model and it shows that some houses along Hilldale Road are impacted by the combined flooding from Black Creek and Lavender Creek, and the industrial property immediately south of Black Creek, on Rockcliffe Court, is also impacted by combined flooding from Black Creek and Lavender Creek. Nonetheless, Scenario 5 results in the largest flood risk benefit across all storm events, and has been selected as the preferred alternative for Lavender Creek.

Figure 5.30. Flooding at Confluence of Black Creek and Lavender Creek for Regional Storm Event.

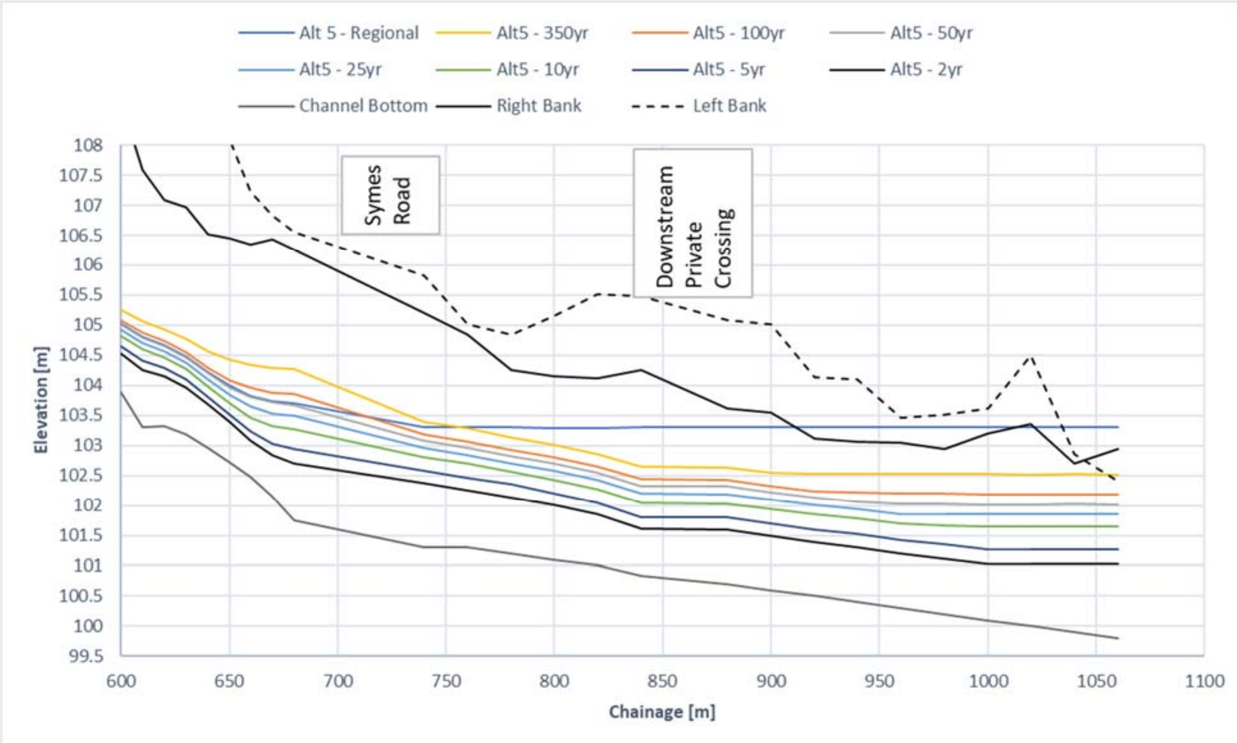

Figure 5.31. Scenario 5 - Max Profile on Lavender Creek from Chainage 600 m to Confluence with Black Creek, All Storm Events

5.2.10 Preferred Alternatives – Lavender Creek and Black Creek (Jane Street to Alliance Avenue)

From the results presented in the previous sections, Scenario 5 for Lavender Creek has been selected as the preferred alternative. The modelling for Scenario 5 also included the preferred alternatives for Black Creek from Jane Street up to Alliance Avenue. Figure 5.32 presents a comparison of the maximum water levels along Black Creek from upstream of Weston Road to Scarlett Road for each event, and also includes the results for the Regional Storm event for existing conditions (i.e. no changes to Jane Street Crossing, Rockcliffe Boulevard Bridge, Black Creek channel widening or Lavender Creek). These results show that overbank flooding between Weston Road and Rockcliffe Boulevard has been completely eliminated for all events except the Regional Storm event. Figure 5.33. is a map of the maximum flood extents for the Regional Storm event. The flooding for the Regional Storm event is characterized as follows:

- Flooding between Weston Road and Alliance Avenue is caused by a combination of overbank flooding from the Black Creek channel and overtopping of Weston Road but the majority of flooding is caused by overtopping of Weston Road.
- Overbank flooding between Alliance Avenue and Rockcliffe Boulevard is mainly at the confluence of Lavender Creek and the industrial area immediately adjacent to Rockcliffe Court, but there is also mild flooding at one building located on the north side of Black Creek at the confluence with Lavender Creek, and one building located immediately upstream of Rockcliffe Boulevard bridge.
- Overbank flooding between Rockcliffe Boulevard and Jane Street is minimal and does not encroach on the Rockcliffe School property.

- Overbanks flooding between Jane Street and Scarlett Road is mainly contained by the flood protection berm along Black Creek Drive so no buildings are impacted.

These results demonstrate that the improvements proposed in Scenario 5, which includes the preferred alternatives for Black Creek from Jane Street to Alliance Avenue, provide effective flood mitigation for Lavender Creek and do not adversely impact flooding along Black Creek. Furthermore, the proposed upgrade of the Rockcliffe Boulevard Bridge and widening of the channel from Jane Street to Alliance Avenue reduces backwater conditions at the downstream reach of Lavender Creek and also mitigates overbank flooding for the channel upstream of Lavender Creek to Weston Road.

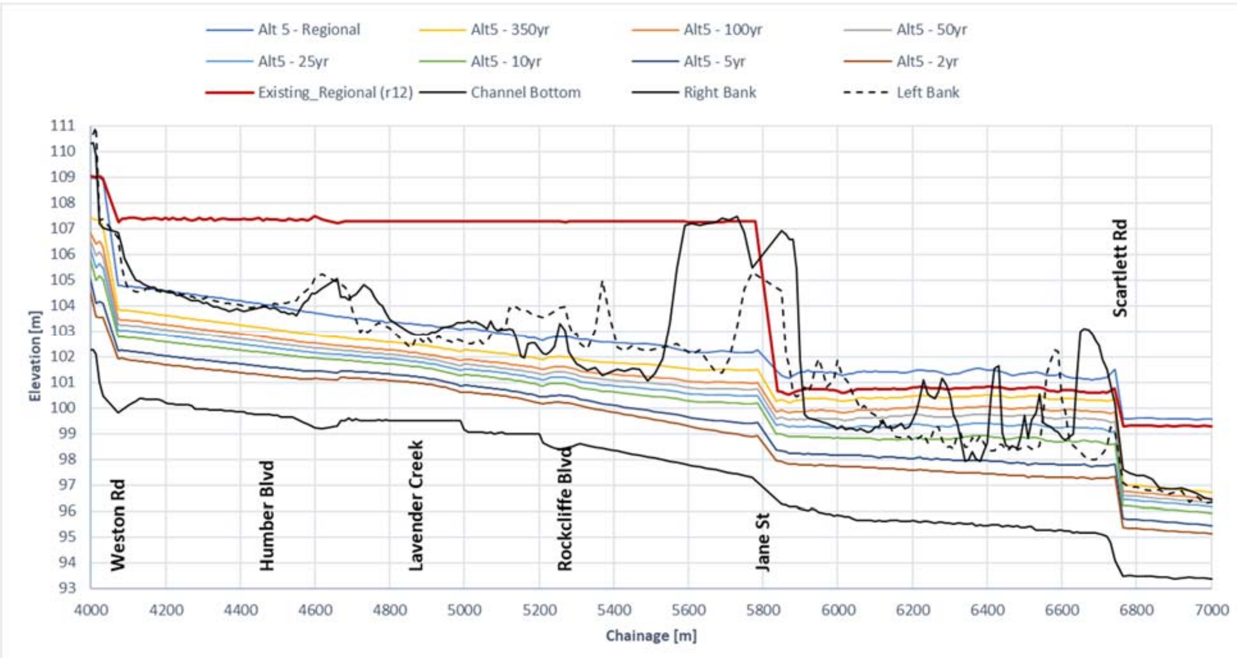

Figure 5.32. Lavender Creek Preferred Alternative (Scenario 5) - Comparison of Maximum Water Level Profile for All Events along Black Creek Profile

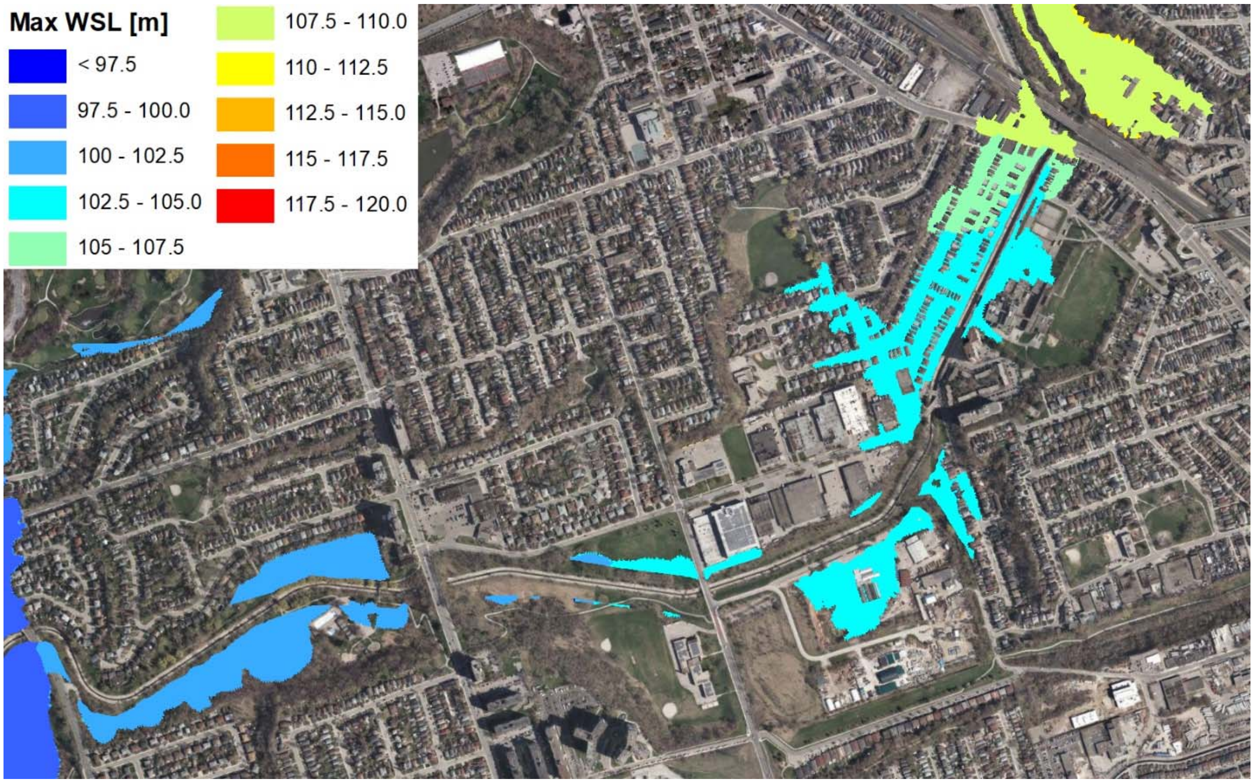

Figure 5.33. Lavender Creek Preferred Alternative (Scenario 5) - Maximum Flood Extents for Regional Storm Event

As flow conveyance is improved, Scenario 5 Regional Storm flood elevations downstream of Scarlett Rd. as indicated in Figure 5.32 would increase and could impact several homes at the west end of Black Creek Boulevard. The flood elevations increase is a result of unsteady state hydraulic modelling with storage in place (i.e. real life conditions) which is not considered by MNRF in determining Regulatory flood limits. In consultation with TRCA the modelling setup, assumptions and associated results are understood, that said, this negative flood risk impact would require further assessment and potential mitigation during the subsequent Class EA.

6.0 Assessment of Black Creek Alternatives Upstream of Alliance Blvd.

6.1 Alternatives

Through discussion with both TRCA and City staff, it was decided that the alternative assessment for the Black Creek system upstream of Alliance Blvd. would focus on preventing overtopping of Weston Road. In summary, the selected alternatives (downstream Black Creek and Lavender Creek systems) would result in the 100 year storm being conveyed by the Black Creek channel downstream of Weston Road to downstream of the Alliance Avenue crossing. Based on these alternatives providing greater than a 100 year level of service (no riverine flooding during the 100 year storm event), the following alternatives have been screened from further consideration:

- *Reconfiguration and widening of Alliance Avenue Crossing*:
- *Reconfiguration and widening of Humber Boulevard Crossing*
- *Removal of the Humber Boulevard Crossing*
- *Widening of Black Creek from Alliance Avenue to Weston Road (which would require reduced pavement width or road elimination for Humber Boulevard South)*

As discussed with TRCA , the feasibility of reducing peak flows in the study area has been assessed by using the attenuated peak flows discharging from the Black Creek Dam, located upstream of Jane Street and Troutbrooke Drive. Details of the dam operation are outlined in the Black Creek Dam Safety Review, 2017, Sanchez Engineering Inc (ref. Table 2.1). The peak flows cited in Table 6.1 indicate that the outflow of the Black Creek Dam for the 350 year storm event and Regional Storm event (Hurricane Hazel) would only be reduced by 9.5% and 1.9% respectively based on the 2017 storage values. The limited attenuation of peak flows associated with the Black Creek Dam would not provide adequate flood mitigation at Weston Road, given the influence of flood wave timing and the associated loss of peak flow attenuation. The Black Creek Dam would not prevent Weston Road from being overtopped by the 350 year storm event and Regional Storm event, hence this alternative has been screened from further consideration.

Table 6.1. Black Creek Inflow/Outflow

Design Storm	Inflow Peak (m^3/s)	Outflow Peak Flow (m^3/s)		Outflow Peak Flow Percent Change
		1997 Storage	2017 Storage	
50 Year 6 Hour AES	79.7	63.2	76.6	21%
50 Year 12 Hour AES	63.3	55.5	62.7	13%
50 Year 24 Hour AES	50.7	48.4	50.6	5%
100 Year 6 Hour AES	90.0	73.2	83.9	15%
100 Year 12 Hour AES	73.4	65.3	72.7	11%
100 Year 24 Hour AES	58.1	55.9	58.0	4%
350 Year 24 Hour AES	111.8	98.4	101.2	3%
Hurricane Hazel	213.8	210.2	209.8	0%

The existing Weston Road crossing of Black Creek is a 38 m long by 12.65 m span by 5.45 m +/- rise structure (ref. Photograph 6.1). Downstream of the crossing, Black Creek is conveyed through a 12.5 m wide by 4.0 m +/-high concrete channel (ref. Photograph 6.2). Upstream of the crossing there are two (2) drop structures (ref. Photograph 6.3). The existing crossing has a parapet wall on the upstream side which is located between two (2) embankments (ref. Photograph 6.4).

Photograph 6.1. Weston Road Existing Crossing

Photograph 6.2. Downstream of Weston Road Existing Crossing

Photograph 6.3. Upstream of Weston Road Existing Crossing

Photograph 6.4. Parapet Wall on Upstream Side of Weston Road Crossing

The Weston Road crossing is located immediately adjacent to the intersection of Weston Road, Black Creek Drive and Humber Boulevard North (ref. Photograph 6.5). Humber Boulevard South is located adjacent to the crossing but does not have an intersection with Weston Road. Immediately upstream of Weston Road is a rail bridge with supporting piers (ref. Figure 6.4 and Photograph 6.6).

Photograph 6.5. Intersection of Weston Road, Black Creek Drive and Humber Boulevard North

Photograph 6.6. Existing Weston Road Crossing and Local Roads Configuration

The proximity of Weston Road adjacent to the Weston Road, Black Creek Drive and Humber Boulevard North intersection results in limited space for crossing improvements. Replacing the existing structure with a larger span is not considered feasible without closing Weston Road, which is considered impractical. Therefore, in order to reduce overtopping of Weston Road, the following flow conveyance improvement alternatives have been assessed:

- ***Alternative 1: Flood Protection Wall/ Berm***

  This alternative would include constructing a flood protection wall/ berm along the upstream side of Weston Road to prevent overtopping, with the height of the wall/ berm dependent upon the level of flood protection to be provided. The existing parapet wall has been determined to be structurally adequate to act as a flood protection wall as per structural engineers' assessment of the parapet wall, hence the balance of the flood protection wall could be connected to the existing parapet wall and be tied into the embankments on either side of the crossing.

- ***Alternative 2: Supplemental 3.25m by 3.25 m Arch Culvert***

  A supplemental or relief culvert would provide additional flow conveyance at Weston Road. Based on review of spatial constraints, a 3.25 m by 3.25 m arch culvert is considered feasible on the west side of the existing crossing. The construction approach would need to adapt the sequential excavation method (SEM). The east side of the existing crossing has limited space for adding a new culvert given the configuration of roadways, the orientation of the existing crossing and the downstream channel, hence has been screened out as a location to add another culvert.

- ***Alternative 3: Supplemental Twin 3m Diameter Culverts***

  Using SEM as the construction method, this alternative considers twin 3 m culverts on the west side of the existing crossing.

- ***Alternative 4: Combined Flood Protection Wall/ Berm and Supplemental 3.25m by 3.25 m Arch Culvert (Alternatives 1 and 2)***

  To provide additional flow conveyance this alternative consists of combining Alternatives 1 and 2.

- ***Alternative 5: Combined Flood Protection Wall/ Berm and Supplemental Twin 3 m Diameter Culverts (Alternatives 1 and 3)***

  To provide additional flow conveyance this alternative consists of combining Alternatives 1 and 3.

6.2 Hydraulic Assessment of Alternatives

As part of the assessment of alternatives for this reach/location, it was observed that the Regional Storm event was still resulting in flooding at the downstream end of Lavender Creek at the confluence with Black Creek, due to backwater from Black Creek. The Black Creek had been widened from Alliance Avenue through to Jane Street and the channel maintained the original slope through to the upstream side of Jane Street. This was due to the channel widening between Rockcliffe Boulevard and Jane Street being considered in a different phase of the project than the widening from Alliance Avenue to Rockcliffe Boulevard. However, since widening of the entire reach was being considered, it was considered that the slope of the channel could also be adjusted to lower the flood elevations at Lavender Creek. As result, the scenarios for this reach/location have been all setup with a constant channel slope from Alliance Avenue through to Jane Street (ref.

This adjustment of the channel bottom slope of Black Creek would lower the channel invert and, reduce the peak water level, at the confluence with Lavender Creek by approximately 0.5 m.

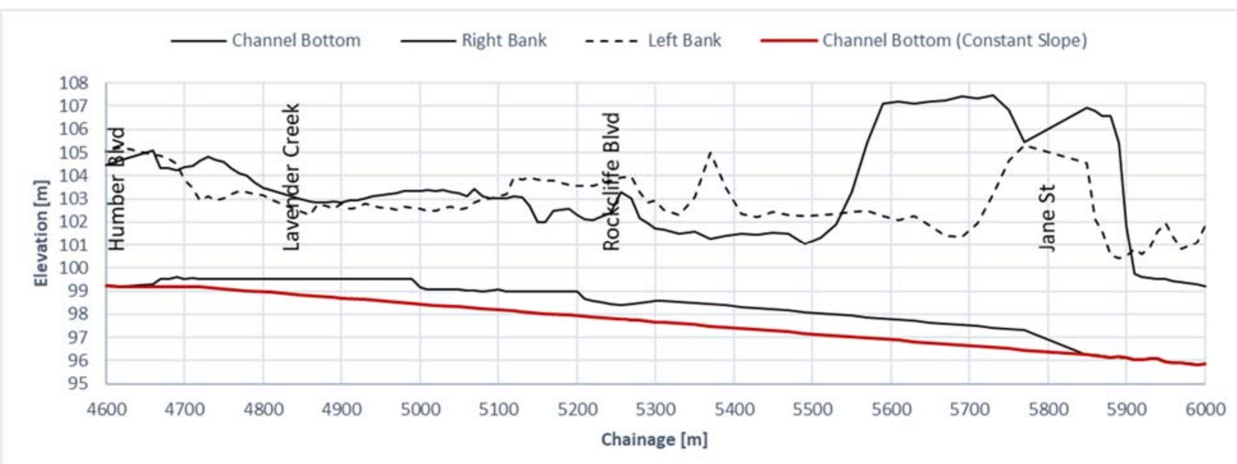

Figure 6.1. Modified Channel Slope for Black Creek Channel from Alliance Avenue to Jane Street

Given that the intent of the assessment of these alternatives is to prevent overtopping of Weston Road, each alternative has been executed for the 350 Year design storm event and the Regional Storm event only.

6.2.1 Alternative 1: Flood Protection Wall

6.2.1.1 Model Setup

The flood protection berm/wall structure upstream of the Weston Road bridge was implemented in the model by removing the lateral link couplings between the 1D and 2D models immediately upstream of the bridge and removing the weir structure in the 1D model representing the deck of the Weston Road bridge (ref. Figure 6.2). This model revision forces all of the water in the 1D model of Black Creek to flow through the structure opening representing the Weston Road crossing. In cases where the crossing becomes surcharged, the water level upstream of the bridge will ponds until it achieves a depth that creates sufficient hydraulic head to force the water through the culvert. The maximum water level upstream of the bridge for each storm event determines the required height of the flood protection wall/ berm.

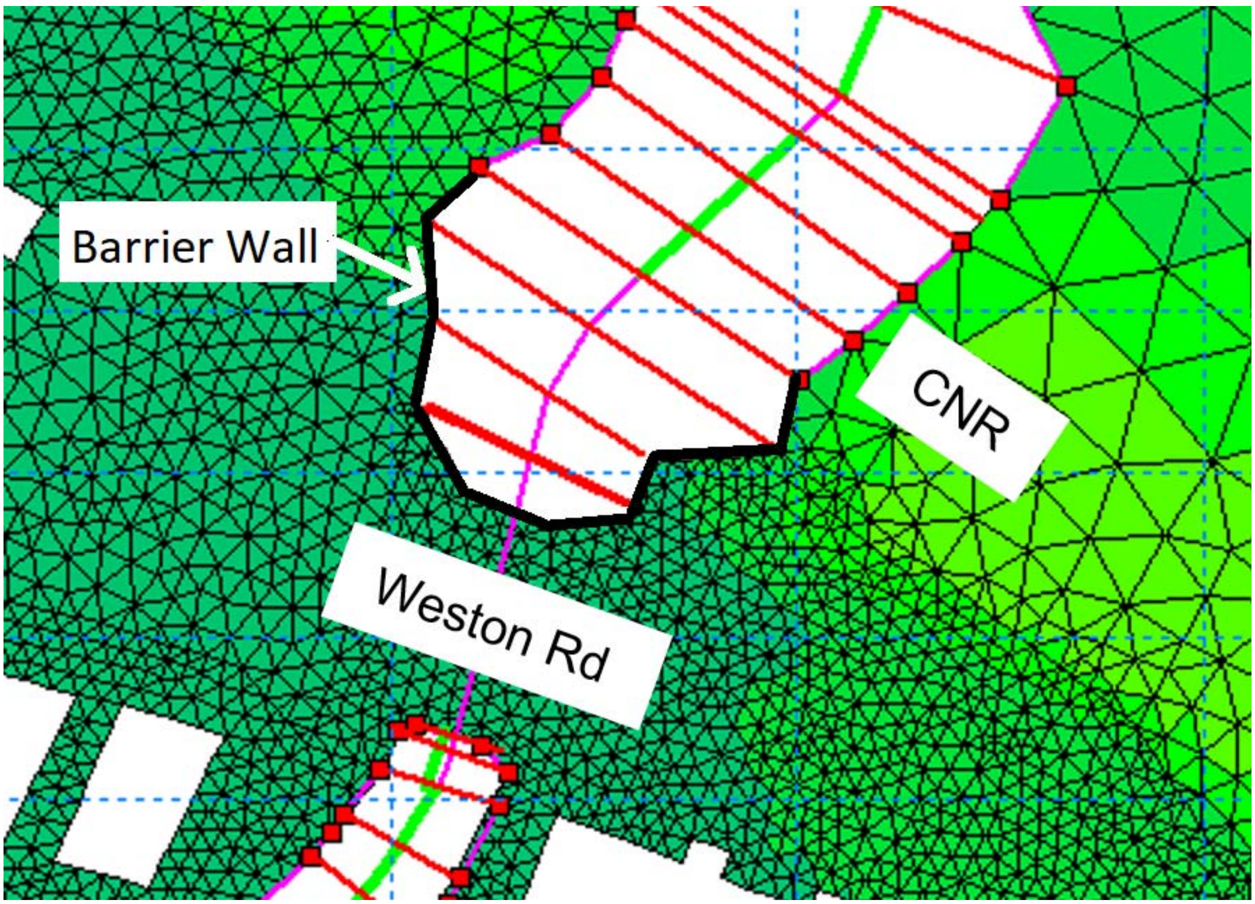

Figure 6.2. 1D and 2D Model Setup at Weston Road Bridge Indicating Location of Modelled Flood Protection Wall/ Berm

6.2.1.2 Model Results

The Alternative 1 model was run for the Regional Storm event and the 350 Year storm event. The results from the Regional Storm event simulation indicate the maximum water level upstream of the Weston Road bridge to be approximately 110.8 m while the existing top of bank is approximately 107.0 m (ref. Figure 6.3). These results indicate that a flood protection wall/ berm would need to be approximately 4 m high to prevent overtopping of the Weston Road bridge during a Regional Storm event.

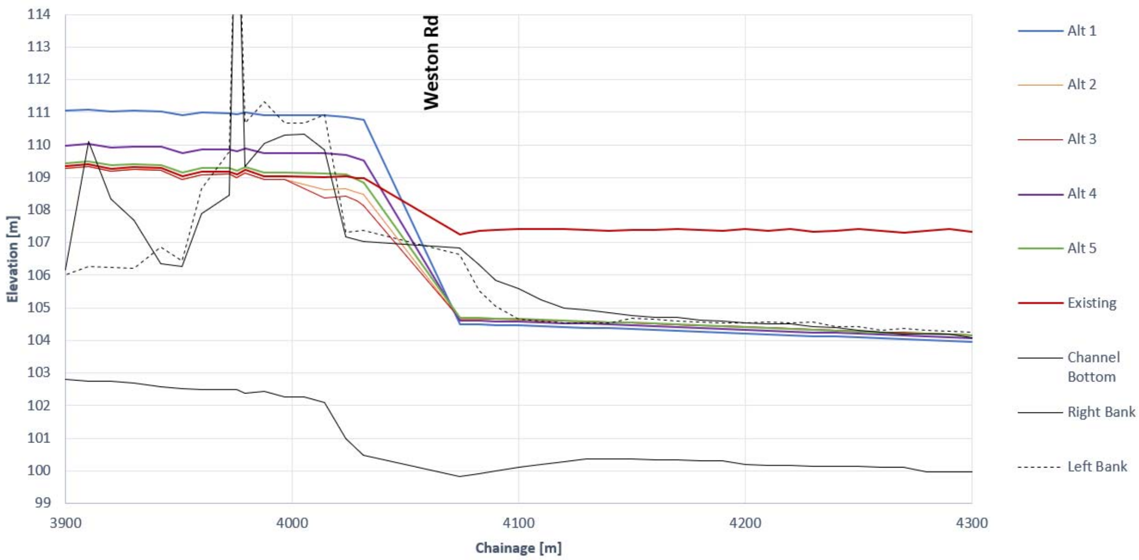

Figure 6.3. Channel Profile Indicating the Maximum Water Level Upstream of the Weston Road Bridge for the Regional Storm Event for Alternatives 1-5 and Existing Conditions

The results for the 350 Year storm event simulation indicate the maximum water level upstream of the Weston Road bridge to be approximately 107.4 m while the existing top of bank is approximately 107.0 m (ref. Figure 6.4). These results indicate that a flood protection wall/ berm approximately 0.4 m plus freeboard would be required to prevent overtopping of the Weston Road bridge during a 350 Year storm event.

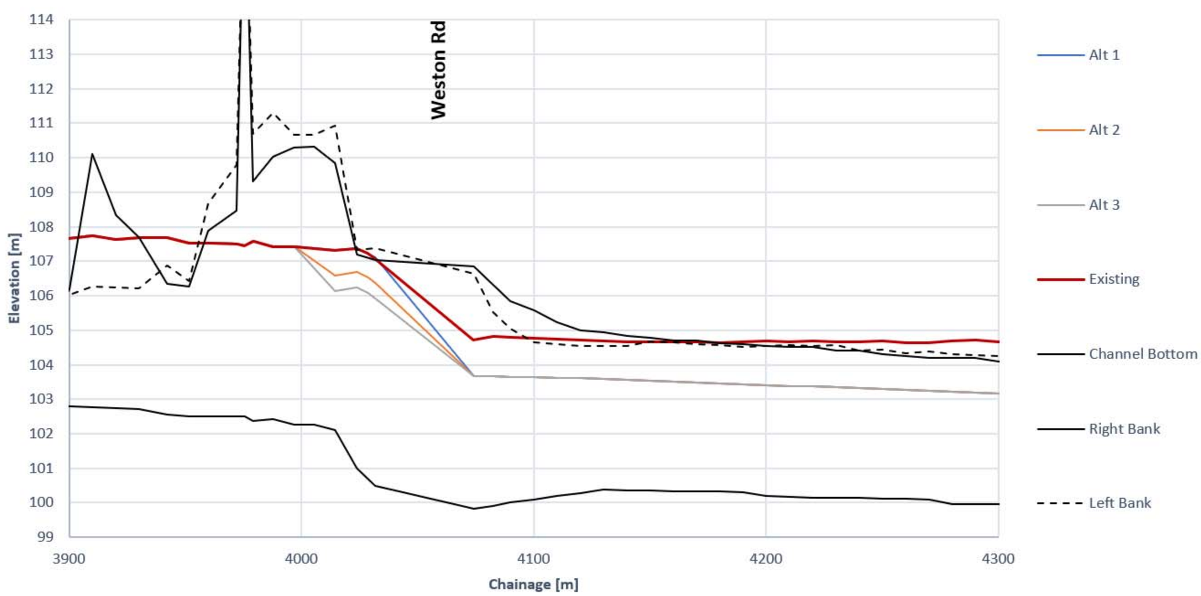

Figure 6.4. Channel Profile Indicating the Maximum Water Level Upstream of the Weston Road Bridge for the 350 Year Design Storm Event for Alternatives 1-3 and Existing Conditions

6.2.2 Alternative 2: Supplemental 3.25m Arch Culvert

6.2.2.1 Model Setup

The 3.25 m arch culvert was implemented as an additional parallel culvert structure beside the existing culvert structure representing the bridge opening. The arch culvert geometry was assigned using a level width curve to describe the geometry with an upstream invert level of 100.5 m, a length of 60 m, and downstream invert level of 99.9 m. The culvert used a Manning's roughness value of 0.013, an inflow loss coefficient of 0.5, and an outflow loss coefficient of 1.0.

6.2.2.2 Model Results

The Alternative 2 model was run for the Regional Storm event and the 350 Year storm event. The results from the Regional Storm event simulation show the maximum water level upstream of the Weston Road bridge to be approximately 108.5 m (ref. Figure 6.3) with flow overtopping Weston Road at a maximum rate of 73 m^3/s. While the rate of flow overtopping Weston Road would be reduced, this alternative would not provide any meaningful mitigation of flooding along Cordella Avenue and Humber Boulevard North. The flooded area upstream of the Weston Road bridge would also be slightly expanded in the industrial area south of Black Creek.

The results for the 350 Year storm event simulation show the maximum water level upstream of the Weston Road bridge to be approximately 106.4 m (ref. Figure 6.4) with no overtopping of the Weston Road bridge and no impacts on the extent of flooding upstream of the bridge.

6.2.3 Alternative 3: Supplemental Twin 3 m Diameter Culverts

6.2.3.1 Model Setup

The dual 3.0 m diameter culverts were implemented as additional parallel culvert structures beside the existing culvert structure representing the bridge opening. The culverts each had an upstream invert level of 100.5 m and a slope of 1% with lengths of 55 m and 60 m, and downstream inverts of 99.95 m and 99.90 m, respectively. Each culvert used a Manning's roughness value of 0.013, an inflow loss coefficient of 0.5, and an outflow loss coefficient of 1.0.

6.2.3.2 Model Results

The Alternative 3 model was run for the Regional Storm event and the 350 Year storm event. The results from the Regional Storm event simulation show the maximum water level upstream of the Weston Road bridge to be approximately 108.1 m (ref. Figure 6.3) with flow overtopping Weston Road at a maximum rate of 50 m^3/s. While the rate of flow overtopping Weston Road would be reduced, it would not provide any meaningful mitigation of flooding along Cordella Avenue and Humber Boulevard North. The flooded area upstream of the Weston Road bridge would also be slightly expanded in the industrial area south of Black Creek.

The results for the 350 Year storm event simulation indicate the maximum water level upstream of the Weston Road bridge to be approximately 105.9 m (ref. Figure 6.4) with no overtopping of the Weston Road bridge and no impacts on the extent of flooding upstream of the bridge.

6.2.4 Alternative 4: Combination of Alternatives 1 and 2

6.2.4.1 Model Setup

The combined flood protection wall/berm and 3.25 m span and rise arch culvert alternative have been implemented in the model exactly the same as described in Alternatives 1 and 2.

6.2.4.2 Model Results

The Alternative 4 model was only executed for the Regional Storm event as Alternative 2 demonstrated that the supplemental culvert was sufficient to eliminate flooding for the 350 Year storm event. The results from the Regional Storm event simulation indicate the maximum water level upstream of the Weston Road bridge is approximately 109.5 m (ref. Figure 6.3). While this alternative prevents overtopping of the bridge it does increase the extent of flooding upstream of the bridge in the industrial area south of the creek, and it requires a flood protection wall/ berm height of approximately 2.5 m.

6.2.5 Alternative 5: Combination of Alternatives 1 and 3

6.2.5.1 Model setup

The combined flood protection wall/berm and twin 3.0 m diameter culverts alternative has been implemented in the model as per Alternative 1 and Alternative 3 combined.

6.2.5.2 Model Results

The Alternative 5 model was only run for the Regional Storm event as Alternative 3 demonstrated that the supplemental twin 3 m diameter culverts are sufficient to eliminate flooding for the 350 Year storm event. The results from the Regional Storm event simulation indicate the maximum water level upstream of the Weston Road bridge to be approximately 108.8 m (ref. Figure 6.3). While this alternative prevents overtopping of the bridge it does increase the extent of flooding upstream of the bridge in the industrial area south of the creek, and it requires a flood protection wall height of approximately 1.8 m.

6.2.6 Preferred Alternative

6.2.6.1 Selection of Preferred Alternative

The objective of the overall re-examination of alternatives is to evaluate and recommend feasible flood mitigation alternatives that will reduce flooding and optimize the level of service for the study area from Weston Road to Jane Street. Based on the results of the five (5) alternatives considered for the Alliance Avenue to Weston Road reach, it was determined that a flood protection wall/berm, designed to prevent overtopping of the bridge during the 350 Year design storm event would be the most practical and feasible alternative, as it would be the least disruptive, and it would have the lowest construction cost.

Alternatives 2 and 3 provide a similar level of flood mitigation benefit as Alternative 1 in that both alternatives prevent overtopping of the bridge during the 350 Year design storm event but would not prevent overtopping during the Regional Storm event. However, Alternatives 2 and 3 would both be highly disruptive to the Weston Road and Black Creek Drive intersection, and would be considerably more costly than building a 0.5 m +/- high plus freeboard flood protection wall/berm.

Alternative 4 is effective in preventing overtopping of the bridge during a Regional Storm event but it would require a flood protection wall/berm height of 2.5 m or more on the upstream side of the Weston Road bridge. There is considerable uncertainty about whether it is feasible and practical to design and build the required flood protection wall at this location.

Alternative 5 is also effective in preventing overtopping of the bridge during the Regional Storm event however it requires a flood protection wall/berm height of 1.8 m or more on the upstream side of the Weston Road bridge. Although this height is likely more attainable than what is required for Alternative 4, there remains considerable doubt whether it is feasible to install side-by-side 3 m twin diameter culverts at this location.

Therefore, the preferred alternative for this reach/location has been determined to be a flood protection wall on the upstream side of the Weston Road bridge with a crest elevation of 107.4 m (height 0.5 m +/-) plus freeboard (notionally 0.3 to 0.5 m) to prevent overtopping during a 350 Year storm event. The freeboard height will need to be assessed in the future Class EA to ensure it would not result increased Regional Storm flood elevations upstream of Weston Road that would impact private properties.

7.0 Preferred Alternatives

7.1 Black Creek – Jane Street Bridge

7.1.1 Structural Assessment

Based on the assessment completed herein, the Jane Street Bridge has been revised from a 72 m span to a 102m long, four span (10m, 36m, 36m, and 20m) structure. The original 72 m long bridge assumed a 1.5:1 naturalized slope for the embankments in front of the abutments. Based on the geotechnical investigation findings, it was determined that the very poor soil conditions at Jane Street would not be able to support the 1.5:1 slope. Considerations to addressing the poor soil conditions include either applying soil stabilization to maintain the length or lengthening the bridge span to 102 m using 2:1 slopes and benches. Lengthening the bridge has been considered at this stage of the Feasibility Assessment to be the preferred approach, from a constructability point-of-view (less staging, traffic control, etc.); this has been discussed further in Section 7.1.2.

The bridge would have a proposed width of 29.7m including 1.5m sidewalks on both sides of the bridge. The proposed bridge will carry two 3.5m wide lanes of Northbound traffic, two 3.5m wide lanes of Southbound traffic, and two 2.5m bike lanes along Jane Street over Black Creek. In addition, the City of Toronto has requested a 7.0m wide lane for future LRT construction. For the superstructure type, steel I-girders or precast and prestressed concrete girders can be considered. The conceptual drawing (ref. Appendix H) indicates the steel option.

The length of bridge shown is based on hydraulic and geotechnical recommendations. Through hydraulic modelling, a two-span 72m long bridge with 1.5H:1V embankment slopes was determined to be the preferred alternative for Jane Street. However, the geotechnical investigations determined that the fill along the proposed slope embankments consisted of poor fill material (ref. Appendix I) that would be unstable at such steep slopes. As such, to accommodate the geotechnical requirements, the embankment slopes would either need to be shallowed and the bridge lengthened, or some form of soil stabilization (i.e. geogrid system similar to a Sierra Slope product) be installed. Both options have been assessed, and it was determined that the lengthening of the bridge would be preferred for multiple reasons as it would avoid the following:

1. The extent of excavations and backfilling to accommodate the soil stabilization alternative would be exhaustive due to the significant slope failure zone.
2. The excavations could potentially interfere with underground infrastructure.
3. The staging of the construction and more specifically, the roadway protection effort to maintain some active lanes of traffic along Jane Street would be increased from a design and construction point-of-view.
4. The construction period would be lengthened.
5. With consideration for the above points and in lieu of a more detailed analysis, the increase in cost for both options could potentially be similar.

It is important to note that the effort at this level of assessment (Feasibility Study) for the structural design is only at a conceptual level. Further analysis should be carried out to examine both alternatives in greater detail in the subsequent Class EA.

A conceptual general arrangement drawing is included in the Conceptual Design Report for Jane Street in Appendix H.

7.1.2 Geotechnical Assessment

The proposed 102 m span Jane Street bridge will provide the required flow capacity through the valley section to convey the Regional Storm with minimal hydraulic losses. Ancillary structures include (a) 6 m approach slabs on either side of the bridge, (b) abutment wingwalls, and (c) sub-drainage system. An arch culvert installed within the Black Creek valley during early residential/industrial development will be removed, including 10 m to 17 m fill beneath the existing Jane street.

It is understood the proposed replacement bridge structure will follow the alignment of the existing Jane Street roadway. It is also understood a restricted traffic flow will be maintained during construction by strategically sequencing the construction (i.e. Two stage construction with half of the bridge under construction while other half in operation or top-down construction method).

The Black Creek valley is comprised of up to 9 m thick sandy silt/silty sand at surface which could be potentially liquefiable for the design earthquake loading condition. Seismic liquefaction potential of this layer should be further investigated, preferably with seismic Cone Penetration Testing with Pore Pressure Measurements (sCPTu), during the next stages of planning and design.

Due to deep cut within the existing common fill, permanent cut slope in the fill in front of the abutments should be no steeper than 3H:1V to satisfy long term static conditions and Pseudo-Static seismic stability. A detailed description of foundation stratigraphy, material parameters, design criteria, and analyses methodology is provided in Sub-Appendix C of the Geotechnical Investigation Report (ref. Appendix I) Steeper slopes could be considered if rigid elements such as a pile wall or soil anchor supported wall is provided to withstand lateral loads imposed by potentially straining soil mass. Such options may include, but not limited to:

a) removal and replacement of common fill behind the wall (to an extent for a significant width behind the wall, for global stability) with engineered fill, or

b) soil anchor wall, or

c) secant pile wall designed to take additional lateral load that may be exerted by deformed soil.

A detailed soil – structure interaction modelling analysis should be carried out to support the design of rigid system if option (c) is chosen for the detailed design.

The following additional recommendations are made:

- Structures cannot be founded on man-made fill that is found to contain deleterious materials.
- Any Reinforced Soil Slope (RSS) or Mechanically Stabilized Earth (MSE) system is not recommended within the flood plain where potential for scouring and negatively impacting the foundation is a high possibility.
- The slope surface below the Regional Storm flood level should be provided with erosion protection all along the slope. Within the high flood level, the slope should be protected with an armour stone layer designed for the anticipated flow velocity to avoid high erosive forces and scouring action.

Driven H-piles or drilled caissons are the preferred foundation option. Design recommendations for the deep foundation at the Jane Street bridge extension area is provided in Section 6.6 of the Geotechnical Investigation Report (ref. Appendix I).

7.1.3 Transportation and Traffic Assessment

As part of the flood remedation and transporation feasibility study of the Rockcliffe Special Policy Area, a transportation and traffic needs assessment was conducted to evaluate the impacts which the proposed flood remediation infrastructure may have on the adjacent road network.

As part of this assessment, existing traffic volumes were obtained from traffic count surveys conducted on October 8, 2019 during the AM peak period (7:00 a.m. to 9:00 a.m.) and PM peak period (4:00 p.m. to 6:00 p.m.). Traffic operations under existing conditions were analyzed for the peak hours during the weekday AM (7:00 a.m. to 9:00 a.m.) and weekday PM (4:00 p.m. to 6:00 p.m.).

Proposed flood remediation alternatives were reviewed, and it was noted that only the preferred alternative for Jane Street would have an impact on traffic and it was hence considered for further traffic assessment. The following two scenarios were assessed under the future (2031) horizon year for the Jane Street alternative:

- Scenario 1: without improvement ("Do-Nothing")
- Scenario 2: with improvements + LRT
    - It is important to note that the analysis with the LRT in operation (Scenario 2) was conducted as a high-level analysis to assess the worst-case scenario for the purposes of this study.

The following include the findings and recommendations for the Jane Street preferred alternative:

- The Jane St. alternative without the LRT in place will have minimal impact on the traffic operations.
- The traffic assessment conducted with the LRT in operation as-noted is a high-level analysis for this feasibility planning stage to assess the worst-case scenario. A more detailed analysis of traffic operations with the LRT in operation is required during the next phases of the project.
- Based on the high-level analysis with LRT in operation, the following changes are recommended:
    - N/S left turn movements at signalized intersections will need to be fully-protected
    - The cycle lengths at existing signalized intersections within the study area will need to be increased to accommodate longer E/W pedestrian times.

The proposed Jane Street bridge will need to be constructed in two stages where one lane will be closed in each direction in Stage 1 and Stage 2 to facilitate construction works. Therefore, the capacity along Jane Street will be reduced from two lanes to one lane per direction for the duration of the construction.

The assessment of temporary conditions (i.e. construction staging) is not part of the current scope of work for this study. However, based on a high-level review of the existing traffic data, it is noted that one lane in each direction cannot accommodate existing traffic volumes along Jane Street during the AM and PM peak hours. Figure 7.1. provides a comparison of existing versus construction conditions where one lane would be closed in each direction, based on an assumed capacity of 800 vehicles per hour per lane (vphpl) along Jane Street.

Figure 7.1. Existing versus Construction Staging Jane Street Through Capacity

Figure 7.1. indicates that there will be an excess of approximately 200 to 300 vehicles in the AM and PM peak hours due to the reduced through capacity on Jane Street during the construction period. These volumes will need to be diverted to the adjacent road network to minimize excessive delays drivers may experience due to the lane closures on Jane Street to facilitate construction.

Figure 7.2. provides potential detour routes for traffic diversion(s) during the construction of the Jane Street bridge. Detour 1 is west of Jane Street via Eglinton Avenue, Scarlett Road and St. Clair Avenue while Detour 2 is east of Jane Street via Eglinton Avenue, Weston Road, and St. Clair Avenue. It was noted by the City that Detour 1 may not be feasible due to existing constraints at the intersection of St. Clair Avenue and Scarlett Road.

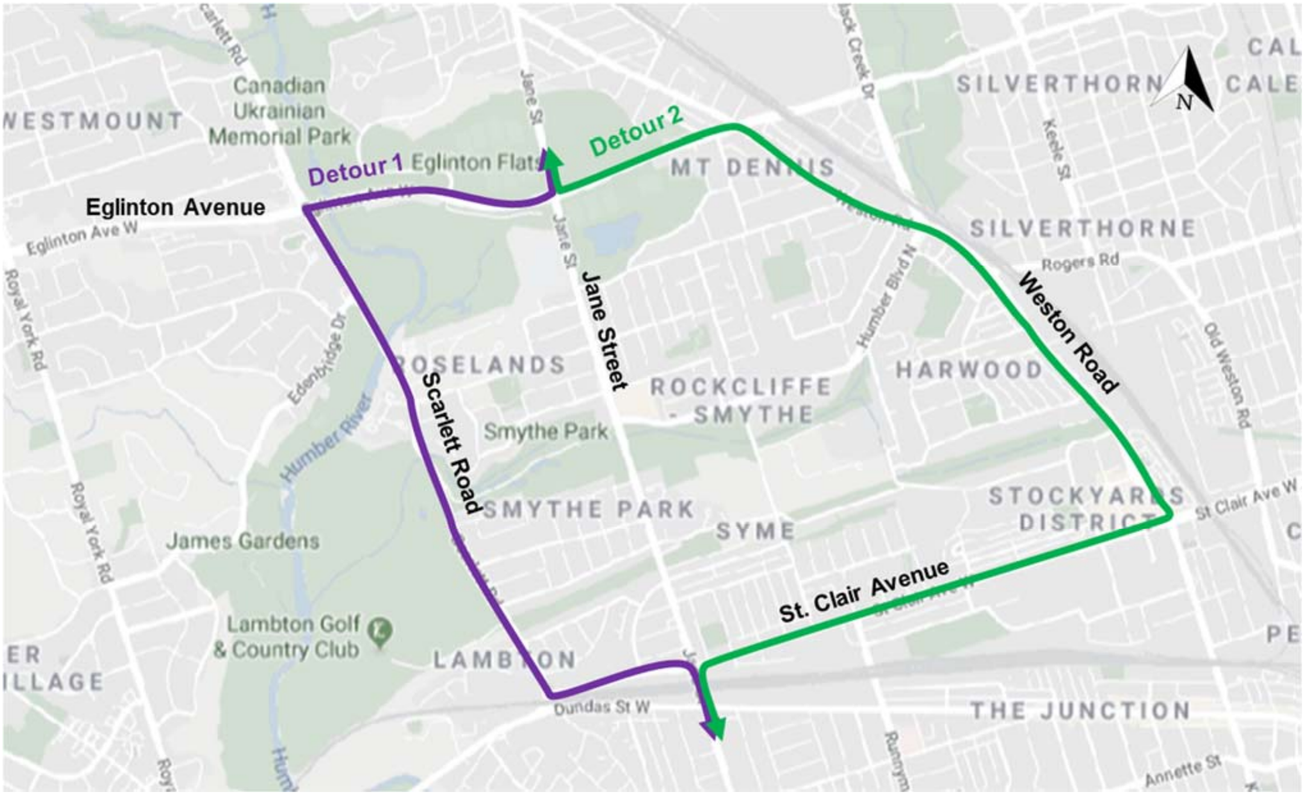

Figure 7.2. Potential Detour Routes

It is important to note that the assessment of the roadway capacity during construction and potential detour routes discussed above are based on a high-level review. A more detailed analysis for the temporary conditions (i.e. construction staging) needs to be conducted in the next stages of this project (Class EA) to further assess traffic operations during construction and the feasibility of potential detour routes.

The full Traffic and Transportation Needs Assessment can be found in Appendix J.

7.1.4 Natural Systems

Immediately downstream (west) of Jane St., for an approximately 30 m length, Black Creek is within an approximately 12 m wide channel bordered by concrete walls and large concrete boulders present within the channel. An elevation increase is present at the downstream end of the Jane St. culvert, which may impede fish movement during part of the year. Continuing upstream (east) Black Creek flows through an approximately 2.5 m wide and 0.6 m deep concrete channel with a 4.5 m wide floodplain on both sides and bordered by 1 m to 2 m high concrete walls outside of the floodplain. Water depth averaged 0.35 m within the concrete channel during a July, 2019 site visit and 0.5 m during the site walk in June, 2019, following a period of rain. The channel is lower than the surrounding landscape throughout the study area, with dense deciduous tree cover along the concrete walls of in this area, providing approximately 70% riparian cover. Approximately 35 m upstream (east) of Jane St. the riparian cover contains increased grasses and shrubs, reducing riparian cover to <40%. The vegetated riparian area upstream and downstream of Jane St. is surrounded by dense urban development. The dense surrounding urban development and concrete channel are indicative of a warm water system. Fish species inhabiting Black Creek within this area would require tolerance for urban runoff into drainage system.

Potential impacts associated with the chosen alternative include the introduction of sediments, concrete and other deleterious substances into the creek and, increased sediment mobilization. Construction may involve, disruption of fish life stages, potential loss of fish habitat, damage and loss of terrestrial and/or riparian vegetation cover and soil compaction. Additional impacts during and post construction may include: disruption of wildlife and wildlife passages, including the potential for the disruption of bird nesting, loss of potential bat maternity roost trees, and contamination of the environment due to exposure to deleterious substances. The proposed width (29.7 m) of the road is wider than the existing road width of 20 m (+/-) and will require the removal of vegetation, however this may be minimal and will be determined during detailed design (Appendix H). Generalized, measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.1.5 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) concluded that the Jane St. structure would not be considered a cultural heritage resource based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the recommended Jane Street bridge would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, provided in Appendix K.

7.1.6 Infrastructure & Utilities

7.1.6.1 Municipal Infrastructure

As part of the Jane Street bridge expansion works, there are several infrastructure considerations required to accommodate the 102 m wide bridge. The potential impacts to municipal infrastructure include the following (ref. Figure 7.3.):

- Three (3) storm sewer outlets, of sizes 400, 450 and 600 mm diameter, located within the channel and on Jane Street would need to be trimmed to the extents of the widened channel & reconstructed.
- The 300 mm diameter watermain currently on Jane Street would need to be strung to the expanded bridge.
- The 1650 mm diameter combined trunk sewer manhole on the southern side of Black Creek would be exposed in the widened channel, therefore it is proposed to be re-aligned and tie it back to the existing sewer on the downstream side of Jane Street.
- The sanitary sewer on Jane Street will need to have two (2) new connection points to the combined trunk sewer, servicing both the north (300 mm) and south (250 mm) sanitary connections. The northern sanitary sewer connection would need to be lowered to travel beneath the channel bed, and the southern sanitary sewer would need to be re-aligned outside of the 102 m span structure.

Municipal Infrastructure & Utility Impact Plans have been prepared for the study area (ref. Appendix L).

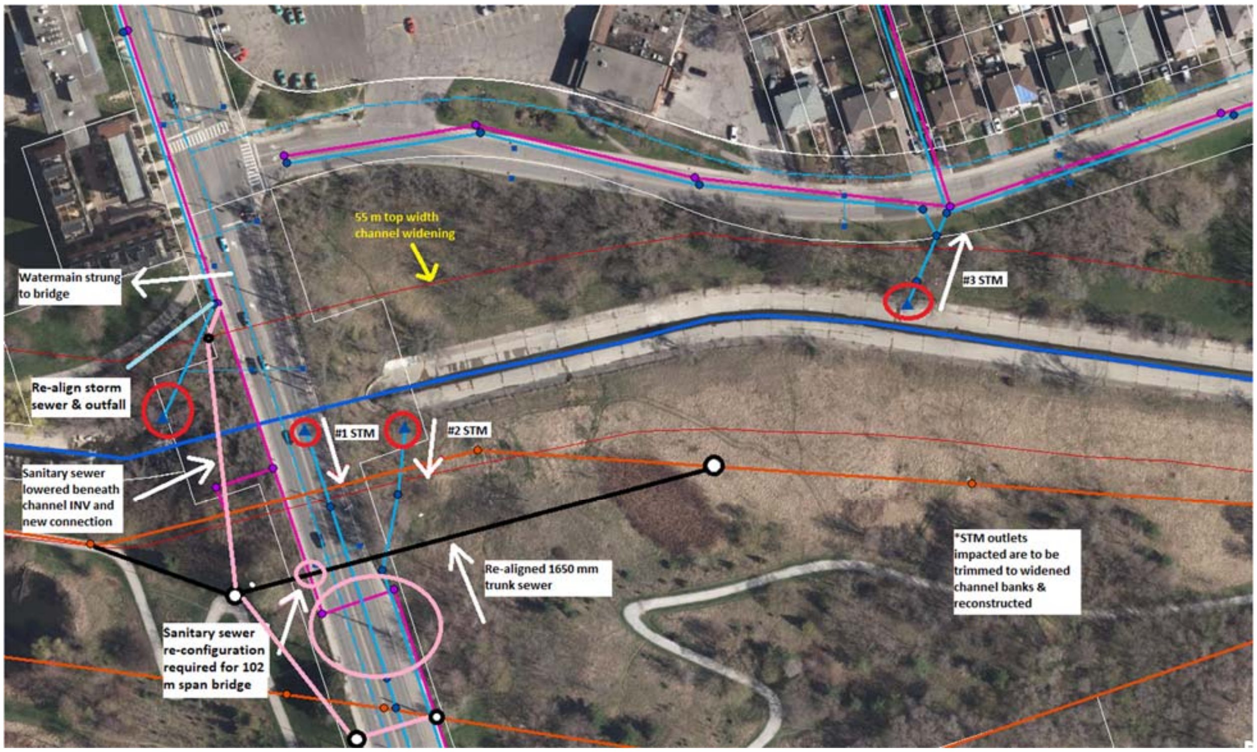

Figure 7.3. Infrastructure Considerations for Black Creek Channel Widening Between Jane Street and Rockcliffe Blvd (1)

7.1.6.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the Jane Street preferred alternative, T2UE noted the following large-scale conflicts with existing private utilities:

- Toronto Hydro primary poles, which host telecoms (east side) and joint use THES street lighting on both the east and west sides of Jane Street will require relocation. Since the proposed bridge is encompassing the entire Jane Street right-of-way, and will see large excavation for the naturalization of the Black Creek channel, the relocation solution will likely involve relocating the poles outside of the proposed excavation limits in a preparatory works relocation. This will require easements and extensive planning with THES and attached telecom companies.
- Toronto Hydro Underground 3W2H duct structure, this structure is on west side of the Jane Street Right-of-way across from Alliance Avenue and will have to be relocated as a result of the pole relocations.
- Existing underground THES 4W8H duct structure on the east side of the Jane Street will be in conflict with the proposed bridge and excavation. This is a recently installed structure (2018-2019), and as a result may not be utilized. Detailed discussions with THES are required to confirm status and relocation options. It is likely that a relocation solution will mirror that of the aerial relocation (relocated off of bridge, requiring easements).
- Existing underground Bell Canada duct structures on the west side of the Jane Street will be in conflict with the proposed bridge and excavation. Detailed discussions with Bell are required to

confirm status and relocation options. It is likely that a relocation solution will mirror that of the aerial relocation (relocate off bridge, requiring easements).

- Enbridge Gas appears to be vacant from the project area.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.1.7 Conceptual Costing

A Class D conceptual cost estimate for the Jane Street preferred alternative has been prepared and is estimated to cost $27.97 million, which includes costing elements for the bridge works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.1, and an itemized cost breakdown is provided in Appendix M.

Table 7.1. Conceptual Cost Summary – Jane Street Bridge

Proposed Works	Conceptual Cost Estimate
Bridge Upgrade	$23,892,000
Municipal Infrastructure	$2,161,000
Utilities (50% Cost Sharing)	$1,913,000
Total	**$27,966,000**

7.2 Black Creek – Jane Street to Rockcliffe Boulevard – Channel Widening

7.2.1 Channel Widening

As outlined in the previous sections, the Black Creek channel between Jane Street to Rockcliffe Boulevard is proposed to be widened, lowered and naturalized as part of the preferred flood mitigation alternatives. The channel works will include removal of the existing concrete channel , widening and naturalization to an approximate bottom width of 45 m (+/-) with 2:1 side slopes, (resulting in a top width of approx. 55 m (+/-)) to increase channel conveyance capacity and accommodate the proposed bridge expansions along the reach. The proposed lowering of the channel (ref. Section 6.2), would result in a constant slope from Alliance Boulevard to Jane Street, to further reduce flood elevations along the length of the channel reach.

7.2.2 Natural Systems

Between Jane St. and Rockcliffe Blvd., Black Creek continues upstream within an approximately 2.5 m wide and 0.6 m deep concrete low flow channel, having an approximately 4.5 m wide floodplain on each side, bordered by 1 m to 2 m high concrete walls. Water level averaged 0.35 m during a July, 2019 site visit and >0.6 m during the site walk in June, 2019, following a period of rain. Stormwater outfalls are present within this approximately 520 m long section. The channel remains lower than the surrounding landscape, with deciduous trees, grasses and shrubs atop the concrete walls, providing <30% riparian cover. A 25 m to 360 m wide vegetated buffer is present along this entire section, surrounded by dense urban development. The dense surrounding urban development and concrete channel are indicative of a warm water system. Fish species inhabiting Black Creek within this area would require tolerance for urban runoff into drainage system.

Potential negative impacts during construction of the chosen alternative include the introduction of sediments and deleterious substances and concrete introduction through removal of existing concrete channel. The proposed works may disrupt fish life stages, and result in damage and loss of terrestrial/ riparian vegetation as well as, soil compaction. The proposed alternative has the possibility to disrupt wildlife and wildlife movement, inclusive of avian and mammalian species and nesting/roosting. Generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Design the realigned channel and riparian habitat to improve the ecological function from its current state and provide suitable fish and wildlife habitat;
- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Positive impacts resulting from the channel alterations include increased fish habitat due to naturalizing the channel, increased riparian cover which may assist with moderating temperatures, reduced potential for flash flood events due to the sinuous nature of the proposed channel realignment (ref. Figure 7.12), and increased wildlife habitat within the naturalized floodplain.

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.2.3 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) assessed the hydraulic structures within the Black Creek channel between Jane Street to Rockcliffe Boulevard and found there are no cultural heritage resources based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the proposed channel works would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report (ref. Appendix K).

7.2.4 Infrastructure & Utilities

7.2.4.1 Municipal Infrastructure

The subject reach of the Black Creek is proposed to be widened to an approximate top width of 55 m (+/-) from Jane Street to Alliance Boulevard. The infrastructure considerations required for the channel widening include the following (ref. Figure 7.4 and Figure 7.5.):

- A 750 mm diameter storm sewer outlet, located along the northern side of the channel would need to be trimmed to the extents of the widened channel & reconstructed.
- A 525 mm diameter storm sewer outfall coming from Alliance Avenue would need to be trimmed and reconstructed.
- Two (2) combined sewer overflow outlets located downstream of the Rockcliffe Boulevard crossing would need to be trimmed/reconstructed. These include a 1050 mm and a larger rectangular pipe (1.52 x 4.12 m) which would need to be re-aligned to outlet downstream of the Rockcliffe Blvd bridge.
- The 450 mm diameter combined trunk sewer which currently travels beneath the channel on the downstream side of Rockcliffe Boulevard would need to be shifted, as the manhole on the north side would be exposed in the widened channel extents.
- The elevations for the 500 mm diameter watermain travelling beneath the channel are currently unknown, but there is a potential for impact due to channel widening.

A Municipal Infrastructure & Utility Impact Plan has been prepared for the study area, (ref. Appendix L).

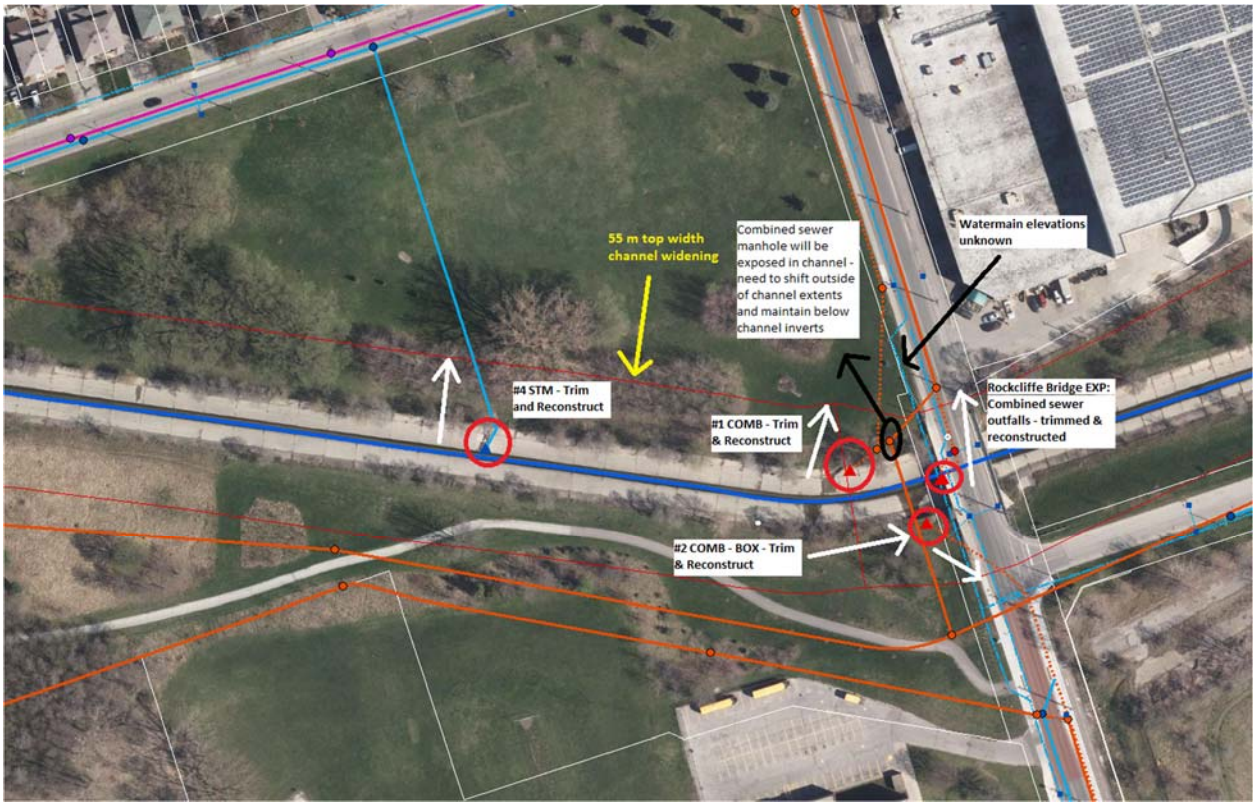

Figure 7.4. Infrastructure Considerations for Black Creek Channel Widening Between Jane Street and Rockcliffe Blvd (2)

7.2.4.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the proposed channel widening and naturalization of Black Creek, between Jane Street to Rockcliffe Boulevard, no private utility conflicts are expected based on existing Utility Records. Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.2.5 Conceptual Costing

A Class D conceptual cost estimate for the channel widening of Black Creek from Jane Street to Rockcliffe Boulevard is $6.25 million, which includes costing elements for the channel works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.2, and an itemized cost breakdown can be found in Appendix M.

Table 7.2. Conceptual Cost Summary - Channel Works from Jane Street to Rockcliffe Boulevard

Proposed Works	Conceptual Cost Estimate
Channel Works (widening, lowering, etc.)	$4,108,000
Municipal Infrastructure	$2,139,000
Utilities (50% Cost Sharing)	-
Total	**$6,247,000**

7.3 Black Creek – Rockcliffe Boulevard Bridge

7.3.1 Structural Assessment

The recommended Rockcliffe Boulevard Bridge is a 52m long, two span (26m and 26m) structure with a proposed width of 15.85m including 1.5m sidewalks on both sides of the bridge. The proposed bridge is assumed to maintain the existing lane width, which will carry one 4.87m wide lane of Northbound traffic and one 4.87m wide lane of Southbound traffic along Rockcliffe Boulevard over Black Creek; the proposed lane width can be refined in future studies as required. For the superstructure type, the use of precast and prestressed boxes is recommended due to clearance issues. Further details and a conceptual general arrangement drawing have been provided in Appendix H.

7.3.2 Geotechnical Assessment

For the proposed 52 m span Rockcliffe Boulevard bridge, the following specific geotechnical recommendations are provided, in addition to general recommendations which are discussed in the Preliminary Geotechnical Investigation Report (ref. Appendix I):

- Deep foundations (driven H-piles or drilled caissons) are the preferred foundation option for bridge piers and abutment structures that are sensitive to settlement. Foundation design parameters for the Rockcliffe Blvd bridge location are provided in Section 6.6.
- Existing fill is 2.4 m thick at the north abutment area, and the fill thickness is 3 m at the south. For preliminary design purposes, the slope should be 3H:1V or shallower with erosion protection (such as vegetation cover) above High Flood Level (HWL). Appropriately designed rock armour protection should be provided below the HWL as per OPSS 1004.
- Due to the uncertainty about the quality of existing fill, any structures (such as retaining walls) above elevation 99 m should be founded on engineered fill. Existing common fill should be sub-excavated and replaced with Granular B Type II (or equivalent) fill. The thickness of such sub-excavation shall not be less than the width of the foundation.

7.3.3 Natural Systems

Within proximity to Rockcliffe Blvd. Black Creek continues within the approximately of 2.5 m wide, 0.6 m deep concrete low flow channel, having a concrete floodplain on each side, approximately 4.5 m wide downstream and 3 m wide upstream, bordered by 1 m to 2 m high concrete walls. Water depth averaged 0.55 m during a July 2019 site visit and >0.6 m during the June 2019 site walk, which followed a period of rain. A large stormwater outfall is present just west of the road. Consistent with upstream and downstream, a vegetation buffer is present north and south of the channel, atop the concrete walls, surrounded by dense urban development. The dense surrounding urban development, concrete channel and low riparian cover are indicative of a warm water system. Fish species inhabiting Black Creek within this area would require tolerance for urban runoff into drainage system.

Potential negative impacts during construction of the chosen alternative include the introduction of sediments, sediment mobilization, concrete and other deleterious substances into the creek, along with disruption of fish life stages and damage and loss of terrestrial/riparian vegetation, and soil compaction. This alternative may also result in disruption of wildlife and, wildlife movement. The width of the chosen alternative (15.85 m) is similar to the existing road (14.85 m), with negligible impacts anticipated due to the slight increase in width (Appendix H). Generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.3.4 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) concluded that the Rockcliffe Blvd. structure would not be considered a cultural heritage resource based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the proposed works would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, located in Appendix K.

7.3.5 Infrastructure and Utilities

7.3.5.1 Municipal Infrastructure

As part of the proposed Black Creek channel widening and structure improvements downstream, the Rockcliffe Boulevard bridge is proposed to be upgraded to a 52 m span bridge. The following infrastructure considerations would be included with these works (ref. Figure 7.5):

- Two (2) combined sewer overflow outfalls (600 mm and 1200 mm diameters) on the existing Rockcliffe bridge would need to be removed and reconstructed at the limits of the bridge expansion.
- The 300 mm diameter watermain on Rockcliffe Blvd. would need to be strung to the bridge.

- Rockcliffe Court would need to be re-aligned to accommodate the bridge expansion; therefore, a new road surface and local storm sewer would be required.
- The 1650 mm diameter combined trunk sewer along Rockcliffe Court should be able to remain as is, despite the road works at the surface.

A Municipal Infrastructure & Utility Impact Plan has been prepared for the study area, and is located in Appendix L.

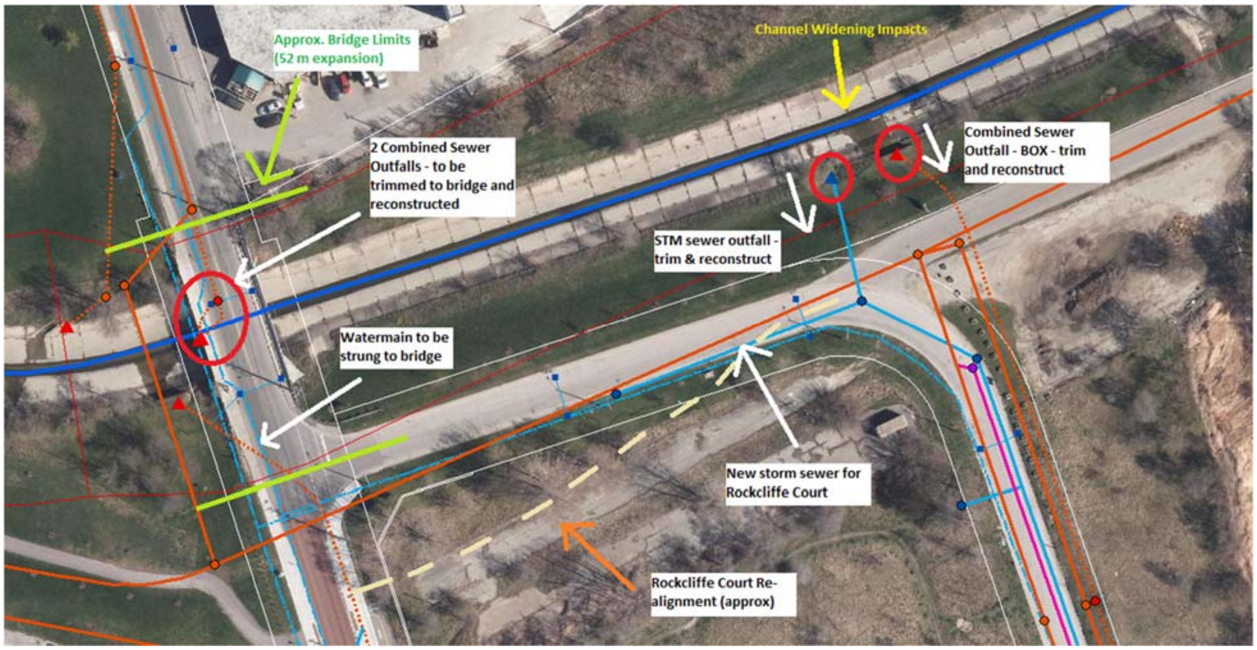

Figure 7.5. Infrastructure Considerations for Rockcliffe Blvd Bridge Expansion and Black Creek Channel Widening

7.3.5.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the Rockcliffe Boulevard preferred alternative and the re-alignment of Rockcliffe Court, T2UE noted the following conflicts with existing private utilities:

- Three (3) Toronto Hydro Poles carrying 2 x 3 phase primary aerial circuits and a joint use telecom are present on the west side of Rockcliffe Blvd and in conflict with the proposed works. The poles to the north and south of the bridge are in conflict with the proposed additional spans. The second THES pole south of the bridge is conflicting with the realigned Rockcliffe Ct. All poles will require relocation, preferably at an offset of 5m or greater from the bridge to allow construction to occur without restriction for crane operation.
- The first two primary THES poles south of the bridge also contain 3 phase primary risers, which sends primary feeders (2 alignments of 5W x 1H duct structures) east on Rockcliffe Ct. These feeders will need relocation to meet the revised riser pole locations. The feeders may also be conflicting with the proposed realignment of Rockcliffe Ct.
- Toronto Hydro Underground 5W1H duct structure, this structure is in the Rockcliffe Blvd right-of-way and will have to relocate to complete the span extension to the South of the existing bridge on Rockcliffe Blvd.

- There is an existing Bell Canada duct structure under the west boulevard of Rockcliffe Blvd, signs indicate that the structure runs within the bridge structure under the west sidewalk. Confirmation of bridge detailed design is required to determine if the cables may remain in place during the addition of the new spans or if a relocation is required. City of Toronto may also wish to force private utilities off the bridge, discussion required with Bell / City to confirm.
- Bell Canada has an existing chamber currently within the west sidewalk of Rockcliffe Blvd. directly adjacent to Rockcliffe Ct. Review with Bell required to determine if the existing chamber can accommodate road loading if the road is to be widened as currently indicated.
- Bell Canada also has an existing conduit / duct structure within the Rockcliffe Ct right-of-way. Realignment of Rockcliffe Ct. may cause conflict with this buried infrastructure, causing relocation.
- Enbridge Gas has an existing 750mm SC HP Vital gas main crossing under Black Creek to the west of the Rockcliffe Blvd bridge, which is not within the SUE QLB investigation limits. Currently the replacement design for the 1050mm storm sewer may conflict with this main. Confirming the alignment of this gas main will be critical to this project's success, as relocation of the main can be approximately $20,000 per/m.
- Enbridge Gas has a 150mm SC IP gas main on the east side of Rockcliffe Boulevard that appears to avoid conflict with the proposed bridge extension. This main may be in conflict with the proposed road base of the realigned Rockcliffe Ct. Test holes will be required to confirm elevation of the gas main where crossing the proposed road base and / or any proposed municipal infrastructure.
- Two (2) THES 5W1H underground structures and two (2) THES chambers exist on Rockcliffe Blvd, and will likely require relocation as a result of the Rockcliffe Ct. realignment, and as a result of the Rockcliffe Blvd THES relocations.
- Bell Canada has an existing conduit / duct structure within the Rockcliffe Ct right-of-way. Realignment of Rockcliffe Ct. may cause conflict with this buried infrastructure, causing relocation.
- Enbridge Gas has a 100mm PE IP service on Rockcliffe Blvd. that may require relocation to the new road alignment. This relocation will likely be required as a result of the Rockcliffe Blvd Enbridge Gas relocation.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.3.6 Conceptual Costing

A Class D conceptual cost estimate for the Rockcliffe Boulevard structure upgrade has been prepared and is estimated to have a cost of $6.0 million, which includes costing elements for the bridge works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.3, and an itemized cost breakdown can be found in Appendix M.

Table 7.3. Conceptual Cost Summary – Rockcliffe Boulevard Bridge

Proposed Works	Conceptual Cost Estimate
Bridge Expansion	$4,808,000
Municipal Infrastructure	$365,000
Utilities (50% Cost Sharing)	$825,000
Total	**$5,998,000**

7.4 Black Creek – Rockcliffe Boulevard to Alliance Avenue – Channel Widening

7.4.1 Channel Widening

As outlined in the Section 7.2.1, the Black Creek channel between Rockcliffe Boulevard to Alliance Avenue is proposed to be widened, lowered and naturalized as part of the preferred flood mitigation alternatives. The channel works are consistent with those proposed for the Jane Street to Rockcliffe Boulevard reach, which will include concrete channel removal and naturalization of the channel system, channel widening to an approximate bottom width of 45 m (+/-) with 2:1 side slopes, resulting in a top width of approximately 55 m (+/-), to increase channel conveyance capacity and accommodate the bridge expansions along the reach. Channel lowering has also been recommended (ref. Section 6.2), to produce a constant slope from Alliance Boulevard to Jane Street, to further reduce flood elevations along the channel reach.

7.4.2 Natural Systems

Black Creek continues within the approximately of 2.5 m wide and 0.6 m deep concrete channel which is lower than the surrounding landscape, having an approximately 3 m wide concrete floodplain on each side, bordered by 1 m to 2 m high concrete walls. Water depth averaged 0.55 m during the July 2019 site visit and >0.6 m during the June 2019 site walk, following a period of rain. Stormwater outfalls are present within this approximately 610 m length of Black Creek and Lavender Creek flows into Black Creek approximately 415 m upstream (east) of Rockcliffe Blvd. Deciduous trees, grasses and shrubs are present atop the concrete walls of channel, providing <30% cover between the road and Lavender Creek, with increased tree density upstream (northeast) of this, providing approximately 75% riparian cover. Lavender Creek is approximately 0.6 m higher than the Black Creek concrete floodplain, which would impede fish movement between the watercourses. Dense urban development is present outside of the vegetated riparian area of Black Creek. The dense surrounding urban development, concrete channel, stormwater runoff and low riparian cover, in areas, are indicative of a warm water system. Fish species inhabiting Black Creek within this area would require tolerance for urban runoff into drainage system.

Potential negative impacts during construction of the chosen alternative include the introduction of sediments and sediment mobilization, introduction of concrete during the removal process and other deleterious substances into the creek. This alternative may disrupt fish life stages, and impact existing habitat along with removal of terrestrial/riparian cover. . Similar to other alternatives, there is a potential to disrupt wildlife and wildlife life processes such as breeding, foraging and movement. Generalized, measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Design the realigned channel and riparian habitat to improve the ecological function from its current state and provide suitable fish and wildlife habitat;
- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to

commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;

- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Positive impacts resulting from the channel alterations include increased fish habitat due to naturalizing the channel, increased riparian cover which may assist with moderating temperatures, reduced potential for flash flood events due to the sinuous nature of the proposed channel realignment (Figure 7.13) and increased wildlife habitat within the naturalized floodplain.

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.4.3 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) assessed the hydraulic structures within the Black Creek channel between Rockcliffe Boulevard to Alliance Avenue and found there are no cultural heritage resources based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the proposed channel works would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, located in Appendix K.

7.4.4 Infrastructure and Utilities

7.4.4.1 Municipal Infrastructure

As part of the proposed channel widening of Black Creek between Rockcliffe Blvd and Alliance Ave, the following implications to municipal infrastructure should be considered (ref. Figure 7.6):

- Two (2) sewer outfalls (975 mm storm sewer and 1.52 m x 4.12 m box combined sewer) from Rockcliffe Court would need to be trimmed to channel extents and reconstructed (ref. Figure 7.7).
- A 900 mm diameter storm sewer outlet from private property would need to be trimmed/reconstructed.
- The 1350 mm diameter combined trunk sewer which crosses Black Creek would have an exposed manhole within the widened channel; therefore, the sewer would need to be re-aligned outside of the channel extents and lowered to remain beneath the channel invert.

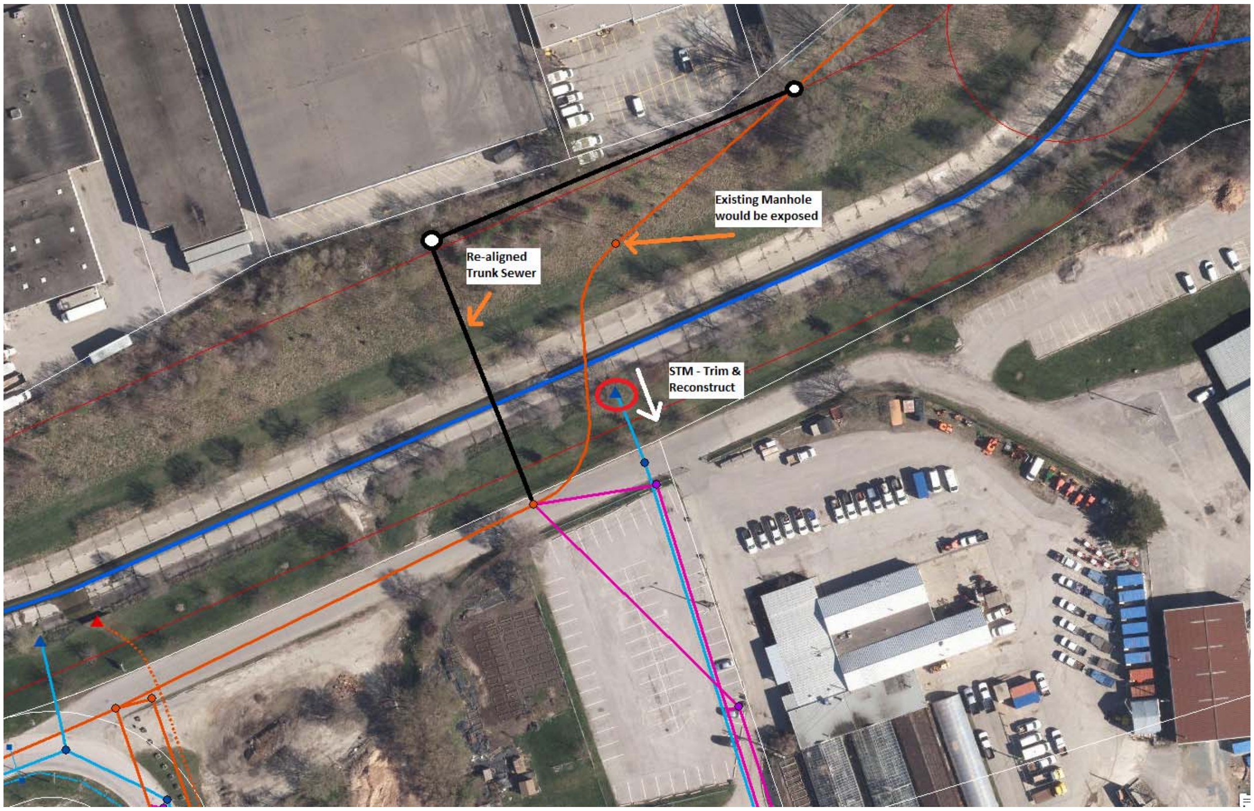

Figure 7.6. Infrastructure Considerations for Black Creek Channel Widening Between Rockcliffe Blvd and Alliance Ave (1)

For the section of Black Creek from Alliance Avenue to the confluence with Lavender Creek, the following infrastructure implications should be considered (ref. Figure 7.6):

- Three (3) storm sewer outlets (300, 900, 1050 mm diameter) would need to be trimmed and reconstructed within channel limits.
- Currently, there would be at least four (4) combined sewer manholes exposed within the widened channel (various sizes). The multiple connections on the south bank would need to be moved East, and if possible, have a single connection travelling beneath Black Creek to the trunk sewer on the north bank.
- A combined sewer storage pipe (1.88 m x 2.59 m) is located on the south bank, behind the western houses on Hilldale Road. Depending on the extent and alignment of both Black Creek and the Lavender Creek connection, the combined sewer storage pipe and connecting sewers may be impacted. Re-alignment of the storage pipe along the residential property limit may be required.

A Municipal Infrastructure & Utility Impact plan has been prepared for the study area, located in Appendix L.

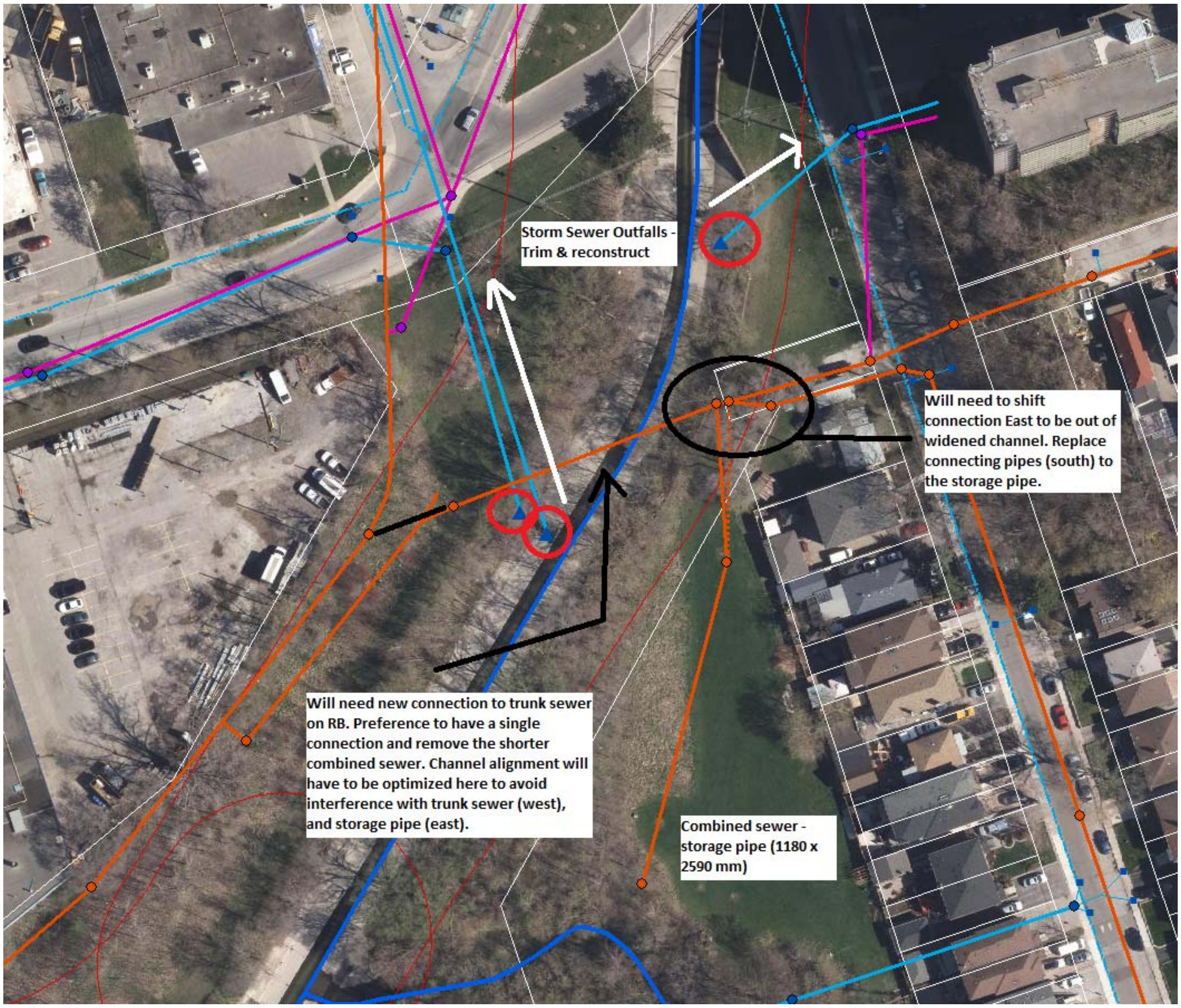

Figure 7.7. Infrastructure Considerations for Black Creek Channel Widening Between Rockcliffe Blvd and Alliance Ave (2)

7.4.4.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the proposed channel widening and naturalization of Black Creek, from Rockcliffe Boulevard to Alliance Avenue, T2UE noted the following conflicts with existing private utilities:

- The proposed naturalization limits may be conflicting with two (2) existing THES primary poles and anchors near Hilldale Road and Alliance Avenue. Relocation of both poles outside of the proposed naturalization limits seem feasible.
- Relocation and replacement of two (2) 1050mm storm sewers and chambers within the Alliance Avenue right of way may be in conflict with an existing 150mm SC MP gas main. Confirm presence and alignment of Enbridge (and other utilities) within the area via a QLB investigation for conflict analysis.

- Replacement of a 300mm Storm sewer pipe onto Hilldale Road appears to be in close vicinity to an existing Toronto Hydro pole. Relocation or support of that pole may be required to facilitate the open cut construction likely required to place the new 300mm storm sewer.
- Next steps – confirm locations of existing utility surface features (i.e. poles, anchors) through topographic survey, and determine grading impacts or extent of construction in vicinity of those features. For areas of construction outside of the completed QLB investigation limits, it is recommended that a SUE investigation to QLB accuracy be completed to ensure no additional utilities are present.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.4.5 Conceptual Costing

A Class D conceptual cost estimate for the channel widening of the Black Creek channel between Rockcliffe Boulevard to Alliance Avenue has been prepared and is estimated to have a total cost of $5.80 million, which includes costing elements for the channel works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.4, and an itemized cost breakdown has been provided in Appendix M.

Table 7.4. Conceptual Cost Summary - Channel Works from Rockcliffe Boulevard to Alliance Avenue

Proposed Works	Conceptual Cost Estimate
Channel Works (widening, lowering, etc.)	$ 4,652,000
Municipal Infrastructure	$ 1,131,000
Utilities (50% Cost Sharing)	$12,500
Total	**$ 5,795,500**

7.5 Black Creek – Alliance Avenue to Weston Road – Weston Road Flood Wall

7.5.1 Structural Assessment

As discussed in Section 6.2, the preferred alternative for this location is a flood protection wall on the upstream side of the Weston Road bridge with a crest elevation of 107.4 m (height 0.5 m +/- plus freeboard) to prevent overtopping during a 350 Year Design Storm event. The flood wall would extend 20 m on the left bank of the Weston Road bridge, and 15 m on the right bank, for a total flood wall length of approx. 47 m (+/-) which includes the existing concrete parapet wall for the Weston Road bridge. A conceptual drawing for the flood wall has been prepared and provided in Appendix H.

7.5.2 Geotechnical Assessment

Geotechnical recommendations for the Weston Road flood protection wall fall within general design recommendations for site preparation, shallow foundation and lateral earth pressure, as outlined below. Each of these recommendations are discussed further in the Geotechnical Investigation Report which is provided in Appendix I.

- Site Preparation:
    - For footing excavation into native sand or clayey silt to silty clay, subsequent to stripping/removal of surficial incompetent soils, any exposed soils which contain excessive organic matters and other compressible, weak and deleterious materials (if encountered) should be sub-excavated and removed.
- Shallow Foundation – Spread/Strip Footing:
    - Shallow foundations (spread/strip footings) may be used if the footings are founded on engineered fill, competent clay till deposit, and/or sound bedrock.
    - Recommended bearing capacity for spread footing has been provided in the Geotechnical Investigation Report. The recommended values assume that the soils within the zone of influence of the footing (a depth of about 2 times the footing width below the foundation grade) are not weaker than the indicated subgrade soils.
    - The recommended values should be used for preliminary design in order to assess the feasibility of using shallow foundations and/or assessing the sizes of shallow foundations.
    - For detail design, detailed foundation analyses may be required to confirm that the bearing pressures and corresponding settlements/foundation movements are within tolerable limits.
- Lateral Earth Pressure:
    - It is recommended that non-frost susceptible soil be used as backfill behind retaining walls, which should extend horizontally behind the wall for a distance equal to the depth of frost penetration, which as previously stated is 1.2 m.

7.5.3 Natural Systems

Within this section, Black Creek flows south through a concrete channel and is bordered by concrete walls. The concrete channel commences upstream of Weston Road with limited to no riparian cover. Trees are present sporadically adjacent to the rail bridge. The channel has two (2) drop structures that also impede fish passage.

This portion of Black Creek was visually observed from the adjacent roadways during the July and June 2019 site visits. The dense surrounding urban development, concrete channel and absence of riparian cover within this section are indicative of a warm water system. This section of creek would provide low quality fish habitat and fish species inhabiting Black Creek within this area would require tolerance for urban runoff into drainage system.

Potential negative impacts during construction of the chosen alternative include the introduction of sediments and sediment mobilization as well as introduction of other deleterious substances into the creek (i.e., concrete, and fluids etc.). The alternative may impact fish life stages and existing habitat (inclusive of riparian cover). Generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Design the realigned channel and riparian habitat to improve the ecological function from its current state and provide suitable fish and wildlife habitat;
- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.5.4 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) completed by MHBC concluded that the Weston Road structure would not be considered a cultural heritage resource based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the proposed works at this structure would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, provided in Appendix K.

7.5.5 Infrastructure & Utilities

7.5.5.1 Municipal Infrastructure

The preferred alternative of a flood wall at Weston Road would not impact any of the known buried municipal infrastructure in the areas, as the required work would be primarily be completed above ground, but would have to consider existing parapet wall footings. The infrastructure elevations and locations are to be confirmed in subsequent SUE investigations.

7.5.5.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the Weston Road preferred alternative, T2UE noted the following conflicts with existing private utilities:

- Toronto Hydro street light secondary feed alignment crosses the proposed work area. Contractor will likely require relocation of secondary feed to allow freedom within the workspace. Coordination with THES Street lighting required for temporary removal or relocation.
- A telecommunications conduit / cable was located during the QLB investigation attached to the north side of the culvert. Confirm owner of the cable and determine if in conflict with the proposed works.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.5.6 Conceptual Costing

A Class D conceptual cost estimate for the Weston Road Flood Wall alternative has been prepared and is estimated to cost $360K, which includes costing elements for the structural wall and utility considerations (reported at an assumed 50% cost sharing with private utilities), as there are no known infrastructure considerations for this alternative. The costing has been summarized in Table 7.5, and an itemized cost breakdown has been provided in Appendix M.

Table 7.5. Conceptual Cost Summary - Weston Road Flood Wall

Proposed Works	Conceptual Cost Estimate
Flood Wall	$342,000
Municipal Infrastructure	-
Utilities (50% Cost Sharing)	$17,500
Total	**$359,500**

7.6 Lavender Creek – Channel Widening – Black Creek to Symes Road

7.6.1 Channel Widening

As outlined in Section 5.2.9, the Lavender Creek channel between the confluence with Black Creek to Symes Road is proposed to be widened, lowered and naturalized as part of the preferred flood mitigation alternatives. The channel works will include concrete channel removal and naturalization of the channel system. The channel widening will be to a maximum top width of 22.5 m (+/-) with 2:1 side slopes, resulting in a bottom width of approx. 11.5 m (+/-) to increase channel conveyance capacity. The channel lowering is proposed to produce a constant slope of 0.5% from the confluence with Black Creek, up to the Symes Road culvert crossing. Minor channel works will also be required upstream of the Symes Road culvert, in order to accommodate the culvert upgrade (ref. Section 7.7) and tie into the existing channel.

7.6.2 Natural Systems

Lavender Creek between Black Creek and the Symes Road culvert crossing is within a natural channel, generally ranging from approximately 3 m to 4 m wide, bordered by dense deciduous tree and shrub cover providing approximately 90% riparian cover. Riprap is present along both banks for a short distance downstream (north) of the Symes Road crossing, with the west side riprap unstable. Upstream of Symes Road the creek is within a concrete channel and floodplain within a vegetated riparian area. Depths observed in June 2019 and July 2019 generally ranged from <0.1 m to 0.3 m and <0.1 m to 0.25 m, respectively. At one location, in the upstream portion of this section, an improvised public path through the creek was present, with flat rocks scattered across the channel. This was observed during the July 2019 site visit, with water level less than 0.05 m at this location. Gravel, sand, silt and cobble substrate is present downstream of the Symes Road crossing. Dense urban development is present outside of the vegetated riparian area and the dense riparian vegetation may assist with moderating water temperatures within this section of the creek. Fish species inhabiting Lavender Creek within this area would require tolerance for urban runoff into drainage system and low water levels in areas of the creek would impede fish passage, at least part of the year.

Potential negative impacts during construction of the chosen alternative include the introduction of sediments inclusive of sediment mobilization, introduction of concrete through concrete channel removal, as well as other deleterious substances. This alternative may result in disruption of fish and wildlife life stages, as well as damage and loss of terrestrial/ riparian vegetation and, soil compaction. ,. Generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Design the realigned channel and riparian habitat to improve the ecological function from its current state and provide suitable fish and wildlife habitat;
- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;

- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

Positive impacts resulting from the channel alterations include increased fish habitat due to naturalizing the channel upstream of Symes Road and the reduced potential for flash flood events due to the sinuous nature and widened channel of the proposed realignment (Figure 7.14).

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.6.3 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) completed by MHBC assessed the hydraulic structures within the Lavender Creek channel between the confluence with Black Creek to Symes Road and found there are no cultural heritage resources based on the cultural heritage evaluations as per Ontario Regulation 9/06. Therefore, the proposed channel works would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report (ref. Appendix K).

7.6.4 Infrastructure & Utilities

7.6.4.1 Municipal Infrastructure

Lavender Creek is proposed to be widened and regraded as a natural channel from upstream of Symes Road to the confluence with Black Creek. It is proposed to have a top width of 22.5 m (+/-) and would have the following infrastructure considerations (ref. Figure 7.8):

- The combined sewer storage pipe (1.88 m x 2.59 m) previously discussed as part of the Black Creek widening, may also be impacted under the Lavender Creek widening, depending on the final alignment – the estimated 22.5 m (+/-) top width is indicated in green in Figure 7.8.
- The 525 mm diameter storm sewer outlet from Hilldale Road will need to be trimmed and reconstructed.

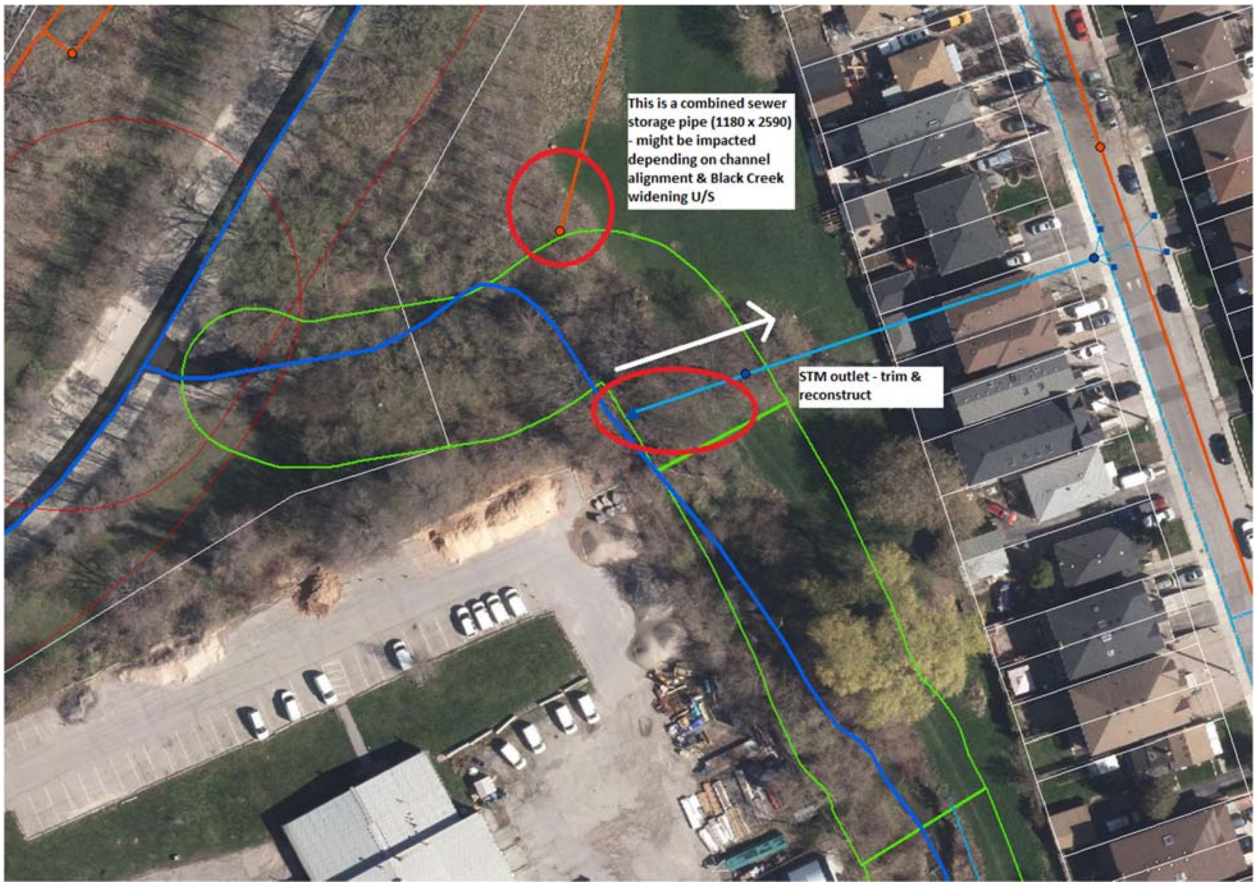

Figure 7.8. Infrastructure Considerations for Lavender Creek Channel Widening Between the Confluence with Black Creek and Symes Road (1)

Continuing upstream, the channel widening would impact the following infrastructure (ref. Figure 7.9):

- A 150 mm diameter watermain which currently travels along the right bank of Lavender Creek will need to be moved out of the widened channel extents.
- The 300 mm diameter storm outlet from Orman Avenue would need to be trimmed and reconstructed.
- The elevations of the 150 mm diameter watermain crossing the channel north of Hillborn Avenue is currently unknown but could potentially be impacted since the channel would be deepened to accommodate the new culvert (ref. Figure 7.9).
- The 675 mm diameter storm sewer outlet from Hillborn Avenue would need to be trimmed and reconstructed (ref. Figure 7.9).

A Municipal Infrastructure & Utility Impact plan has been prepared for the study area, located in Appendix L.

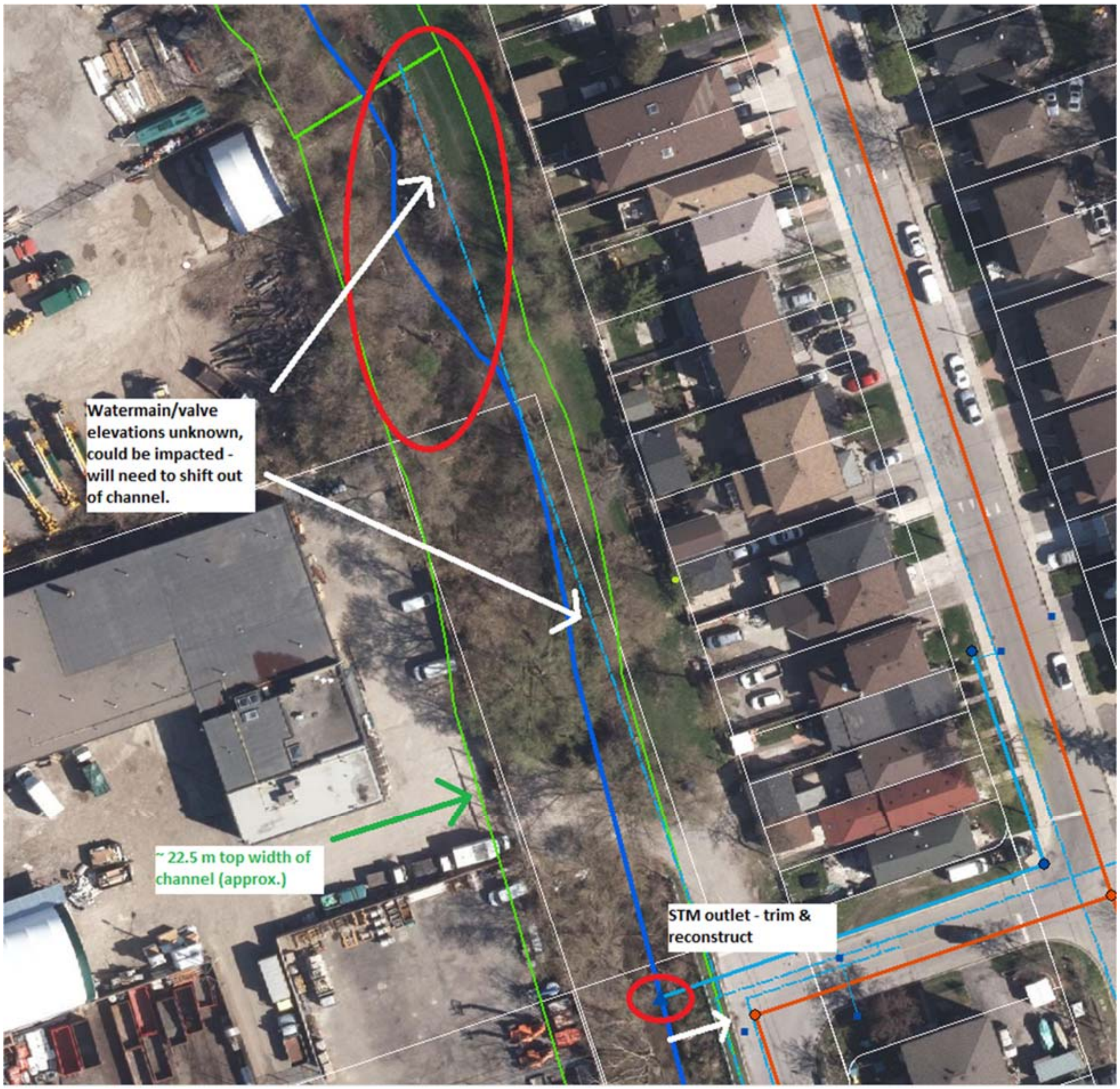

Figure 7.9. Infrastructure Considerations for Lavender Creek Channel Widening Between the Confluence with Black Creek and Symes Road (2)

7.6.4.2 SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the proposed channel widening and naturalization of Lavender Creek, between the confluence with Black Creek to Symes Road, no private utility conflicts are expected due to the channel works alone. Utility conflicts are foreseen as a result of the channel widening to accommodate the proposed structure works at both the northern private crossing and the Symes Road culvert locations, these will be discussed in the subsequent sections. Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.6.5 Conceptual Costing

A Class D conceptual cost estimate for the channel work from the confluence of Black Creek up to Symes Road preferred alternative has been prepared and is estimated to cost $2.89 million, which includes costing elements for the channel works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities), as well as the southern private crossing removal. The channel works is assumed to be completed in two (2) different phases, given the length of the channel and the required coordination with the Lavender Creek structure upgrades; the proposed phasing has been discussed further in subsequent sections. The costing has been summarized in Table 7.6, and an itemized cost breakdown has been provided in Appendix M.

Table 7.6. Conceptual Cost Summary - Lavender Creek Channel Works

Proposed Works	Conceptual Cost Estimate
Channel Works (widening, lowering, etc.)	$2,137,000
Municipal Infrastructure	$752,000
Utilities (50% Cost Sharing)	-
Total	**$2,889,000**

7.7 Lavender Creek – Northern Private Crossing and Symes Road Culvert

7.7.1 Private Crossing

7.7.1.1 Structural Assessment

The new Private Crossing Bridge providing access to the private commercial business at the North end of Symes Road is a 20m single-span structure with side-by-side prestressed concrete box girders. The side-by-side girders will be used to minimize the vertical depth of the structure and therefore improve hydraulic properties at the crossing. The lengthening of the structure will primarily occur on the private property side, contingent on land acquisition.

The roadway cross-section will need to be reconstructed to match existing conditions with one lane for Eastbound traffic and one lane for Westbound traffic. The overall width of the proposed bridge will be similar to the existing bridge.

The construction will be carried with full road closure. Access for the commercial business will only be possible from the West side through Rockcliffe Boulevard.

Further details and a conceptual general arrangement drawings have been provided in the Conceptual Design Report in Appendix H.

7.7.1.2 Geotechnical Assessment

The proposed 20m span bridge across Lavender Creek replaces the existing bridge and provides design flow capacity and an access road to a private property off Symes Road. The channel bottom will also be lowered as part of flood flow enhancement. The Design high flood elevation is understood to be 102.84 m. The access road will have 5157 mm traffic lane with 500 mm shoulder width each way. An existing 150 mm diameter watermain is proposed to be realigned out of the channel widening area.

Based on one borehole, BH12, the stratigraphy at this location consists of silty sand embankment fill overlying loose to compact sandy silt. The borehole was terminated within the upper sandy silt stratum and therefore complete stratigraphy could not be described for the purpose of this Feasibility Study. As such, additional investigations should be carried out to fully understand the subsurface condition at this location during the next stages of planning and design. As such, the following recommendations are preliminary in nature and are in reference to the Geotechnical Investigation Report provided in Appendix I.

- Deep foundations (either driven H-piles or drilled caissons) are the preferred foundation option. Design recommendations discussed in Section 6.6 can be followed for deep foundation design for a preliminary design.
- For shallow footings and retaining walls (such as for wing walls) founded on compact to dense sandy silt layer, bearing capacity values provided in Table 6.5, and lateral earth pressure coefficients provided in Table 6.2, can be considered.
- Due to the anticipated 5.6 m fill overlying loose to compact sandy silt, the Symes Road bridge abutment slope should also be graded to not steeper than 3H:1V. Alternatively, structural elements such as piles can be designed to withstand slope induced lateral load, similar to the abutment slope recommendations provided in Section 7.2 for the Jane Street bridge replacement.

7.7.1.3 Natural Systems

As stated in Section 7.6.2, Lavender Creek between Black Creek and Symes Road is within a natural channel, generally ranging from 3 m to 4 m wide and <0.1 m to 0.3 m deep, bordered by dense deciduous trees and shrubs providing approximately 90% riparian cover. Gravel, sand, silt and cobble substrate is present and shallow water, <0.1 m deep, was observed within and adjacent to this bridge. Dense urban development is present outside of the vegetated riparian area and the dense riparian area may moderate temperatures within Lavender Creek.

Potential negative impacts during construction of the proposed bridge crossing include the introduction of sediments/sediment mobilization and introduction of deleterious substances (e.g., concrete and fluids etc.). This crossing may also impact fish and wildlife life cycle stages/processes as well as result in damage or loss of vegetation/riparian cover and soil compaction. Some generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;

- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

The increased bridge width from 13.4 m to 20 m will require the removal of vegetation, however this also provides better conditions during high water events and may reduce the potential for channel erosion (Appendix H).

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.7.1.4 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) for the Private Crossing structure concluded that it would not be considered a cultural heritage resource based on the cultural heritage evaluations as per Ontario Regulation 9/06. One property, located at 150 Symes Road, was identified to be a cultural heritage resource as designated under Part IV of the Ontario Heritage Act. However, this property is located approx. 400 m away from the proposed works along Lavender Creek and will not be impacted. Therefore, the proposed works at this structure would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, provided in Appendix K.

7.7.1.5 Infrastructure and Utilities

Municipal Infrastructure

There are no direct implications to the local municipal infrastructure associated with the expansion of the private crossing on Lavender Creek. This is being confirmed by the ongoing SUE investigation.

SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the northern Private Crossing on Lavender Creek preferred alternative, T2UE noted the following conflicts with existing private utilities:

- The existing structure is to be removed and replaced with a widened bridge. Minimal private utility conflicts foreseen with exception to a Bell Canada service conduit indicated to enter the property containing the proposed bridge. Confirm existence and alignment of service in the proposed bridge and naturalization area for conflict assessment.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.7.1.6 Conceptual Costing

A Class D conceptual cost estimate for the Private Crossing preferred alternative has been prepared and is estimated to cost $2.07 million, which includes costing elements for the bridge works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.7, and an itemized cost breakdown has been provided in Appendix M.

Table 7.7. Conceptual Cost Summary - Symes Road Northern Private Crossing

Proposed Works	Conceptual Cost Estimate
Bridge Expansion	$ 2,070,000
Municipal Infrastructure	-
Utilities (50% Cost Sharing)	-
Total	**$ 2,070,000**

7.7.2 Symes Road Culvert

7.7.2.1 Structural Assessment

The new Symes Road Culvert is a twin 5.4m by 1.8m precast box culvert structure. An existing trunk sewer (2886 x 2591 mm) on top of the existing culvert will require temporary support or temporary relocation to accommodate the construction work and installation of the new culvert panels.

The roadway cross-section will need to be reconstructed to match existing conditions with one lane for Northbound traffic and one lane for Southbound traffic. The construction will need to be carried out with full road closure; thus temporary traffic conditions will need to be assessed in future studies as required.

Further details and a conceptual general arrangement drawing have been provided in the Conceptual Design Report in Appendix H.

7.7.2.2 Geotechnical Assessment

At present, Lavender Creek (a tributary to Black Creek) flows through a single culvert crossing at Symes Road. The creek flow capacity will be increased with provision of twin 5.4 m x 1.8 m precast box culverts. The invert of the culvert is 101.75 m at the upstream and 101.3 m downstream with a slope of 1%. Wingwalls or retaining walls are proposed at the inlet/outlet of the culvert structure.

Based on BH-11 advanced at this location, the founding stratum of the box culverts will be alluvial or shallow water deposited loose to compact sandy silt/silt. With available geotechnical information, it is assumed the stratum below elevation 100 m will be compact sandy silt/silt. As such, it is recommended any soil between elevation 100 m and the underside of the culvert be removed and replaced with Granular A material compacted to 98% SPMDD. A Lean concrete working mat could also be considered. Consideration should be given to the existing 1200 mm diameter combined sewer line which runs underneath the proposed box culverts. This would also provide the working platform for culvert installation and ensure the subgrade integrity. The following recommendations are made in reference to the Geotechnical Investigation Report provided in Appendix I.

- Bearing capacity of the native competent sandy silt founding layer at approximate elevation 100m is provided in Table 6.5. Given that a grade raise of the existing roadway embankment is not required and that the existing native overburden will not experience additional loading in excess of its loading history, settlements of the culverts should be less than 25 mm.

- Excavation for the foundation, dewatering to keep the working platform safe, and protection of existing utilities (such as 1200 mm dia. RCP combined sewer, manhole etc.) are critical components of construction of the Symes Rd box culvert. Refer to Section 6 for detailed discussion on these aspects. Alternatively, an engineered trench box or shoring system (temporary excavation support) could be utilized for excavation support in these materials.
- Due to erosive nature of the founding stratum, and to prevent under-seepage, a cut-off wall shall be provided at either ends of culverts.
- Requirement for erosion protection measures at the inlets and outlets of the culverts should be assessed by a hydraulic engineer in consideration to the design peak flow of the creek and high flood level. As a minimum, rip-rap treatment of the culvert outlets should be in accordance with OPSD 810.01 (Rip-Rap Treatment for Sewer and Culvert Outlets).

7.7.2.3 Natural Systems

Downstream (north) of Symes Road, Lavender Creek flows north, with rip rap along both banks for a short length, which is unstable along the west bank. The riparian vegetation is dense upstream of Symes Road, providing 100% covert in proximity to the culvert. Substrate is comprised of sand, silt, gravel and cobble. Upstream of the culvert the creek flows west through a concrete channel with dense riparian vegetation in proximity to the culvert, providing approximately 75% cover. Water level was low during the June 2019 and July 2019 site visits, with depth <0.1 m and <0.03 m, respectively. Dense urban development is present outside of the vegetated riparian area. The dense riparian vegetation may assist with moderating water temperatures along Lavender Creek within this area. The low water level within the culvert and length of the culvert (40 m) would impede fish passage, at least part of the year.

Potential negative impacts during construction of the proposed culvert replacement include the introduction of sediments and sediment mobilization, as well as potential for introduction of, deleterious substances. The culvert replacement may disrupt fish life stages, and cause damage and loss to riparian vegetative cover in and around the work area. Additional impacts associated with wildlife may also occur, depending on work limits and removal of habitat, and/or timing of work. Generalized measures to minimize/avoid and/or mitigate potential negative impacts are included below, however this is not a complete list and the avoidance/mitigation measures will be determined during the detailed design phase:

- Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
- Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
- Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;

- Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
- Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
- Follow appropriate DFO timing windows to protect fish during critical life stages.

The increased span from 3.5 m to and twin 5.4 m span culvert will help reduce flash flood events which is beneficial to fish and channel stability downstream (Appendix H).

Studies to assess the existing natural system and potential impacts of the proposed works will be required to meet conditions of the future Municipal Class EA and are identified in Section 8.1.2 and 2.4.3.

7.7.2.4 Cultural Heritage

The Cultural Heritage Evaluation Report (CHER) concluded that the Symes Rd structure would not be considered a cultural heritage resource based on the cultural heritage evaluations as per Ontario Regulation 9/06. One property, located at 150 Symes Road, was identified to be a cultural heritage resource as designated under Part IV of the Ontario Heritage Act. However, this property is located approx. 400 m away from the proposed works along Lavender Creek and will not be impacted. Therefore, the proposed works at this structure would not require a review by way of a Heritage Impact Assessment. Further details can be found in the CHER report, provided in Appendix K.

7.7.2.5 Infrastructure and Utilities

Municipal Infrastructure

To facilitate the Symes Road culvert upgrade and associated channel improvements, the following infrastructure considerations would apply (ref. Figure 7.10):

- To accommodate a widened channel and culvert upgrade at Symes Road, the 1200 mm diameter trunk sewer on the south bank which currently travels beneath the existing culvert would need to be re-aligned; preferably out to the road and connect back on the downstream side outside of the channel extents.
- There is currently a 900 mm diameter connection between the two (2) trunk sewers on the Lavender Creek banks on the upstream side of Symes Rd. This connection would be exposed in the deeper and wider channel; therefore, it would need to be relocated, if in fact it is required.

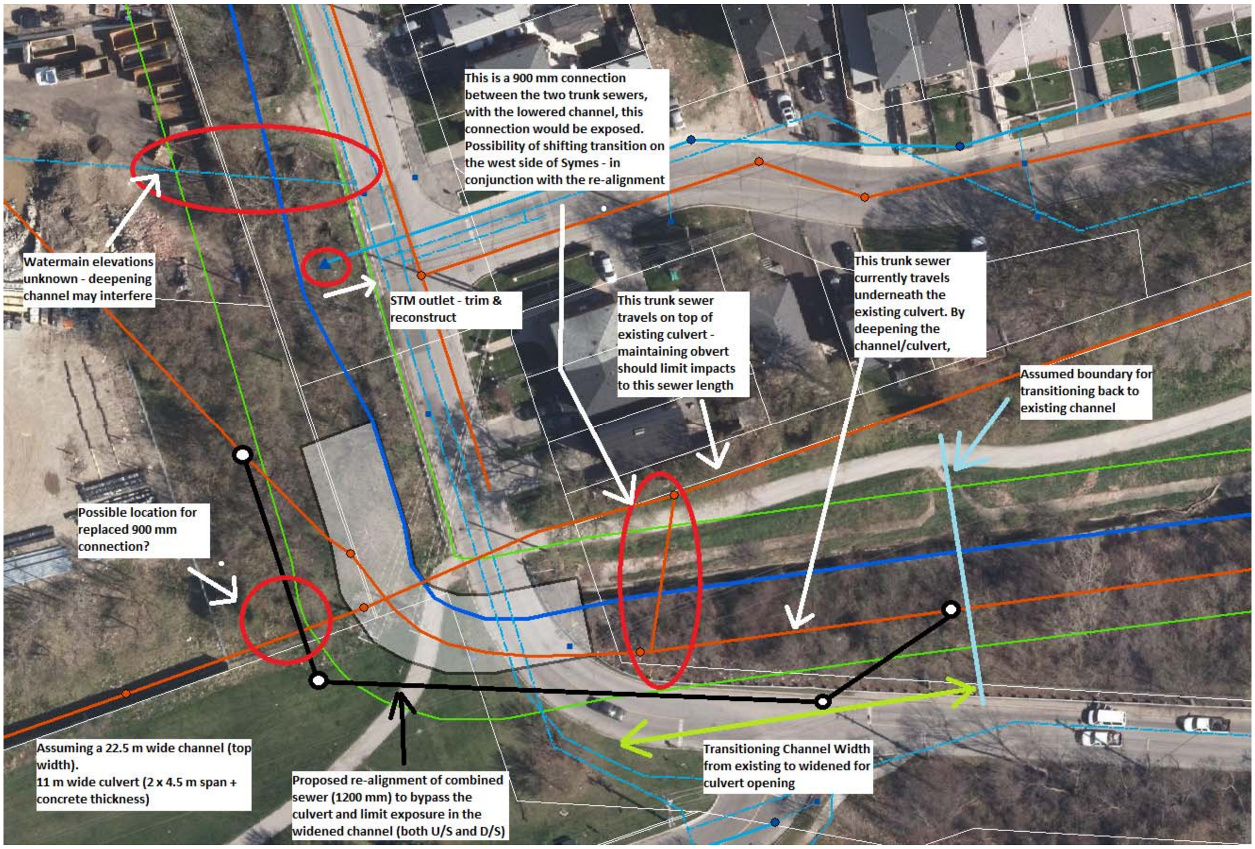

Figure 7.10. Infrastructure Considerations for Lavender Creek Channel Widening and Symes Road Culvert Upgrade

SUE Investigation

A Utility Conflict Assessment and SUE investigation has been completed by T2UE for the study area to assess the potential utility impacts of the preferred alternatives. For the Symes Road Culvert preferred alternative, T2UE noted the following conflicts with existing private utilities:

- The existing and proposed twin box culverts are proposed under an existing Hydro One transmission line (not illustrated within the utility drawings provided). Due to the low elevation of the existing transmission circuits, operation of equipment and construction of the proposed culverts may prove to be extremely difficult. Safe working distance from the closest circuits may be up to 4.5m (for a 230kV line), this could alter the approach to this culvert replacement (precast sections delivered and moved into place via crane may be heavily restricted. Confirmation of circuit elevations must be requested from Hydro One, as circuit elevations can vary greatly during peak periods. Coordination with Hydro One is required.
- The proposed widening of the channel east of Symes Road is reducing the width of the existing Lavender Creek Trail. Hydro One may require this trail as an access to existing Hydro towers in this area. Hydro One also requires that a minimum of 30% of their corridor width remain accessible at all times, which may severely restrict the proposed widening of the creek basin. Further coordination with Hydro One is required.

- Isolation or outages for Hydro One transmission lines are typically not available due to the critical nature of their service, however communication with Hydro One is required to confirm. Summer and winter is considered peak use periods, and therefore outages are typically only available (if at all) during spring and fall off peak periods. As a result, outages are typically not be feasible during cold water construction window (assumed this is a cold-water fishery) of June to August. Further coordination with Hydro One is required to confirm.
- Two (2) existing THES primary poles, complete with risers are in conflict with the proposed culverts on the west side of Symes Road. Relocating these poles is required, however relocation options will be extremely challenging due to the presence of the Hydro One corridor (THES circuits are underground across the corridor due to the low elevation of the transmission circuits). If the THES circuits must remain active during construction, an extensive relocation solution may be required. Further coordination with THES / Hydro One is required to determine an appropriate solution.
- Based on mapping provided, Enbridge Gas and Bell Canada appear to be outside of the impact area.
- It is noted that many municipal utility relocations are occurring outside of the scope of the completed SUE QLB investigation limits. It is recommended that QLB be completed in the area of any proposed municipal utility relocation to minimize risk of utility conflict.

Further details regarding the SUE investigation and the Utility Conflict Assessment can be found in Appendix L.

7.7.2.6 Conceptual Costing

A Class D conceptual cost estimate for the Symes Road Culvert preferred alternative has been prepared and is estimated to cost $5.23 million, which includes costing elements for the culvert works, infrastructure and utility considerations (reported at an assumed 50% cost sharing with private utilities). The costing has been summarized in Table 7.8, and an itemized cost breakdown has been provided in Appendix M.

Table 7.8. Conceptual Cost Summary - Symes Road Culvert

Proposed Works	Conceptual Cost Estimate
Culvert Upgrade	$3,334,000
Municipal Infrastructure	$651,000
Utilities (50% Cost Sharing)	$1,246,000
Total	**$5,231,000**

7.8 Preferred Alternatives – Summary

In summary, the preferred alternatives include the following recommended flood mitigation alternatives:

- Flood protection wall/ berm upstream of the Weston Road bridge with a crest elevation of 107.4 m (0.5 m +/- wall height plus freeboard).
- Lowering and widening of the Black Creek channel reach from Alliance Avenue to Jane Street (50 m to 55 m wide) with average slope from Alliance Avenue to Jane Street (0.20 % +/-).
- Widening the Rockcliffe Boulevard bridge opening to 52 m via two 26 m span openings and lowering the invert of the opening.
- Widening the Jane Street crossing to a 102 m span bridge (72 m required for hydraulics) with three (3) support piers. Additional span width required to accommodate valley side slopes (due to geotechnical constraints).
- Widening, lowering and naturalizing the Lavender Creek channel from Symes Road to the confluence with Black Creek (22.5 m wide +/-) with an average channel slope (0.50 % +/-).
- Removing the unused private crossing on Lavender Creek.
- Replacing the northern Symes Road crossing on Lavender Creek with a 20 m span structure and lowering the invert of the structure.
- Replacing the Symes Road culvert on Lavender Creek with 2 side-by-side rectangular culverts (5.4 x 1.8 m) and lowering the invert by 1 m.

The various preferred alternatives have been depicted on Figure 7.11 to Figure 7.15.

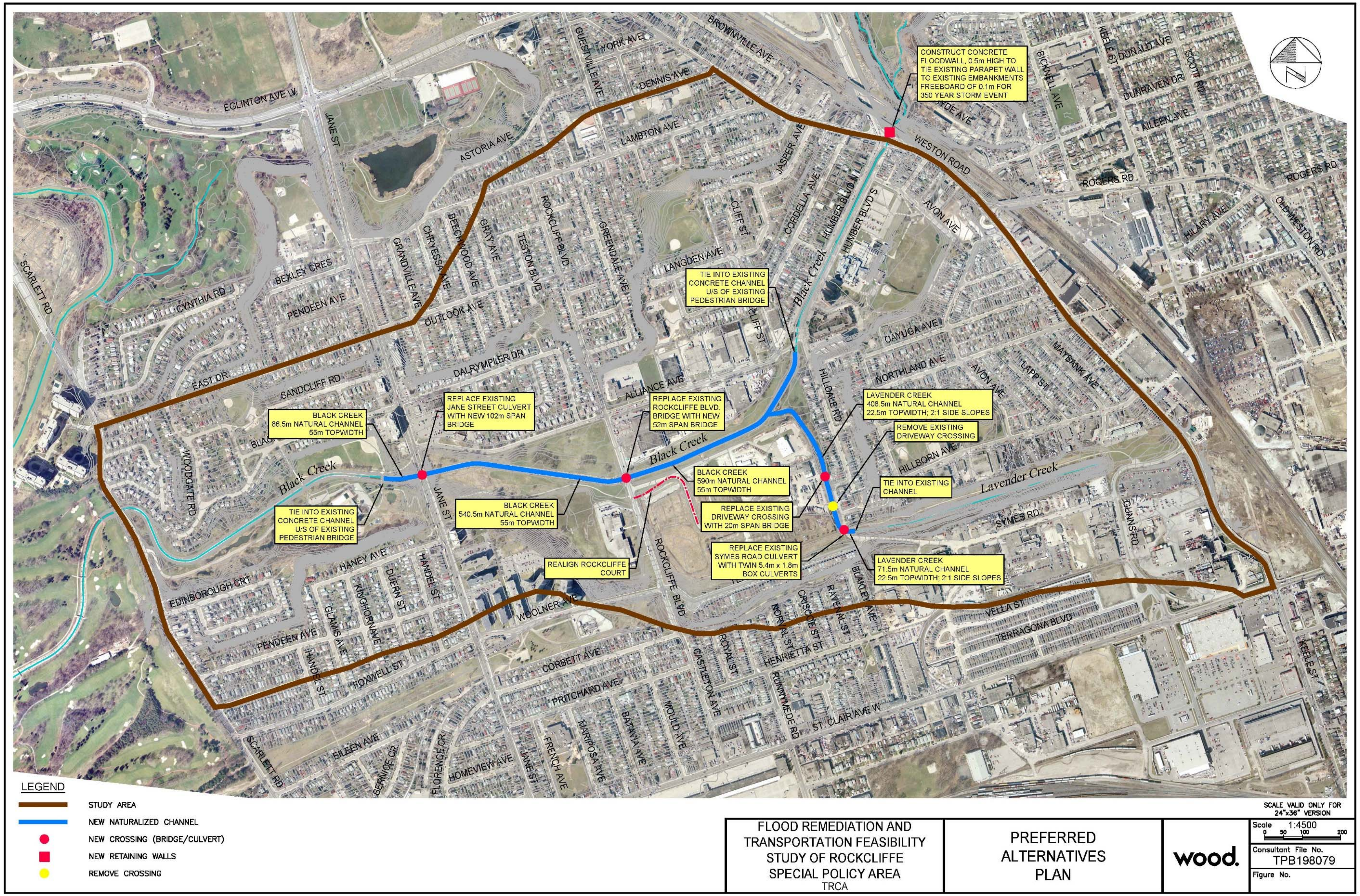

Figure 7.11. Preferred Alternatives Plan

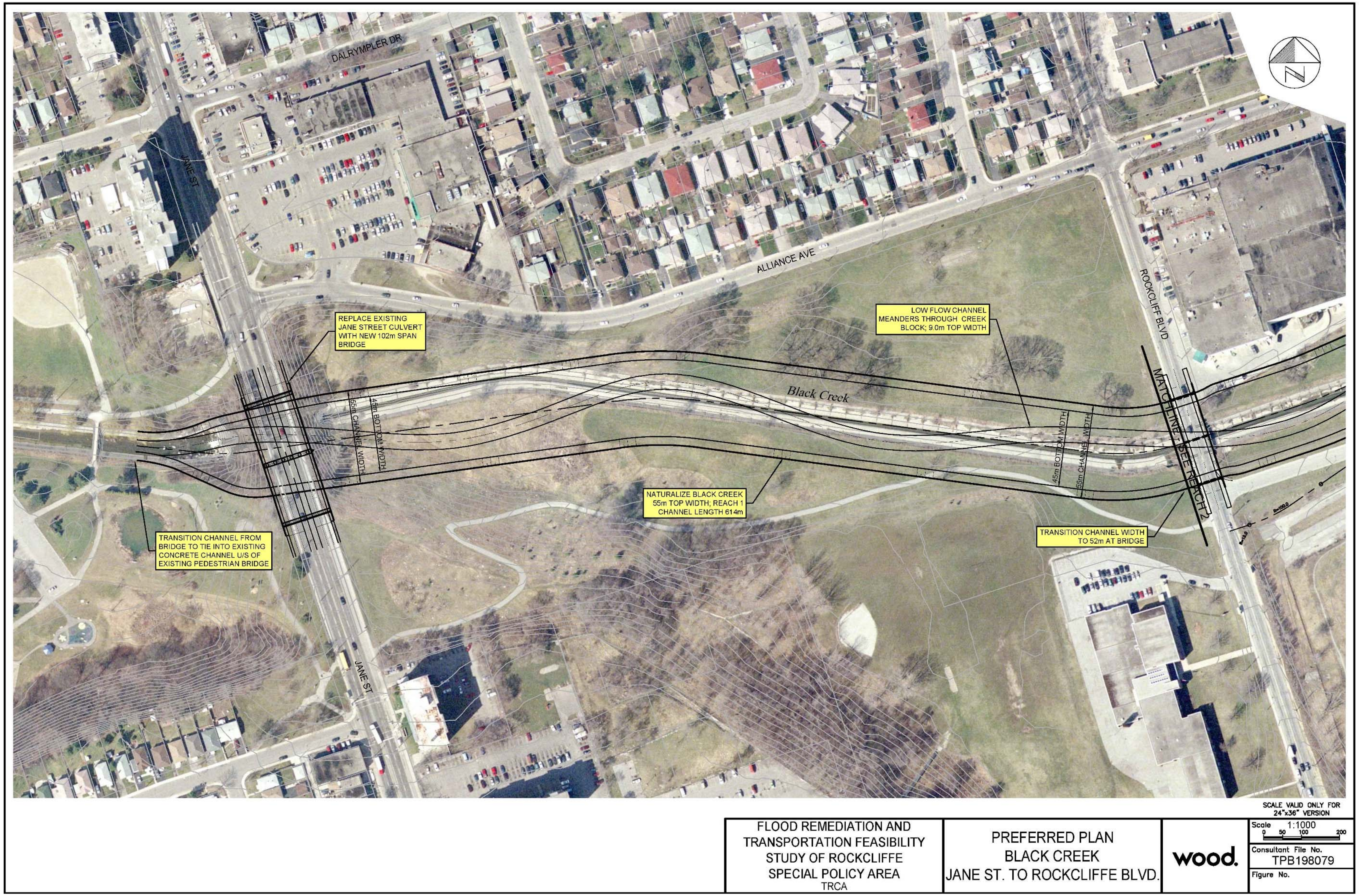

Figure 7.12. Preferred Alternatives – Black Creek - Jane Street to Rockcliffe Blvd.

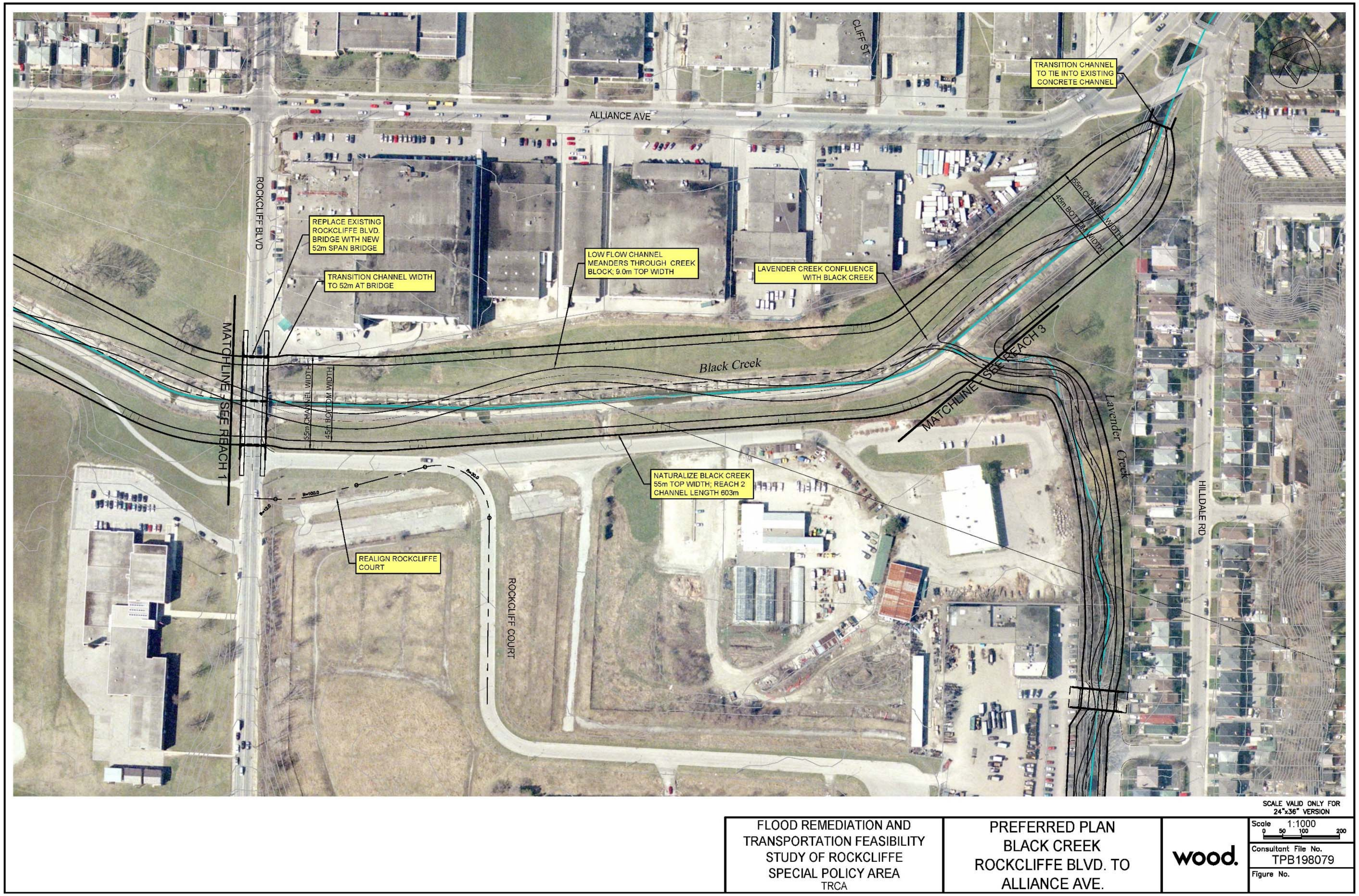

Figure 7.13. Preferred Alternatives – Black Creek – Rockcliffe Blvd. to Alliance Ave.

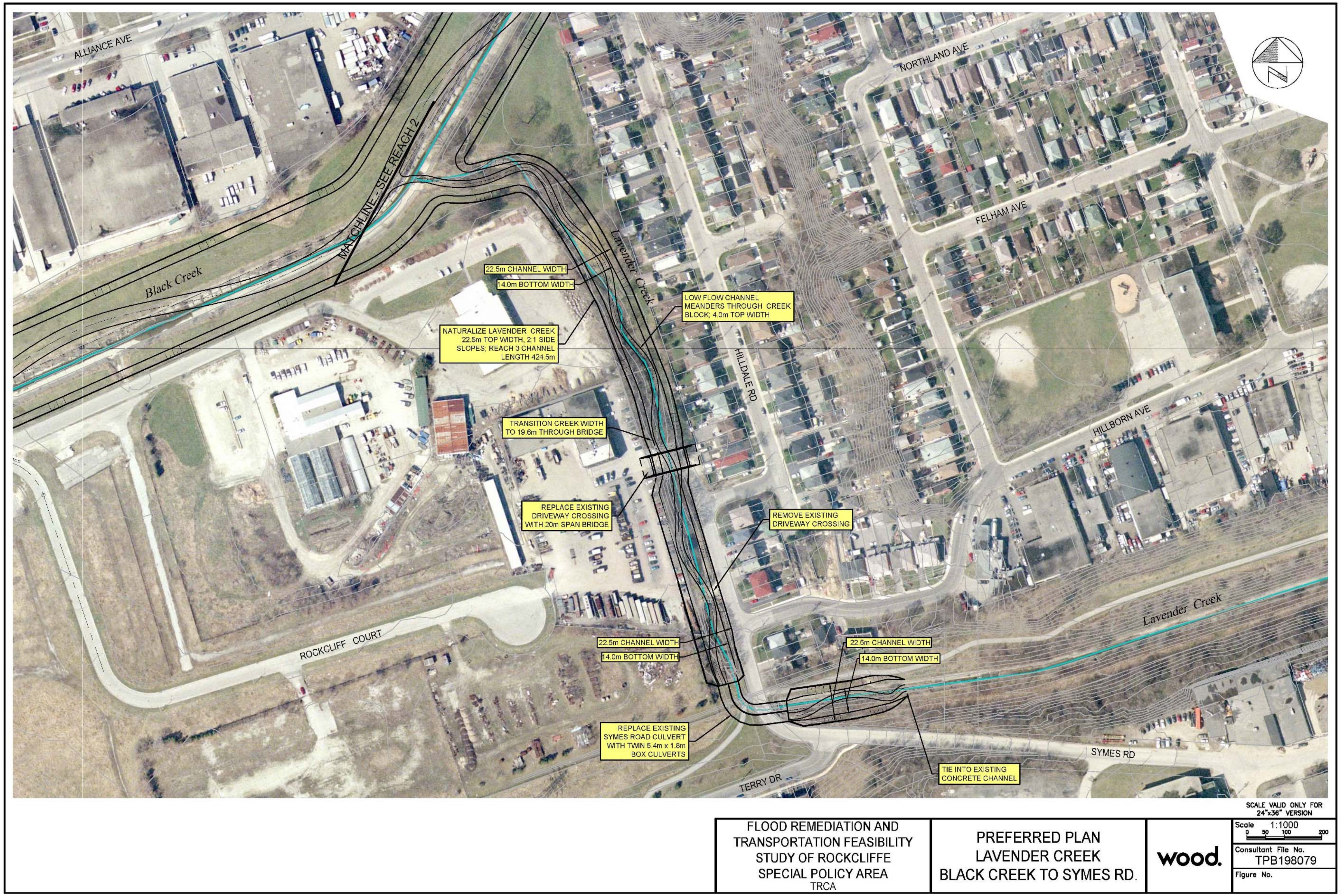

Figure 7.14. Preferred Alternatives – Lavender Creek – Black Creek to Symes Rd.

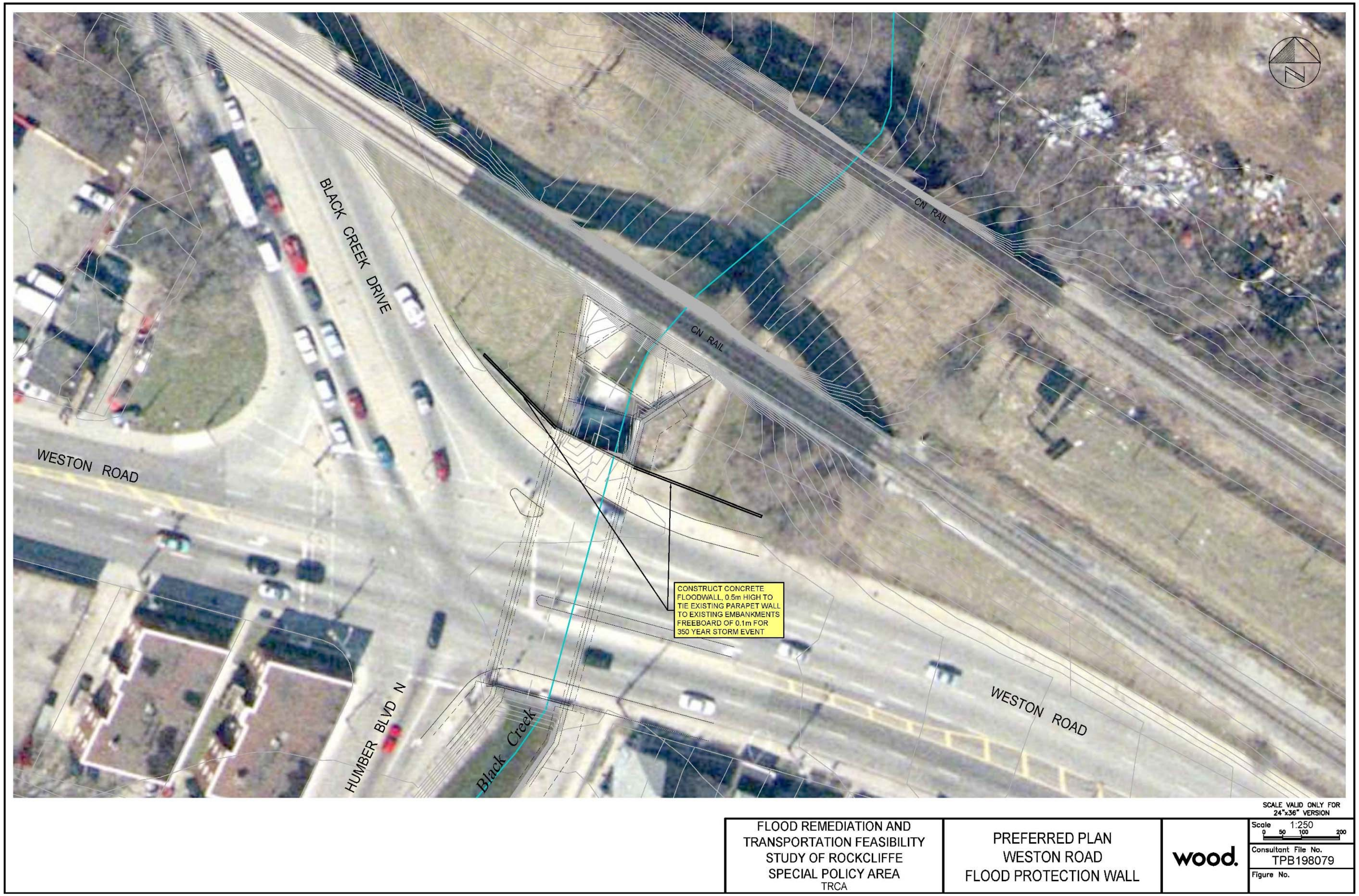

Figure 7.15. Preferred Alternatives - Weston Road Flood Protection Wall

7.8.1.1 Preferred Alternatives Modelling Results

The hydraulic model incorporating the preferred alternatives has been executed for the 2, 5, 10, 25, 50, 100, and 350 year storm events, and the Regional Storm , with the results presented in Appendix G, as maps of maximum water levels, maximum flood depths, maximum velocities and maximum velocity x depth product. The maps of maximum flood depth also provide the extent of flooding for the existing condition for comparison purposes. Table 7.9 provides a comparison of the number of buildings impacted by flooding for existing conditions and with the preferred alternatives implemented, while Table 7.10 presents a summary of maximum water levels for each of the bridges within the study area for the 25, 50, 100 and 350 year storm events and the Regional Storm event.

Table 7.9. Comparison of the Number of Buildings Impacted by Flooding (Existing Conditions vs. Preferred Alternatives)

Storm Event Return Period	Existing Conditions	Preferred Alternatives
Regional Storm	366	184
350 yr	215	3
100 yr	113	3
50 yr	57	3
25 yr	47	2
10 yr	33	0
5 yr	26	0
2 yr	15	0

With the implementation of preferred alternatives there would be a significant improvement in the level of service within the study area. Although the preferred alternatives would not fully eliminate flooding for the Regional Storm event, the alternatives would significantly reduce the number of buildings impacted by riverine flooding from 366 to 184, and would almost eliminate the riverine flooding impact to buildings for all the remaining events analyzed. The 2 to 3 buildings indicated in Table 7.9 that would continue to flood are located at the west end of Black Creek Blvd.; as discussed with TRCA, further refined assessment of the study area would be required in the future Class EA.

The majority of the remaining Regional Storm flood risk locations following the implementation of the preferred alternative would be a result of the undersized Black Creek crossing at Weston Road. The elevated water levels upstream of the bridge would result in overbank spilling to the east and west of the creek as well as overtopping of the proposed flood protection wall. The flooding to the east of Black Creek would occur south along Humber Boulevard South, where it impacts several buildings before the spill re-enters the creek. The flooding to the west of Black Creek would occur south along Humber Boulevard North and Cordella Avenue, where the majority of impacted buildings are located prior to re-entering the creek. While flooding still persists for the Regional Storm event, the extent and depth of flooding for those affected properties would be significantly reduced.

In addition to the overtopping of Weston Road during the Regional Storm event, there is also some overbank flooding at the downstream end of Lavender Creek, however it does not directly impact any buildings; there is also overbank flooding along Rockcliffe Court, where one building is impacted.

Although the preferred alternatives significantly reduce the maximum riverine water levels between Weston Road and Jane Street during the Regional Storm event, the increased flow through the proposed Jane Street bridge would increase the maximum water levels downstream of Jane Street, compared to the existing conditions model (ref. Figure 7.16) due to a reduction in artificial storage upstream of the existing bridge. Based on the foregoing, further assessment of flood conditions downstream of Jane Street will be required in the future Class EA. The increase in peak flows would occur as a physical condition, but would not be considered by regulatory policy as flow attenuation behind structures and would not be considered in preparation of Regulatory floodline mapping.

For all of the remaining design storm events, the riverine flooding within the study area would be mitigated.

Table 7.10. Maximum Water Level at Bridges for Extreme Events – Preferred Alternative in-Place

Branch	Bridge	Chainage	Bridge Invert (m)		Max Upstream Water Level (m)				
			U/S	D/S	Reg	350 yr	100 yr	50 yr	25 yr
Black Creek	Scarlett Road	6754	94.10	93.90	101.50	100.38	99.83	99.47	99.07
Black Creek	Jane Street	5808	96.39	96.34	102.28	101.34	100.88	100.65	100.41
Black Creek	Rockcliffe	5263	97.78	97.76	102.49	101.56	101.11	100.88	100.63
Black Creek	Alliance	4642	99.20	99.20	103.17	102.24	101.88	101.70	101.50
Black Creek	Humber	4610	99.24	99.22	103.23	102.30	101.94	101.75	101.56
Black Creek	Weston Rd	4048	100.87	99.82	109.00	107.10	106.27	105.87	105.47
Lavender Creek	Private Crossing	860	100.83	100.77	102.84	103.21	102.88	102.73	102.54
Lavender Creek	Symes Road	708	101.75	101.30	103.71	104.28	103.85	103.68	103.49

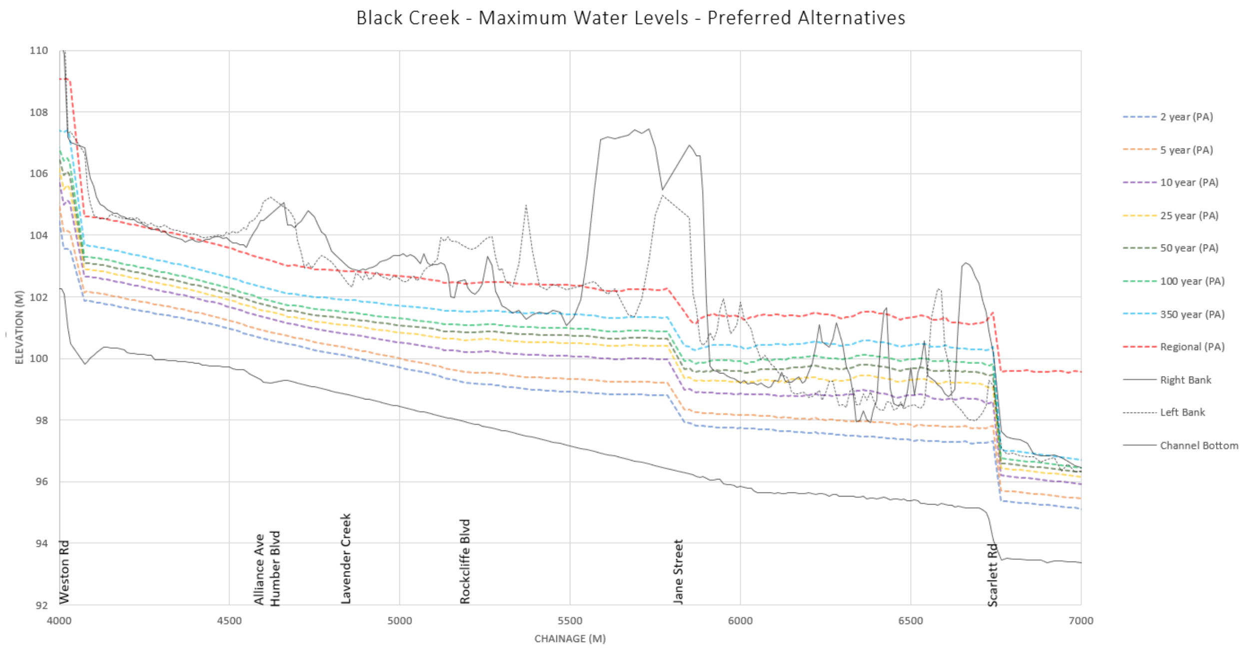

Figure 7.16. Profile of Maximum Water Level during Regional Storm Event

8.0 Flood Remediation Plan

8.1 Implementation Strategy

8.1.1 EA Process and Schedules / Proponency

The Municipal Class Environmental Assessment (MCEA) process classifies projects according to their level of complexity and potential environmental impacts. These are termed "Schedules" and are summarized as follows:

- **Schedule 'A' and 'A+'** include projects that involve minor modifications to existing facilities. Environmental effects of these projects are generally small; therefore, the projects are considered pre-approved. The difference between a Schedule 'A' and 'A+' project is the latter requires a mechanism to inform the public.
- **Schedule 'B'** includes projects that involve improvements and minor expansion to existing facilities. There is a potential for some adverse environmental impacts and, therefore, the proponent is required to proceed through a screening process, including consultation with those affected. Schedule 'B' projects are required to proceed through Phases 1, 2 and 5 of the Class EA process.
- **Schedule 'C'** includes projects that involve construction of new facilities and major expansion of existing facilities. These projects proceed through the environmental assessment planning process outlined in the Class EA document, and are required to fulfill the requirements of all five phases of the Class EA process.

The alternatives outlined in Table 8.1 are categorized as Schedule 'B' projects. Schedule 'B' undertakings, would require consultation with stakeholders, agencies, public and Indigenous Communities. It would also require the need for alternative design evaluation and the preparation of preliminary (30%) design drawings. Although the projects have been categorized as Schedule 'B' undertakings, Schedule 'C' could also be applied for the projects should the City decide accordingly on the more stringent process. Schedule 'C' would require additional public consultation for each project.

These requirements are consistent with those of the Conservation Ontario Class Environmental Assessment (COEA). COEA does not however classify projects under different 'schedules' like the MCEA. Instead, COEA provides guidance on various solutions for specific remedial erosion and flooding problems. Any remedial erosion or flooding problem, being addressed by a Conservation Authority and subject to the COEA must follow the same process. This process is comparable to the Schedule 'B' MCEA process, as both processes include similar requirements. Figures 6.1 and 6.2 include the planning and design processes provided by MCEA and COEA, respectively. Both processes require the following similar phases:

1. Notice of Study Commencement (MCEA) / Notice of Intent (COEA)
2. Establish Mailing List (MCEA)/Establish Community Liaison Committee (COEA)
3. Environmental Inventory
4. Evaluate Alternatives
5. Determine Preferred Recommended Solution(s)
6. Prepare Environmental Study Report
7. Publish Notice of Completion (MCEA) / Notice of Filing (COEA) for Review

In the instances where the MCEA or COEA requirements differ, the more onerous process is to be followed. This would occur in those situations where the MCEA undertaking is classified as anything less than a Schedule 'B', however given that the recommended alternatives are all suggested to be MCEA Schedule 'B' projects, this would not be expected to occur. Based on the anticipated scope of the preferred alternatives, TRCA or the City has been noted as potential Class EA Proponents. Based on consultation over the course of this Feasibility Study, it is understood that the City is considering being the proponent for a future Class EA given the inter-related functionality of the suite of preferred alternatives. As indicated previously, it would be up to the City's discretion to fulfill the Schedule 'B' or the Schedule 'C' requirements. The MEA Class EA should provide the need and justifications for the preferred alternatives, therefore satisfying the needs of the MEA Class EA process..

Table 8.1 provides a summary of the recommended projects emanating from this Feasibility Study and the associated MCEA and COEA requirements, as well as assumed proponency.

Table 8.1. Summary of MCEA and COEA Project Requirements

Description of Alternative	Municipal Class Environmental Assessment (MCEA) Schedule Determination	Conservation Ontario Class Environmental Assessment (COEA)	MCEA/COEA	Potential Proponent
General				
Flood protection wall or berms	**Schedule B –** *15. Construct berms along a watercourse for purposes of flood control in areas subject to damage by flooding.*	Riverine Flooding	MCEA or COEA	TRCA
	16. Modify existing water crossings for the purposes of flood control	Riverine Flooding	MCEA or COEA	City of Toronto
Creek naturalization and channel widening between Jane Street to Alliance Avenue, and from Black Creek to Symes Road	**Schedule B –** *17. Works undertaken in a watercourse for the purposes of flood control or erosion control, which may include:* *- relocation, realignment or channelization of watercourse*	Riverine Flooding	MCEA or COEA	TRCA
Structure Improvements (Jane Street, Rockcliffe Boulevard, Lavender Creek Structures) Altering an existing Bridge (Lowering the invert)	**Schedule B -** *33. Reconstruction of a water crossing where the reconstructed facility will not be for the same purpose, use, capacity but remains at the same location (Capacity refers road capacity but does not include alterations to include or remove facilities for cycling, pedestrians or to support utilities. This includes ferry docks.* *Note: Should no alteration to the structure be required related to adding or removing facilities for cycling, pedestrians or to support utilities, the project would become a Schedule A+.*	Riverine Flooding	MCEA or COEA	City of Toronto
Altering an existing Bridge (Inclusion of relief culverts)		Riverine Flooding	MCEA or COEA	City of Toronto
Widening of Bridge		Riverine Flooding	MCEA or COEA	City of Toronto

The following provides definitions as per the MCEA process, related to the preferred alternatives to be further assessed in the future Class EA.

<u>CULVERT:</u> Means a structure that forms an opening through soil." (CSA-S6-00)

<u>WATER CROSSING:</u> For Municipal Roads: Means a culvert, bridge, tunnel causeway, ferry or other facility or structure carrying a roadway or linear paved facility which crosses a naturally occurring water body or surface drainage feature such as a lake, swamp, marsh, bay, river, creek, stream or man-made drainage facility such as a ditch, canal or municipal drain. As numerous variations in design are possible, the following distinguishing features will be used to differentiate between culverts, bridges and causeways

1. Culverts are usually covered by fill material.
2. Bridges consist of a deck supported by abutments and possibly piers.
3. Causeways are embankments of fill material constructed across bodies of water or wetlands and may include culverts and/or bridges.

Note: For all water crossings, proponents shall contact the local MNRF Office and the Conservation Authority as a minimum.

<u>BRIDGE:</u> Means a structure that provides a roadway or walkway for the passage of vehicles, pedestrians, cyclists across an obstruction, gap or facility and that is greater than 3 m in span." (CSA-S6-00)

In addition to the definitions as per the MCEA Class EA process, the COEA process also provides guidance on alternatives to mitigate riverine flooding. Two main causes of flooding in the riverine system are an increase in water level from a storm event or rapid snow melt, and a result of the formation of ice jams, frazil ice, or other debris in watercourses.

Alternative remedial measures to protect areas from flooding, as outlined within the COEA process, include prevention the entry of floodwater to a specific site or altering the flows through the watercourse systems during flood events. Flows can be altered by increasing the hydraulic capacity of the watercourse, diverting water from flood vulnerable areas and increasing upstream storage. Table 8.2 summarizes alternatives as per the COEA process to mitigate riverine flooding.

Table 8.2. COEA Riverine Flooding Alternative Remedial Measures

Problem Situations	Alternative Remedial Measures	Examples of Alternative Methods/Designs
Riverine Flooding	Prevent Entry of Flood Water	Berming
	Increase Hydraulic Capacity of Waterway	Bridge and Culvert Alterations Bank Regrading Increase Bank Height Revetments Channel Realignment Dredging Dam Decommissioning Ice Control Booms
	Modify River Ice Formation and/or Break-up Processes	Bypass Channel
	Divert Water from Area	Bridge and Culvert Alterations Dry Dams
	Increase Upstream Storage	Weirs

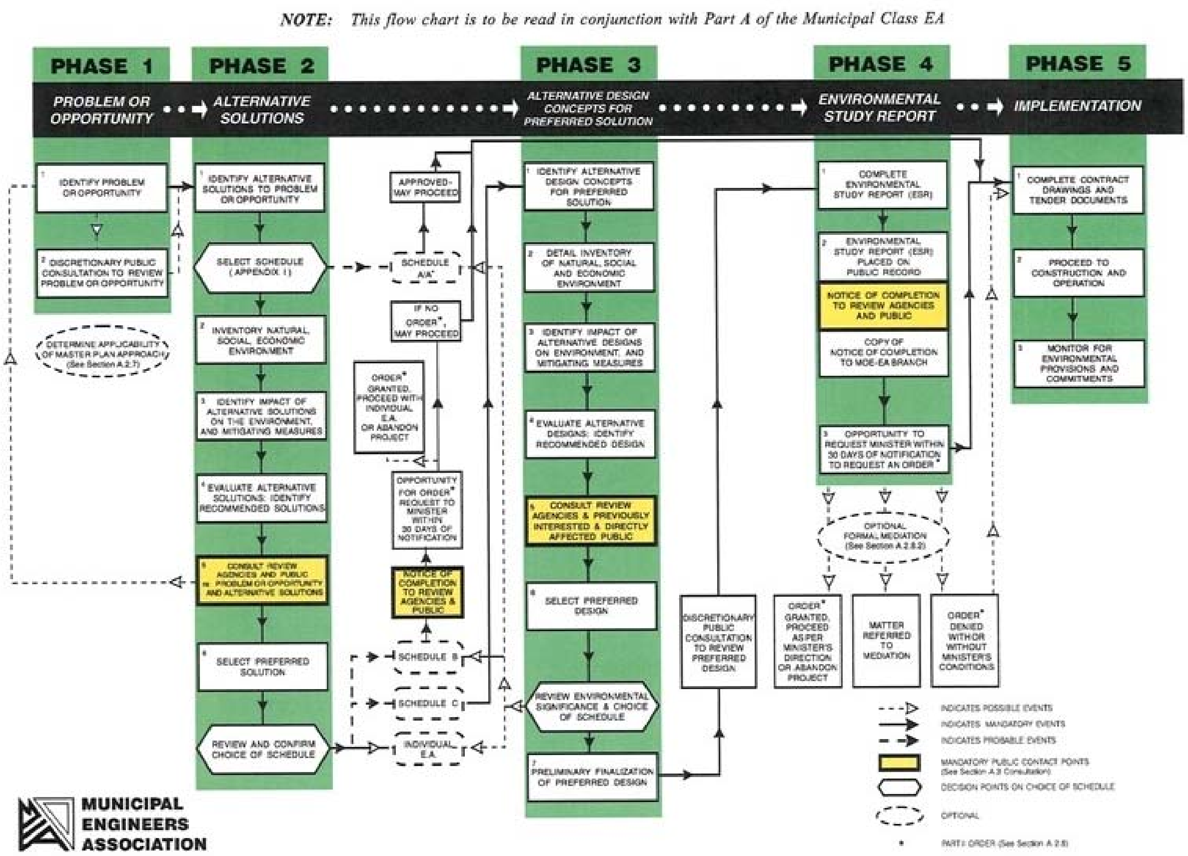

Figure 8.1. Planning and Design Process – Municipal Class Environmental Assessment

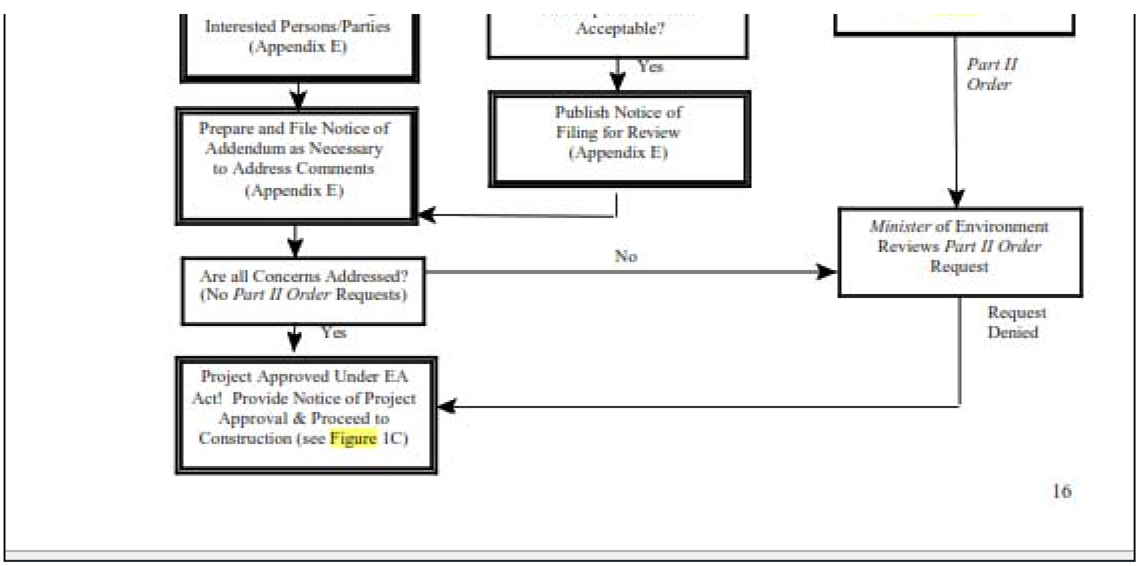

Figure 8.2. Planning and Design Process - Conservation Ontario Class Environmental Assessment

8.1.2 Future Study Requirements

Future studies will be required as part of future Environmental Assessments and follow up studies, as required, based upon the findings from this Feasibility Study, some of which include the following:

- ***Jane Street Corridor Ultimate Condition:*** Based on input from the City of Toronto, the Jane Street roadway at Black Creek, is proposed to be widened to a width of 29.7m including 1.5m sidewalks on both sides of the bridge. The proposed bridge is to carry two 3.5m wide lanes of Northbound traffic, two 3.5m wide lanes of Southbound traffic, and two 2.5m bike lanes along Jane Street over Black Creek. In addition, the City of Toronto has requested the inclusion of a 7.0m wide lane for future LRT construction. Based on a review of the Jane Street right-of-way beyond the limits of the Black Creek Valley, Wood has determined that implementing a 29.7m width for Jane Street would be problematic based on existing right-of-way (ROW) widths and buildings, that are currently within a potential 29.7 m ROW. The future Class EA would need to assess the potential of implementing the 29.7 m ROW or a modified ROW width for the Jane Street crossing of Black Creek. The preferred ROW width would then be used to determine the attainable bridge width.
- ***Lavender Creek North Crossing Configuration:*** The lane widths and sidewalk requirements for the northern Lavender Creek crossing need to be confirmed as part of a future Class EA, prior to the replacement bridge width being established. As part of establishing the roadway configuration, consultation with the private property owner using the crossing should be conducted.
- ***Structural and Transportation Staging Details:*** For each of the four (4) crossings to be upgraded (Jane Street, Rockcliffe Boulevard, Symes Road, Symes Road Private Crossing), preliminary structural and transportation staging details should be prepared. The City of Toronto has communicated over the course of this study, that for construction of the Jane Street crossing, one (1) lane of traffic for each direction would be required. A high-level traffic impact review was conducted to understand the likely impacts, and two potential detour routes were identified to accommodate any excess traffic demand which cannot be accommodated by the lane reduction on Jane Street (from two lanes to a single lane per direction) during construction. Since the assessment of temporary conditions (construction conditions) was not within the scope of the traffic assessment, it was recommended that a more detailed analysis be conducted during the next stages of this study (Class EA) to assess temporary conditions and to confirm the feasibility of the potential detour routes.

  The Rockcliffe Boulevard crossing has also been determined that one (1) lane would have to be maintained. Additional details of temporary lane closures, traffic detours and the associated traffic modelling should be provided in the future Class EA. Structural staging would need to be integrated with the transportation staging.

  The recommended flood mitigation alternative for the Symes Road culvert would not require reconfiguration of the intersection. Notwithstanding, in future, should a reconfiguration be proposed for improved traffic operations, these alternatives should be assessed in the upcoming Class EA.
- ***Jane Street Bridge Configuration:*** To address the poor soils at Jane Street, it has been recommended that a lengthened bridge is preferred from a constructability point-of-view (less staging, traffic control, etc.). Further evaluation of the soils and associated structural arrangement for the Jane Street Bridge should be conducted within the upcoming Class EA.

- ***Refine Hydraulic Modelling:*** It is anticipated that the preferred alternatives will be updated and refined based on additional planning and preliminary design detail. An example relates to the specifics associated with the layout of the Black Creek widening, naturalization and deepening. The coupled 1D/2D MIKE hydraulic model would need to be updated to determine the hydraulic performance of the proposed refinements to the preferred creek reach alternatives. Assessment of Lavender Creek preferred alternatives without the Black Creek alternatives in place should also be conducted.
- ***Properties at Risk:*** It is recommended that the properties at risk of flooding be further refined based upon the updated hydraulic modeling. The impacted buildings and properties are proposed to be identified as part of the future Class EA, to ensure landowner consultation can occur.
- ***Supplemental Homes at Risk on Black Creek Blvd. – Floodproofing & Scarlett Road Crossing:*** The improved hydraulic performance due to implementing the Black Creek preferred alternatives (notably Jane St. bridge upgrade), would result in local increases in flows and flood elevations downstream of Jane Street. There are approximately three (3) homes at the west end of Black Creek Boulevard that may incur flooding at lower storm event return periods. To prevent flooding, the feasibility of floodproofing measures needs to be examined as part of a future Class EA. Additionally, the potential impacts of the Jane Street improvements on the Scarlett Road crossing should be assessed as part of the future Class EA.
- ***Utilities – Identifying Data Gaps:*** The SUE investigation has been completed by T2UE, which encompassed a conflict assessment of both public and private utilities for the proposed mitigation alternatives, based upon the QLB investigation and available mapping. The outcomes of this study found conflicts which will require further investigation, some of which include the following: final re-alignment of municipal infrastructure, private utility relocation options, confirming alignment of Enbridge Gas lines (test holes), detailed QLB investigation of proposed channel widening areas, coordination with Hydro One for construction staging options. The conflict assessment will require further refinement and detail as part of the future Class EA.
- ***Geotechnical – Soil Quality for Removal and Disposal:*** The geotechnical assessment for the Feasibility Study has focused on determining load bearing capacity for constructing structures . To construct the Jane Street Bridge, Rockcliffe Bridge, Symes Road crossings and the Black Creek and Lavender Creek channel improvements, there will be a significant amount of earth removal required. The geotechnical assessment has not conducted a soil quality characterization as per the Provincial requirements in set out in Table 1 Full Depth Background Site Condition Standards. Table 8 Generic Site Condition Standards for Use within 30 m of a Water Body in a Portable Groundwater Condition and Table 9 Generic Site Condition Standards for Use within 30 m of a Water Body in a Non- Portable Groundwater Condition also apply. To determine the number of soil quality samples required for each location, the estimated soil removal volumes should be refined through the future Class EA, as quality sampling is costly.

  At Jane Street, the Black Creek valley is comprised of up to 9 m thick sandy silt/silty sand at surface which could be potentially liquefiable for the design earthquake loading condition of the Jane Street bridge. Seismic liquefaction potential of this layer should be further investigated, preferably with seismic Cone Penetration Testing with Pore Pressure Measurements (sCPTu), during the pending Class EA.
- ***Phase One Environmental Site Assessment (ESA):*** A Phase One ESA should be conducted to identify actual and potential sources of contamination and environmental liabilities within the construction footprints of the preferred alternatives. The preferred alternatives are predominantly located within City of Toronto lands, apart from the private property located immediately west of

Lavender Creek on Rockcliffe Court, that would be required to implement the recommended Lavender Creek widening.

The Phase One ESA would determine the level of risk (low, medium and high) for areas that are considered potentially contaminated, depending on the review of historical environmental reports, documents, plans and through discussion with property owners (including the City) for each location. Depending of the results from the historical data review, areas considered to be of high risk of potential contamination, could have the risk verified through soil and groundwater quality testing as part of the Geotechnical Soil Quality Testing Task.

- ***Natural Systems Assessment:*** Agency consultation (MNRF, TRCA, the City, MECP, DFO) will occur, as required, to confirm the required surveys associated with the proposed project works. Recommendations for ecological assessments and agency consultation are included in Section 2.4.3 and include anuran call surveys, bird surveys, botanical survey including ELC mapping and potential targeted SAR surveys. Based on the proposed works, it is assumed a Request for Review by DFO will be required, and therefore aquatic assessments will be required.

  The ecological assessments will assist with determining mitigation measures which will be determined during the MCEA. General mitigation measures to minimize/avoid potential negative impacts are included below, however this is not a complete list and the mitigation measures will be determined during the detailed design phase:

  - Design bridges, culverts and channel realignments in a manner to increase the ecological function of the study area;
  - Staging and access areas will be minimized as much as feasible to avoid disturbing the natural environment beyond the required disturbance limit;
  - Design and implement standard Erosion and Sediment Control (ESC) measures, consistent with the Erosion and Sediment Control Guideline for Urban Construction, (Toronto and Region Conservation Authority, 2019), and current Ontario Provincial Standard Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) prior to construction. The ESC plan shall be designed to contain/isolate the work area, manage site drainage/runoff and prevent erosion of exposed soils and migration of sediment. ESC measures should be implemented prior to commencement of works, and maintained through all phases of the Project, until vegetation is re-established, and all disturbed ground is permanently stabilized with a vegetative cover. An ESC Plan should be provided as part of the detailed design drawing package. The ESC Plan should illustrate the layout of the proposed ESC measures to be implemented during the course of construction;
  - Implement drip pans under equipment (i.e. generators, pumps, etc.) in operation within the work areas;
  - Any refueling is to be undertaken at least 30 m from any watercourse or any other surface drainage feature as indicated OPSS 180 and OPSS 182; to the greatest extent possible given the limitations imposed by the site layout;
  - Temporarily store, handle and dispose of all materials used or generated (e.g. organics, soils, construction waste and debris, etc.) during site preparation, construction, and clean-up in a manner that prevents their entry to any watercourse. To the extent possible, restrict the temporary on-site storage of sediment generated as part of the Project works; and
  - Follow appropriate DFO timing windows to protect fish during critical life stages.

- ***Archaeologic Assessment – Stage 1:*** A Stage 1 Archaeological Assessment should be conducted to determine the potential for archaeological sites at each of the preferred alternatives locations. A Stage 1 Archaeological Assessment includes a desktop background study and property inspection. Based on each of the preferred alternatives being located on, or adjacent to, a watercourse, there would be strong potential for a Stage 2 Archaeological Assessment to be required, but this would need to verified through the findings of the Stage 1 assessment.

- ***Public and Agency Consultation/Engagement:*** As per the MEA Class EA process, there will be a need to consult the public and affected government agencies. Engagement will also include Indigenous Communities. Consultation for Schedule 'B' level projects would require the following, noting that the City may follow the more stringent Schedule 'C' process:
  - Notice of Study Commencement (MCEA) / Notice of Intent (COEA)
  - Establish Mailing List (MCEA) Community Liaison Committee (COEA)
  - Environmental Inventory
  - Notice of Public Information Centre #1 Existing Conditions Characterization
  - Public Information Centre #1 Existing Conditions Characterization
  - Evaluate Alternatives
  - Determine Preliminary Preferred Recommended Solution (s)
  - Notice of Public Information Centre #2 Alternative Assessment and Preliminary Recommended Solution(s)
  - Public Information Centre #2 Alternative Assessment and Preliminary Recommended Solution(s)
  - Prepare Environmental Study Report
  - Publish Notice of Completion (MCEA) / Notice of Filing (COEA) for Review

8.1.3 Approvals & Permits

As part of the implementation (post-EA) of the proposed preferred alternatives and associated future study requirements, there will be a need for approvals and permits to implement the proposed works. These will include consultation and approvals from various agencies, including:

- *City of Toronto Approval*
  - *Toronto Water:* For proposed alterations to municipal infrastructure.
  - *Toronto Parks, Forestry & Recreation*: For recommended creek improvements within City parks.
  - *Toronto Engineering & Construction Services*: For all engineering works and proposed construction.
  - *Toronto Transportation Services*: For all proposed works impacting road layout and use.
  - *Toronto Corporate Real Estate Management:* To purchase property to facilitate Lavender Creek widening.

- *TRCA Regulatory Approval:* TRCA will be required to approve all works within its regulatory limits.

- *Private Utilities:* Utility companies will be required to approve plans that alter or impact their utilities.

- *Ministry of Environment Conservation and Parks (MECP).* For alterations to infrastructure, that may impact combined or separated sewer conveyance.

- *Department of Fisheries and Oceans (DFO)*: – For temporary and/or permanent impacts to Black Creek and Lavender Creek that would impact fisheries habitat. DFO would not be expected to require extensive consultation, as the creek works would maintain the existing creek lengths and improve fisheries habitat.
- *Indigenous Communities:* Indigenous Communities are required to be consulted in a Stage 3 Archaeological Assessment and are encouraged by the Ministry to Heritage, Sport Tourism and Culture (MHSTC) to be consulted during Stage 1 and Stage 2 Archaeological Assessments. Indigenous Communities may request to review detailed designs of the proposed alternatives, although this is not anticipated.
- *Others:* Public stakeholder groups may request to be involved throughout the planning and design process.

8.1.4 Costing

The cost estimates have been prepared based upon conceptual design assumptions and represent a Class D estimate for the proposed works, which include a mix of structure works, channel works, as well as infrastructure and utility considerations. Through the subsequent MEA Class EA., there will need to be a review and refinement of the conceptual cost estimates, as further details are determined.

The cost estimates for the preferred alternatives have been summarized in Table 8.3 and an itemized cost breakdown can be found in Appendix M.

Table 8.3. Conceptual Cost Summary – All Preferred Alternatives

Preferred Alternative	Conceptual Cost Estimate
Jane Street Bridge Expansion	$27,966,000
Black Creek Channel Widening – Jane Street to Rockcliffe Boulevard	$6,247,000
Rockcliffe Boulevard Bridge Expansion	$5,998,000
Black Creek Channel Widening – Rockcliffe Boulevard to Alliance Avenue	$5,795,500
Weston Road Flood Protection Wall	$359,500
Lavender Creek Channel Widening	$2,889,000
Symes Road Private Crossing Bridge	$2,070,000
Symes Road Culvert Upgrade	$5,231,000
Total Cost Estimate	**$56,556,000**

The total estimated cost for implementing all alternatives is approx. $56.50 million; it should be noted that these are preliminary estimates (Class D) which include costing elements for the proposed structure works, channel modifications and municipal infrastructure considerations; there has been no allowance for design, permitting and land acquisition.

8.2 Prioritization / Phasing Plan

8.2.1 Preliminary Phasing Considerations/Strategy for Flood Mitigation Alternatives

A preliminary Prioritization Plan/Phasing of alternatives has been developed based on the principle of being able to demonstrate action within flood risk areas early, therefore focussing on lower cost/less complex alternatives first which would work towards reducing flood risks, followed by those alternatives providing the greatest flood risk benefit, albeit more costly and more complex to implement. The following is the preliminary recommended phasing strategy and associated justification for the various flood mitigation alternatives.

1. Upgrade Symes Road Crossing of Lavender Creek and Widen/Deepen Lavender Creek to Southern Private Crossing

The primary focus would be to upgrade the Symes Road crossing of Lavender Creek and the associated channel widening/deepening to accommodate the new structure. The existing structure overtops and results in overland flooding during the 2-year event, therefore by improving the conveyance capacity of this crossing, it will result in an immediate flood risk benefit related to high frequency flooding, which will be further improved through the implementation of the subsequent alternatives. The traffic-based performance of the Symes Road preferred alternative is recommended to be assessed under standalone conditions as part of the upcoming Class EA.

2. Remove Southern Private Crossing of Lavender Creek

The removal of the southern private crossing on Lavender Creek is proposed to be implemented as the crossing is not in use and does not require replacement, therefore the structure removal will mitigate any local hydraulic constraints.

3. Construct Flood Wall/Berm at Weston Road

The flood wall proposed at Weston Road is the lowest cost alternative, with limited impacts to municipal infrastructure and utilities. This alternative will provide a 350 year level of service (with downstream improvements in place), by eliminating the overtopping of Weston Road, therefore reducing the overland flooding into the Cordella Avenue neighborhood.

4. Upgrade Jane Street Crossing

The upgrade of the Jane Street crossing is the highest cost of the proposed alternatives, however, will provide significant flood risk benefit. A comparison of maximum water levels for existing conditions vs Jane Street upgrade (alone) has been prepared in Figure 8.3, which demonstrates the flood risk benefit for all events by implementing the upgraded structure. The results presented in Figure 8.3 represent the 72 m hydraulic span of the bridge, however the proposed upgrade is a 102 m span due to soil conditions and geotechnical constraints at Jane Street.

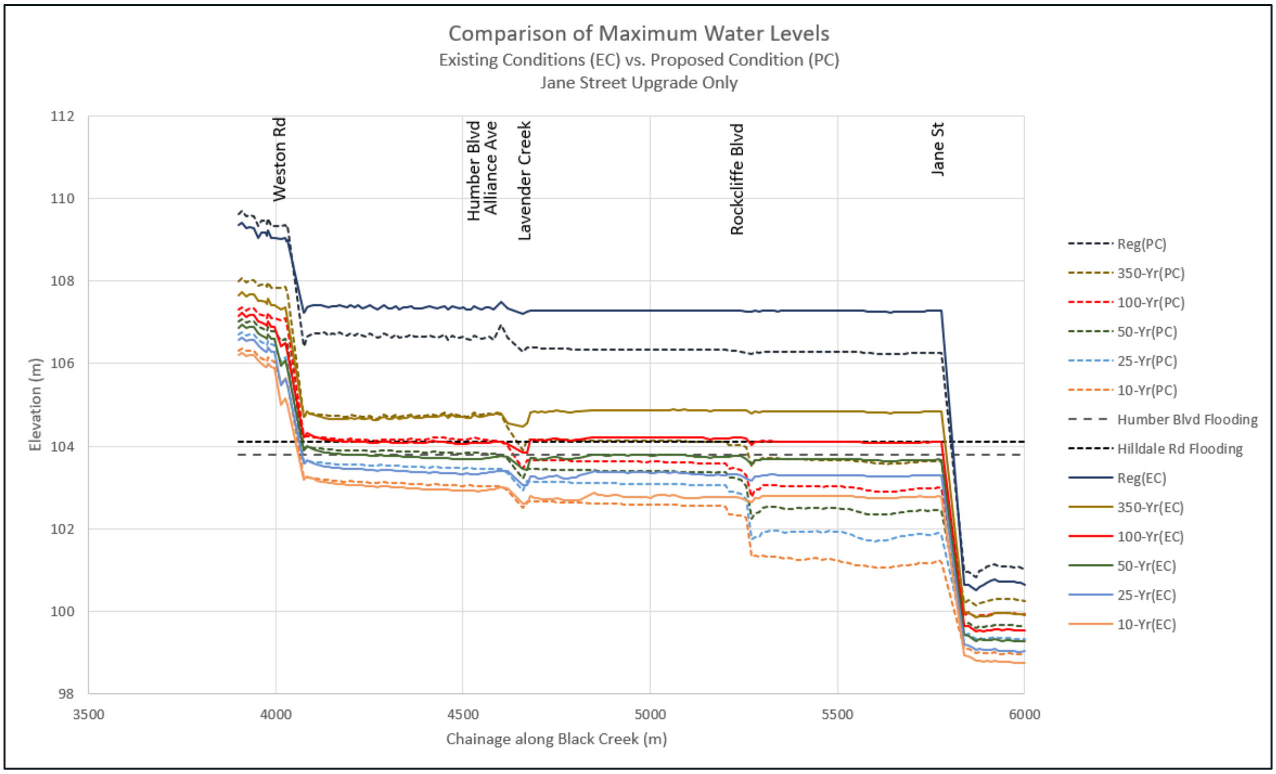

Figure 8.3. Comparison of Maximum Water Levels for Existing vs. Proposed Jane Street 72 m (Hydraulic Span) Bridge for a Range of Storm Events

5. Naturalize, Widen and Deepen Black Creek – Jane Street to Rockcliffe Blvd.

Black Creek is proposed to be naturalized and widened to approximately 50 to 55 m (top width) channel, to provide improved conveyance and accommodate the upgrade of the Jane Street bridge to a 102 m span. In addition to widening, the channel will also be lowered from Jane Street to Rockcliffe Blvd to provide a uniform bottom slope.

6. Upgrade Rockcliffe Blvd. Crossing

With the proposed channel works along Black Creek completed downstream of Rockcliffe Blvd, this can facilitate the construction of the proposed Rockcliffe Blvd bridge to a 52 m span structure. This should be completed subsequent to the Jane Street crossing upgrade and proposed channel works

7. Naturalize, Widen and Deepen Black Creek – Rockcliffe Blvd. to Alliance Avenue

The Black Creek channel works are proposed to continue upstream of the widened Rockcliffe Blvd. crossing, to downstream of Alliance Avenue. The creek bed slope will be maintained in the proposed channel works, to ensure a uniform slope from Alliance Ave to Jane Street.

8. Widen and Deepen Lavender Creek from Southern Private Crossing to Confluence with Black Creek & Upgrade Northern Private Crossing

The channel widening and deepening of Lavender Creek from the southern private crossing to the confluence with Black Creek would be the final stage. With the proposed channel works, the northern private crossing can be upgraded to accommodate the 22.5 m top width of the channel. The proposed works for this section of Lavender Creek should be completed once the flood mitigation alternatives for Black Creek have been implemented as the backwater conditions from Black Creek significantly influence the flooding conditions and hydraulic performance of Lavender Creek.

8.2.2 Transportation Considerations - Staging

As discussed previously, the City of Toronto has communicated that for construction of the Jane Street crossing, one (1) lane of traffic for each direction would be required. To implement one (1) lane of traffic in each direction, a temporary traffic detour plan would be required (ref. Appendix J). As part of the future Class EA, full traffic analyses should be conducted to determine the optimal traffic detour plan.

For the Rockcliffe Boulevard crossing it has been determined that one (1) lane would have to be maintained. Traffic loading should be reviewed to determine if a temporary traffic detour plan is required.

The north Lavender Creek crossing is anticipated to be closed during replacement, with traffic using the Rockcliffe Court for access to properties instead.

The Symes Road crossing of Lavender Creek is anticipated to be closed during construction, with traffic using Hilldale Road for access to properties instead.

Additional details of temporary lane closures, traffic detours and the associated traffic modelling for the proposed structure works should be assessed further and provided in the future Class EA.

8.2.3 Structural Considerations – Staging

8.2.3.1 Jane Street Bridge

Due to the high volumes of traffic along Jane Street, the construction of the bridge would be conducted in stages with roadway protection in the form of soldier piles and lagging. It is anticipated that two stages would be required with traffic being shifted to the newly built section of the bridge to allow for the construction of the remaining half. A high-level traffic impact review was conducted as part of this Feasibility Study to understand the likely impacts, and two potential detour routes were identified to accommodate any excess traffic demand which cannot be accommodated by the lane reduction on Jane Street (from two lanes to a single lane per direction) during construction. Since the assessment of temporary conditions (construction conditions) was not within the scope of the traffic assessment, it was recommended that a more detailed analysis be conducted during the next stages of this study (Class EA) to assess temporary conditions and to confirm the feasibility of the potential detour routes.

It is anticipated that the work could be completed as follows:

- Mobilize and install traffic control measures to allow for one lane of traffic in each direction along Jane Street;
- Install soldier piles;
- Excavate to required depth while simultaneously installing soldier pile lagging to protect roadway above;
- Construct substructure elements for half of bridge;
- Install superstructure elements for half of bridge;
- Construct deck, approach slabs, sleeper slabs, and sidewalks for half of bridge;
- Construct parapet walls for half of bridge;
- Install waterproofing and wearing surface for half of bridge;
- Shift traffic to newly built portion of bridge;
- Excavate and remove existing arch culvert;
- Construct substructure elements for second half of bridge;
- Install superstructure elements for second half of bridge;
- Construct deck, approach slabs, sleeper slabs, and sidewalks for second half of bridge;
- Construct parapet walls for second half of bridge;
- Install waterproofing and wearing surface for second half of bridge; and
- Remove traffic control measures and demobilize.

8.2.3.2 Rockcliffe Boulevard Bridge

For the replacement of the Rockcliffe Boulevard Bridge, it is anticipated that partial closure of the roadway will be required. The work could be completed in one calendar year.

It is anticipated that the work could be completed as follows:

- Mobilize and install traffic control measures to close down traffic along Rockcliffe Boulevard;
- Install piles
- Excavate both approaches of existing bridge simultaneously keeping the height of excavation approximately the same. At no time shall the difference in elevation be greater than 500mm;
- Construct substructure elements for half of bridge;
- Install superstructure elements for half of bridge;
- Construct deck, approach slabs, sleeper slabs, and sidewalks for half of bridge;
- Construct parapet walls for half of bridge;
- Install waterproofing and wearing surface for half of bridge;
- Shift traffic to newly built portion of bridge;
- Construct substructure elements for second half of bridge;
- Install superstructure elements for second half of bridge;
- Construct deck, approach slabs, sleeper slabs, and sidewalks for second half of bridge;
- Construct parapet walls for second half of bridge;
- Install waterproofing and wearing surface for second half of bridge; and
- Remove traffic control measures and demobilize.

8.2.3.3 Symes Road Culvert

For the replacement of the Symes Road Culvert, it is anticipated that full closure of the roadway will be utilized. The work could be completed in six-eight weeks.

It is anticipated that the work could be completed as follows:

- Mobilize and install traffic control measures to close down traffic along Symes Road;
- Temporarily protect/relocate utilities;
- Excavate and remove existing structure;
- Prepare subbase and install new culvert panels;
- Backfill;
- Construct new steel beam guide rail and curbs;
- Install waterproofing and wearing surface; and
- Remove traffic control measures and demobilize.

8.2.3.4 Symes Road Private Crossing

For the replacement of the Symes Road Private Crossing, it is anticipated that full closure of the roadway will be utilized. The work could be completed in eight (8) weeks.

It is anticipated that the work would be completed as follows:

- Mobilize and install traffic control measures to close down access to the bridge;
- Excavate and remove existing bridge;
- Construct substructure elements including piles and abutments and backfill;
- Construct wingwalls/retaining walls along the channel as required;
- Install superstructure elements;

- Construct deck, approach slabs, and curbs;
- Construct barrier system;
- Install waterproofing and wearing surface; and
- Remove traffic control measures and demobilize.

8.2.4 Servicing / Utility Relocation Requirements

The municipal infrastructure and utility impacts associated with each preferred alternative have been outlined in Section 7.0. These impacts/conflicts would need to be considered as part of overall construction staging for each alternative; these will require coordination with the City of Toronto and private utilities, as well as further refinement as part of the future Class EA. A "Municipal Infrastructure & Utility Impacts" plan has been prepared to outline the impacts and associated works as required (ref. Appendix L).

8.2.5 Schedule / Timelines / Construction Costs

Subsequent to completion of this Feasibility Study, the City of Toronto is proposing to conduct a MEA Class EA to fulfil beyond Phases 1 and 2 of the MEA Class EA process. It is anticipated that a MEA Class EA would fulfil the requirements of Schedule 'C' projects, encapsulating all of the preferred alternatives. Based on discussions with the City of Toronto and TRCA at various progress meetings over the course of this study, the Class EA Master Plan is intended to commence in 2020 and could be completed in late 2021.

The City of Toronto has available funding for implementing the preferred alternatives, as such it is anticipated that the following projects could move to detailed design in 2022, subject to successful completion of the Class EA.

- Symes Road Crossing Upgrade: $5,231,000
- Lavender Creek Channel Widening to Southern Private Crossing: $743,000
- Removal of Southern Private Crossing of Lavender Creek: $50,000
- Weston Road Flood Wall: $359,500
- Jane Street Bridge Upgrade $27,966,000

The implementation of the remaining alternatives would be dependent on the available funding from the City of Toronto; however, construction of the alternatives should generally adhere to the alternative prioritization outlined in Section 8.2.1.

9.0 Conclusions and Recommendations

The following conclusions and recommendations have been established based on the findings of this Feasibility Study.

9.1 Conclusions

1. The existing conditions 1D/2D coupled MIKE modelling predicts that the Hilldale Road area adjacent to Lavender Creek has the highest flood risk within the Rockcliffe SPA with flooding risks to homes and infrastructure during a 2 year storm event, largely attributable to the undersized Symes Road crossing of Lavender Creek.
2. Riverine flooding along Black Creek has been predicted to occur at a 10 year frequency, in locations primarily upstream of Jane Street, with the Cordella Avenue area incurring the largest extent and depths of flooding.
3. The primary flooding mechanisms within Rockcliffe SPA along Black Creek include the Jane Street crossing, Rockcliffe Blvd. crossing, the channel configuration and Weston Road crossing.
4. The primary flood mechanisms along Lavender Creek include the three crossings and backwater from Black Creek.
5. The Transportation and Traffic assessment has determined that a detour would be required for the construction of the Jane Street Bridge.
6. Municipal servicing and private utilities at each of the preferred alternatives locations will need to be relocated to accommodate each alternative.
7. The Cultural Heritage Assessment has determined that there are no cultural heritage resources within the vicinity of the preferred flood mitigation alternatives.
8. The preferred alternatives would mitigate riverine flooding for most of the Rockcliffe SPA up to the 350 year storm event, while certain areas would still incur flooding during the Regional Storm.

9.2 Recommendations

1. The preferred flood mitigation alternatives based on this Feasibility Study, and their associated priority phasing are as follows:
    - i. Symes Road culvert upgrade and Lavender Creek improvements from Symes Road to the Southern Crossing.
    - ii. Removal of the Southern Crossing of Lavender Creek.
    - iii. Weston Road Flood Wall
    - iv. Jane Street Bridge
    - v. Black Creek channel widening, naturalization and deepening from Jane Street to Rockcliffe Boulevard
    - vi. Rockcliffe Boulevard Bridge Expansion
    - vii. Black Creek Channel Widening from Rockcliffe Boulevard to Alliance Avenue
    - viii. Widen and Deepen Lavender Creek from Southern Private Crossing to Confluence with Black Creek and Upgrade Northern Private Crossing

2. Subsequent to adoption of this Feasibility Study, City of Toronto in partnership with TRCA to initiate a MEA Class EA to satisfy beyond Phases 1 and 2 of the MEA Class EA process and the requirements for recommended Schedule 'B' alternatives. The City of Toronto at is discretion could decide to conduct a Schedule 'C' Class EA.
3. The future MEA Class EA to incorporate the various future study requirements as outlined herein and listed as per the following:
    i. Assess the Jane Street Corridor ultimate condition and its required right-of-way width.
    ii. Assess the Lavender Creek northern crossing configuration and its required right-of-way width.
    iii. Assess the Symes Road crossing under a standalone condition given proposed priority.
    iv. Further develop structural and transportation staging details through refined traffic modelling.
    v. Refine hydraulic model based on refinements to the preferred alternatives and include consideration of Scarlett Road and properties downstream of Jane Street.
    vi. Address utility data gaps and refine conflict assessment through additional investigation / coordination with private utilities.
    vii. Assess and refine municipal infrastructure impacts / proposed re-alignments with the City of Toronto (Toronto Water).
    viii. Soil quality testing for removal and disposal of material.
    ix. Phase One Environmental Site Assessment (ESA).
    x. Archaeological Assessment – Stage 1.
    xi. Natural Systems assessment.
    xii. Public and agency consultation/ engagement.
4. That currently available funding from the City of Toronto be used to implement flood mitigation alternatives to the extent feasible, and that additional funding sources be considered for implementing the remaining alternatives.
5. It is recommended for the City of Toronto to incorporate the MIKE hydraulic modelling results in identifying the need for storm and combined sewer backflow prevention to prevent local basement flooding.

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