Etobicoke Creek Watershed

Future Management Scenario Analysis Report

July 2022

EXECUTIVE SUMMARY

Watershed planning helps to characterize overall watershed conditions and identify measures to protect, restore, or enhance the health of the watershed.

The last Etobicoke Creek watershed plan was developed in 2002 with a Technical Update completed in 2010 that filled data gaps from the original plan and used updated scientific methods. It is important to regularly update watershed plans to review progress from previous plans, reflect current conditions, use the latest science, policies, and best practices, and adjust management approaches.

A new watershed plan for the Etobicoke Creek watershed is being developed, and is a multi-year, multi-partner exercise. For the purposes of the Etobicoke Creek Watershed Plan (ECWP), the main partners involved in plan development are Toronto and Region Conservation Authority (TRCA), City of Toronto, Region of Peel, City of Mississauga, City of Brampton, Town of Caledon, Mississaugas of the Credit First Nation, and the Greater Toronto Airport Authority. Broader stakeholder and public engagement plays an important role in the development of the watershed plan to ensure it reflects the perspectives of watershed residents and landowners.

The watershed characterization stage of the watershed planning process has been completed, and an updated Watershed Characterization Report was released in June 2021 as part of this watershed plan update.

The purpose of the future management scenarios stage of the watershed planning process is to examine different potential future land use scenarios to understand how watershed conditions may change. This Future Management Scenario Analysis Report presents the findings from extensive watershed modelling and technical analyses, and is organized as follows:

1. Introduction – provides an overview of watershed planning, the future management scenarios stage, and the various future management scenarios analyzed as part of this process.
2. Future Watershed Conditions – identifies the findings and results of the future management scenarios stage and comprises the bulk of this report. This section explains the various technical analyses completed, identifies key findings, and presents detailed results for each technical component.
3. Methodology – provides an overview of the technical methodologies used to complete the analyses for each technical component outlined in Section 2.
4. Maps – contains the maps referenced as figures throughout the report.
5. Glossary – contains the glossary of key terms used throughout the report.
6. References – contains applicable references by subject matter.

Etobicoke Creek forms the western end of TRCA's jurisdiction, originating just south of the Oak Ridges Moraine in the Town of Caledon before flowing through the Cities of Brampton, Mississauga, and Toronto, where it enters Lake Ontario. Urban land uses currently represent 59.5% of the watershed, up from 53.4% in 2002. Approximately 12.3% of the watershed is currently natural cover, down from 14.1% in 2002. Due to the heavily urbanized nature of Etobicoke Creek, there are issues related to flooding and erosion, water quality, low natural cover, and degraded terrestrial and aquatic habitat.

Figure 1 - Aerial Photo, Etobicoke Valley Park

The information contained in this Future Management Scenario Analysis Report will inform the next stage of the watershed planning process: implementation planning. In the implementation planning stage, a management framework will be developed to inform land use and infrastructure planning that improves watershed conditions. An updated watershed plan can be used to assist TRCA and its municipal partners to ensure a cleaner, healthier, and more sustainable Etobicoke Creek.

Watershed Vision:

Etobicoke Creek watershed is protected and restored to a cleaner, healthier, and more natural state, to sustain its waterways, ecosystems, and human communities.

In the fall of 2020, TRCA engaged local stakeholders and residents on what they would like to see in a watershed vision using an online survey. Variations of a vision based on these results were presented to the Steering Committee, consisting of the municipalities within the watershed, TRCA, Mississaugas of the Credit First Nation, and the Greater Toronto Airport Authority. The vision for the Etobicoke Creek watershed noted above reflects survey feedback and was agreed to by Steering Committee members.

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Acronyms

BMI	Benthic Macroinvertebrates
CEW	Cumulative Effective Work
DCI	Dendritic Connectivity Index
DCIA	Directly Connected Impervious Area
DEM	Digital Elevation Model
DPSI	Depression Storage Parameter
ECWP	Etobicoke Creek Watershed Plan
ELC	Ecological Land Classification
FBI	Family Biotic Index
FVC	Flood Vulnerable Cluster
GTA	Greater Toronto Area
HDF	Headwater Drainage Feature
IBI	Index of Biotic Integrity
IDF	Intensity, Duration, Frequency
KHA	Key Hydrologic Area
KHF	Key Hydrologic Feature
LAM	Landscape Analysis Model
LID	Low Impact Development
NHS	Natural Heritage System
NSE	Nash-Sutcliffe Efficiency
QEW	Queen Elizabeth Way
RCA	Reach Contributing Areas
RCP	Representative Concentration Pathway
RWMP	Regional Watershed Monitoring Program
SWMM	Stormwater Management Model
TOE	Time of Exceedance
TRCA	Toronto and Region Conservation Authority
TSS	Total Suspended Solids
VO	Visual OTTHYMO
WRS	Water Resource System

1. INTRODUCTION

This section provides an overview of the watershed planning process as well as details on the Future Management Scenarios Stage (Stage 3 of the watershed planning process), and the various scenarios analyzed as part of the watershed planning process for the Etobicoke Creek watershed.

The purpose of future management scenario analysis is to assess the implications of different land use changes and climate change on the health and conditions of the watershed. This enables testing of different management interventions to see how watershed conditions may respond. Based on the results of the future management scenario analysis, combined with watershed characterization (completed in Stage 2), a management framework can be developed during the Implementation Planning Stage (Stage 4) to identify measures to protect, restore, and enhance watershed conditions. Since Etobicoke Creek flows into Lake Ontario, the health of the Etobicoke Creek watershed also influences the health of Lake Ontario ((including water temperature, amount of fine sediment, and flow regime). Ensuring a cleaner, healthier, and more sustainable Etobicoke Creek watershed will also help manage and maintain the health and resiliency of Lake Ontario and the habitats and species that Lake Ontario supports.

The future management scenarios analyzed as part of the ECWP are hypothetical future land uses, and do not represent specific municipal planning decisions. In other words, the scenarios do not constitute a land use decision, or a particular recommendation on land use patterns and specific management interventions. Additionally, the future management scenarios incorporate the best available future climate data, where possible, to better understand how climate change will affect watershed conditions. The results of watershed modelling and technical assessments for these potential future land uses, their associated management interventions, and future climate conditions, can be used to inform municipal land use and infrastructure planning.

1.1 Watershed Planning Context

Watershed planning helps to characterize overall watershed conditions and identify measures to protect, restore, or enhance the health of the watershed. Future management scenario analysis occurs after watershed characterization in the watershed planning process. **Figure 2** provides an overview of the stages of the watershed planning process. As part of this process, a monitoring program is also developed to assess watershed conditions over time and assess progress on watershed plan goals and objectives. After the watershed plan has been completed, implementation of the plan and monitoring of progress can begin.

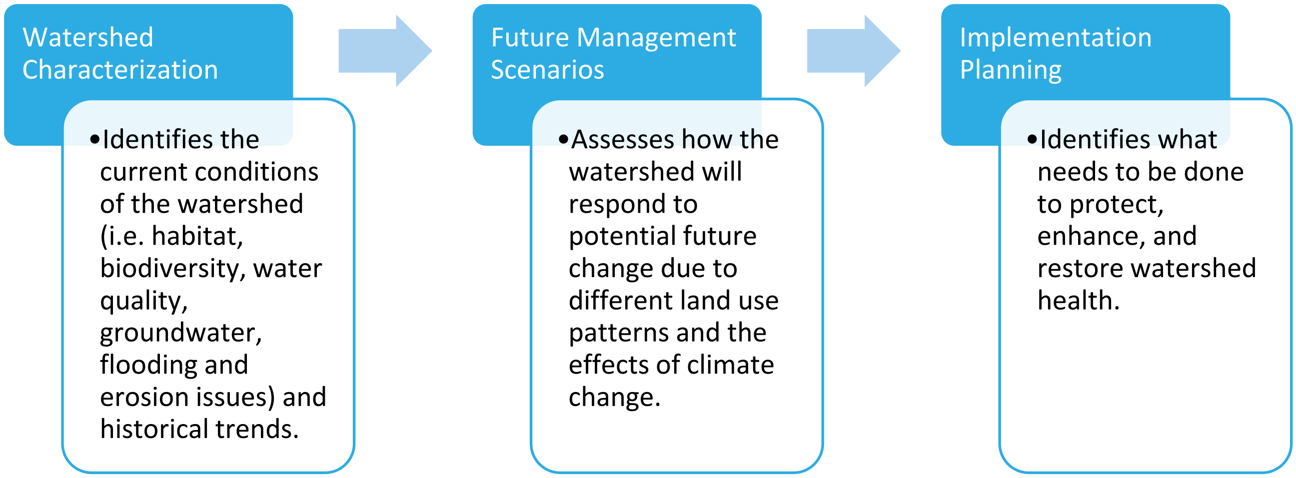

Figure 2 - Overview of the Watershed Planning Process

The development of a watershed plan is a multi-year, multi-partner exercise. For the purposes of the ECWP, the main partners involved in plan development are TRCA, City of Toronto, Region of Peel, City of Mississauga, City of Brampton, Town of Caledon, Mississaugas of the Credit First Nation, and the Greater Toronto Airport Authority. Broader stakeholder and public engagement plays an important role in the development of the watershed plan to ensure it reflects the perspectives of watershed residents and landowners.

Policy direction in the *Provincial Policy Statement*, encourages a coordinated approach to planning to protect, improve or restore the quality and quantity of water by using the watershed as the ecologically meaningful scale for integrated and long-term planning. The *Growth Plan for the Greater Golden Horseshoe* and the *Greenbelt Plan* require municipalities, partnering with conservation authorities as appropriate, to undertake watershed planning to inform the identification of water resource systems, the protection, enhancement or restoration of the quality and quantity of water, decisions on allocation of growth and planning for water, wastewater, and stormwater infrastructure.

1.2 Overview of the Future Management Scenarios

For the Etobicoke Creek watershed, the future management scenarios were designed to:

- Project potential future land use change based on growth projections by examining different land use and infrastructure practice scenarios to 2051 (i.e. the planning horizon for municipal Official Plans)
- Assess the effects of different levels of ecosystem restoration and enhancement (e.g. increase natural cover quantity and quality) on watershed conditions
- Assess the effects of different levels of stormwater control on watershed conditions
- Assess the potential impacts of climate change on watershed conditions, where possible

The following research questions guided analyses:

- How will trends associated with each watershed component change under each scenario (i.e. improve, deteriorate, stay the same)?

- What interventions would have noticeable impacts on watershed conditions (e.g. priority areas for stormwater retrofits)?
- What impact will intensification and further urbanization have on watershed conditions?

Four future management scenarios were assessed. The baseline for comparison is the current conditions of the watershed, as identified during the characterization stage of the watershed planning process. **Table 1** provides a description and rationale for each of the four future management scenarios.

Table 1 - Overview of Four Future Management Scenarios

	Scenario 1: Urban Expansion with Minimal Enhancements	**Scenario 2:** Urban Expansion with Mid-range Enhancements	**Scenario 3:** Urban Expansion with Optimal Enhancements	**Scenario 4:** Existing Urban Boundary with Optimal Enhancements
Description	Assumes urbanization of the remaining whitebelt* lands in the headwaters of the watershed. No enhancements to natural cover or stormwater management.	Same as Scenario 1, with some enhancements to stormwater management, urban forest, and natural cover. Includes the potential Greater Toronto Area (GTA) West Highway (i.e. 413).	Same as Scenario 1, with a greater level of enhancements to stormwater management, urban forest, and natural cover than Scenario 2.	Same as Scenario 3, except the current urban boundary is maintained in the headwaters.
Rationale	Compares current conditions to further urbanization in the headwaters with minimal other watershed enhancements.	Compares additional watershed interventions to Scenario 1 to determine the relative benefits of the enhancements.	Compares an even higher level of watershed interventions to Scenario 1 to determine the relative benefits of the enhancements.	Compares the same high level of interventions as Scenario 3 without further urbanization to determine the relative benefits of the enhancements and maintaining the existing urban boundary.

Notes:
* The whitebelt refers to lands between the built boundary of urban settlement areas and the boundary of the Greenbelt Plan Area.

For the purposes of the results in this report, Scenario 1 is compared to current conditions (i.e. watershed characterization), while Scenarios 2, 3, and 4 are compared to Scenario 1. This is to compare and assess the relative benefits of the different levels of enhancements in Scenarios 2, 3, and 4 against the minimal enhancements in Scenario 1.

See **Figure 19** for maps of what these future management scenarios would look like by land use (i.e. urban, rural, and natural) in the watershed. The enhancements referred to in the future management scenarios consist of improvements to the amount of natural cover and urban forest, as well as stormwater retrofits and Low Impact Development (LID) implementation. **Figure 19** is based on 2019 land use data. Future Scenarios 1 through 4 maps were developed in 2021 based on the best available information and data at the time with guidance from the Etobicoke Creek Watershed Plan Steering Committee. At the time, the Future Scenario maps were developed, many municipalities were in the process of updating their Official Plans, thus the land use data (e.g., projected urban boundaries) may differ slightly from mapping in municipal Official Plans. However, these differences are not expected to change the key messages of the analysis and still provides useful insights to inform decision making. The future management scenarios do not constitute a land use decision, or specific recommendations on land use patterns and watershed enhancements.

Table 2 outlines the assumptions for each of the above noted enhancements that were included in the four future management scenarios analyzed.

Table 2 - Enhancement Assumptions for Future Management Scenarios

	Scenario 1: Urban Expansion with Minimal Enhancements	**Scenario 2:** Urban Expansion with Mid-range Enhancements	**Scenario 3:** Urban Expansion with Optimal Enhancements	**Scenario 4:** Existing Urban Boundary with Optimal Enhancements
Natural Cover (12.3% of the watershed currently)	Assumes existing natural cover remains with no enhancements. Existing areas of natural cover in the headwaters would stay natural with urban expansion. (12.4% of the watershed)	Assumes that Conservation Authority recommended Natural Heritage System (NHS)[1] from 2018 provided to the Region of Peel is implemented. (18.5% of the watershed)	Assumes the regional 2021 enhanced NHS[2] refined for this watershed is implemented. (22.8% of the watershed)	See Scenario 3. (22.8% of the watershed)
Urban Forest (14.7% current tree canopy cover across watershed)	Assumes tree canopy cover remains the same as current conditions, except for the headwaters urban	Assumes tree canopy cover increases for each land use type by amount of plantable area within the habitat contributing areas of the enhanced NHS only. The habitat	Assumes tree canopy cover increases for each land use type by amount of plantable area throughout the watershed.	Same assumptions as Scenario 3. (26.7% tree canopy cover)

[1] This recommended NHS focused on terrestrial criteria and areas for improved habitat connectivity and enhancements to climate vulnerable habitats. It identified existing and potential natural cover.
[2] The 2021 enhanced NHS incorporates both terrestrial and aquatic criteria to identify priority areas for protection and enhancement.

	Scenario 1: Urban Expansion with Minimal Enhancements	**Scenario 2:** Urban Expansion with Mid-range Enhancements	**Scenario 3:** Urban Expansion with Optimal Enhancements	**Scenario 4:** Existing Urban Boundary with Optimal Enhancements
	expansion, which assumes increases to tree canopy cover consistent with residential land uses. (14.7% tree canopy cover)	contributing areas are parts of the watershed near natural features that can provide ecological services. No urban forest enhancements would occur outside these areas under this scenario. (18.8% tree canopy cover)	(26.5% tree canopy cover)	
Stormwater Retrofits and LID implementation[3]	Assumes stormwater controls in whitebelt urban expansion are consistent with guidelines (TRCA stormwater quantity criteria for the Etobicoke Creek Headwaters; post development outflow to be controlled to 60% of existing conditions). A 5 mm retention[4] applied through the watershed.	Assumes retrofits of previously identified stormwater pond improvement opportunities to provide 25 mm of runoff retention. Assumes stormwater controls in whitebelt urban expansion consistent with guidelines (see Scenario 1). A 12.5 mm retention applied throughout the watershed.	Assumes retrofits of previously identified stormwater pond improvement opportunities to provide 25 mm of runoff retention. Assumes stormwater controls in whitebelt urban expansion consistent with guidelines (see Scenario 1). A 25 mm retention applied throughout the watershed.	Assumes retrofits of previously identified stormwater pond improvement opportunities to provide 25 mm of runoff retention. A 25 mm retention applied throughout the watershed.

[3] For the purposes of watershed modelling, runoff retention was used to model LID implementation by adjusting the amount of assumed retention across the watershed. This approach assumes that future developments will provide the specified amount of retention. While retrofit of all existing impervious surfaces is unrealistic, the elevated retention amounts can help identify areas of the watershed that would benefit greatly from retrofits or LID implementation.

[4] This means that the models assume the first 5 mm of precipitation events are retained in stormwater management or LID infrastructure rather than being released as runoff.

See **Appendix A** for statistics on what the natural cover and urban forest enhancements represent on a subwatershed-scale. **Table 3** identifies what these four future management scenarios represent for land use change at the watershed-scale.

Table 3 - Land Use Change by Future Management Scenarios

Land Use	**Current Conditions (2019)**	**Scenario 1:** Urban Expansion with Minimal Enhancements	**Scenario 2:** Urban Expansion with Mid-range Enhancements	**Scenario 3:** Urban Expansion with Optimal Enhancements	**Scenario 4:** Existing Urban Boundary with Optimal Enhancements
Urban	59.5%	68.0%	66.5%	64.8%	58.9%
Rural	28.2%	19.6%	14.9%	12.4%	18.3%
Natural	12.3%	12.4%	18.5%	22.8%	22.8%
Impervious	47.9%	52.1%	51.5%	50.1%	47.0%

Climate Change

Since future management scenario analysis is about assessing future watershed conditions, incorporating climate change into assumptions and analyses is a necessity.

Climate change was incorporated quantitatively and qualitatively into certain modelling and technical analyses based on available data, available resources, and expertise. The detailed results in **Section 2. Future Watershed Conditions** that will identify how climate change is expected to affect that particular watershed component.

2. FUTURE WATERSHED CONDITIONS

As part of future management scenario analysis, TRCA conducted watershed modelling and performed technical analyses to determine how the watershed may respond to future land uses and climate change (where possible). Watershed level modelling was completed for natural hazards (hydrology/event based peak flows and erosion), groundwater, and water quality components of the watershed plan. These models incorporated land use and climate information, where possible. For terrestrial and aquatic ecosystem health, a comprehensive impact assessment was completed based on the available field and modelled data. Climate implications were inferred based on future climate data projections. All the findings were combined to infer potential watershed conditions for the future scenarios, where possible. **Figure 3** provides an overview of the modelling and technical analyses conducted during this stage of the watershed planning process.

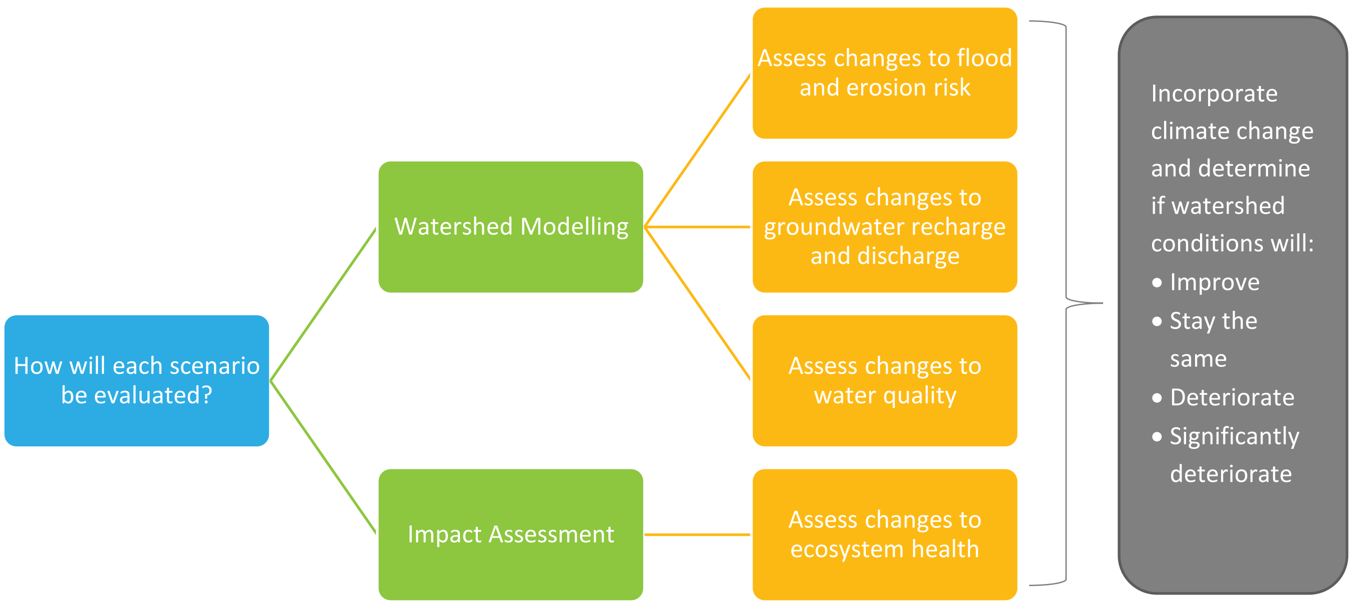

Figure 3 - Future Management Scenario Analysis Process

The key findings of the Etobicoke Creek watershed future management scenarios analyses are organized into four watershed plan component categories. These include the Water Resource System (WRS), Natural Heritage System (NHS) and Urban Forest, Water Quality, and Natural Hazards. Details of key findings are presented in **Table 4.**

Table 4 – Future Management Scenarios Key Findings

Watershed Plan Component Categories	Key Findings
Water Resource System (includes aquatic habitat, in-stream barriers, groundwater conditions, etc.)	• Aquatic habitat quality will decrease as impervious surfaces increase. • With increasing urbanization, sensitive fish species will be replaced with species more tolerant of disturbance, and benthic communities will shift towards more pollution tolerant species. • With natural cover enhancements, the number of coolwater, coldwater, and stable stream reaches could increase and make the system more resilient. • Groundwater discharge and recharge will be negatively affected in the Headwaters without enhancements to natural cover, urban forest, stormwater management, and LID implementation.
Natural Heritage System and Urban Forest (includes habitat quantity and quality, tree canopy, sensitive species, etc.)	• Even with optimal natural cover enhancements, this watershed remains below recommended federal guidelines for natural cover quantity, TRCA's 2007 Terrestrial NHS target and the previous 2002 Etobicoke Creek Watershed Plan target (minimum of 30% forest cover and 10% wetland cover recommended at the watershed scale), and there are limited opportunities for sensitive species. • There are opportunities to increase the quantity and quality of the urban forest to provide ecosystems goods and services, increase climate resiliency, and provide socio-economic benefits.
Water Quality (focused on Total Suspended Solids and chlorides)	• Changes in water quality parameters (e.g. Total Suspended Solids and chlorides) demonstrate the negative impact of urbanization and the benefits of improved stormwater management and natural cover enhancements in a changing climate.
Natural Hazards (includes flooding and erosion)	• Increasing enhancements to natural cover and stormwater management help reduce peak flow levels, though not as effectively when considering climate change. • Land use changes can manage peak flows for all design storms through enhancements and interventions (if TRCA's stormwater management quantity criteria for the Etobicoke Creek Headwaters is applied), but climate change will cause peak flows to exceed current stormwater infrastructure design standards. • Increasing enhancements to natural cover and stormwater management help mitigate erosion, which would otherwise increase with further urbanization.

Table 5 provides further details on potential future watershed conditions associated with each future management scenario for each of these categories. Potential future conditions are expressed by percent change for each technical component.

Percent Change

Please note that for all calculations of percent change throughout this report, Scenario 1 is compared to current conditions, while Scenarios 2, 3 and 4 are compared to Scenario 1. This is to compare and assess the relative benefits of the different levels of enhancements in Scenarios 2, 3, and 4 against the minimal enhancements in Scenario 1.

To aid in interpreting **Table 5**, cells for percent change are colour coded to indicate whether watershed conditions improve, are roughly equal, deteriorate, or significantly deteriorate from a hydrological or ecological perspective.

	>+5% change, watershed conditions improve
	0 to +5% or 0 to -5% change, watershed conditions stay roughly the same
	-6% to -10% change, watershed conditions deteriorate
	>-10% change, watershed conditions significantly deteriorate

It is important to note that percent change is identified by the thresholds listed above solely based on watershed conditions and not whether the reported value is a positive or negative number. For example, a decrease in chloride concentrations or peak flows is a good thing from a hydrological or ecological perspective. So, in **Table 5**, this example would be presented as a positive percent change.

Table 5 - Scenario Analysis Consolidated Results

Watershed Plan Component		**Current Conditions (as of 2019)**	**Scenario 1 Urban Expansion + Minimal Enhancements *(compared to Current Conditions)***	**Scenario 2 Urban Expansion + Mid-range Enhancements *(compared to Scenario 1)***	**Scenario 3 Urban Expansion + Optimal Enhancements *(compared to Scenario 1)***	**Scenario 4 Existing Urban Boundary + Optimal Enhancements *(compared to Scenario 1)***
Water Resource System						
Riparian corridors	Area (ha)	600.4 ha	600.4 ha	757.8 ha	797.4 ha	797.4 ha
	% change	**N/A**	**0%**	**26%**	**33%**	**33%**
Aquatic habitat quality[5]	Area (ha)	10,718.9 ha	11,663.0 ha	11,530.6 ha	11,219.8 ha	10,537.6 ha
	% change	**N/A**	**-9%**	**1%**	**4%**	**10%**
Groundwater recharge[6]	mm/yr	133 mm/yr	119 mm/yr	124 mm/yr	128 mm/yr	138 mm/yr
	% change	**N/A**	**-11%**	**4%**	**8%**	**16%**
Groundwater discharge[7]	mm/yr	118 mm/yr	107 mm/yr	111 mm/yr	114 mm/yr	122 mm/yr
	% change	**N/A**	**-9%**	**4%**	**7%**	**14%**
Natural Heritage System/Urban Forest						
Habitat quantity	Area (ha)	2,617	2,617	4,153	5,108	5,108
	% change	**N/A**	**0%**	**59%**	**95%**	**95%**
Habitat quality	Average LAM score[8]	7.56	7.33	7.47	7.74	7.91
	% change	**N/A**	**-3%**	**2%**	**6%**	**8%**
Urban forest	Area (ha)	3,290 ha	3,290 ha	4,338 ha	5,947 ha	5,984 ha
	% change	**N/A**	**0%**	**32%**	**81%**	**82%**
Water Quality[9]		-				-
Chlorides	**% change**	**N/A[10]**	**30%**	**-49%**	**-3%**	**-6%**
Total Suspended Solids (TSS)	**% change**	**N/A[11]**	**-21%**	**68%**	**135%**	**186%**
Natural Hazards						
Flooding[12]				-	-	-
100-year storm at Dixie/Dundas Flood Vulnerable Cluster (FVC) without climate change	Peak flows (m^3/s)	106.9	108.4	105.7	91.3	91.3
	% change	**N/A**	**-1%**	**3%**	**16%**	**16%**
100-year storm at Dixie/Dundas FVC with climate change	Peak flows (m^3/s)	106.9	134.2	132.3	120.7	120.7
	% change	**N/A**	**-26%**	**1%**	**10%**	**10%**
5-year storm at Dixie/Dundas FVC without climate change	Peak flows (m^3/s)	63.1	63.8	58.6	41.9	41.9
	% change	**N/A**	**-1%**	**8%**	**34%**	**34%**
5-year storm at Dixie/Dundas FVC with climate change	Peak flows (m^3/s)	63.1	68.4	63.5	46.9	46.9
	% change	**N/A**	**-9%**	**7%**	**31%**	**31%**
Erosion	See **Subsection 2.4.2. Erosion Risk** for detailed results by subwatershed for two indicators.					

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[5] This is based on the amount of impervious cover in the watershed as a metric of aquatic habitat quality. Less than 10% impervious cover is considered stable for channel stability, good for water quality, and good for biodiversity. Impervious cover between 11% - 25% is considered urbanizing and impacted. Greater than 25% impervious cover is considered non-supporting, meaning unstable channels, fair-poor water quality and poor biodiversity. Aquatic habitat quality is expected to decrease as impervious surfaces increase. However, even under Scenario 4 (with existing urban boundary (less impervious cover) and optimal enhancements), the percent of impervious cover for the watershed is almost 47%. So, Scenario 4 only represents an improvement compared to Scenario 1, but does not indicate overall healthy aquatic habitat.

[6] The current conditions results for groundwater recharge are based on the model results over the entire study area, rather than baseflow analysis conducted for watershed characterization.

[7] See footnote 6.

[8] LAM, known as Landscape Analysis Model, combines the metrics of patch size (larger patches support larger populations), patch shape (habitat fragmentation), and matrix influence (influence of surrounding land uses) to determine an average score. LAM has a rating scale of 13-15 (Excellent), 11-12 (Good), 9-10 (Fair), 6-8 (Poor), 0-5 (Very poor).

[9] Percent change amongst future management scenarios for water quality is based on averages for all stream segments. Results for chlorides are presented as winter season only, while TSS results represent all seasons.

[10] Due to the partially calibrated nature of the water quality model, absolute concentrations are not being reported. Instead, percent change observed in the model is reported for the future scenarios, with Scenario 1 still being compared to current conditions.

[11] See footnote 10.

[12] See 2.4.1 Flooding for complete results for multiple design storms at each of the six FVCs with and without climate change. Only the 100-year and 5-year storm with and without climate change at the Dixie/Dundas FVC inflow are shown in this table. Dixie/Dundas is the highest risk FVC in this watershed. Climate change only applies to the future management scenarios and not current conditions.

2.1 Water Resource System

The following subsections characterize components of the WRS that support aquatic habitat and biodiversity, including riparian corridors, in-stream barriers, fish community health, benthic community health, aquatic habitat quality, groundwater conditions, and streamflow.

Provincial policy requires municipalities to identify the WRS (consisting of Key Hydrologic Features (KHFs) and Key Hydrologic Areas (KHAs) - defined in **Section 5. Glossary**), and to implement policies to protect these features and areas, and their functions over the long term. Based on the future management scenario analysis conducted, the quantity of KHFs in areas of natural and rural land use decreases by 6% in Scenario 1 compared to current conditions, stays equal to Scenario 1 under Scenario 2, and increases by 4% and 7% for Scenarios 3 and 4 respectively compared to Scenario 1. For the quantity of KHAs in areas of natural and rural land use, there is a decrease of about 25% under Scenario 1, compared to current conditions, and an increase of 7% under Scenario 2, increase of 16% under Scenario 3, and an increase of 37% under Scenario 4, compared to Scenario 1.

Headwater Drainage Features (HDFs) are non-permanently flowing drainage features that may not have defined beds or banks (i.e. intermittent or ephemeral streams). Headwater systems are important for the terrestrial and aquatic integrity of the entire watershed (and ultimately for the health of Lake Ontario) as most of a river's flow may be derived from headwater areas. Due to their small size, HDFs are vulnerable to impacts from land use change. HDFs are also not explicitly defined as a component of the WRS. This future management scenario analysis focused on the whitebelt area of the Etobicoke Headwaters, since this is where future urban growth may occur. Under Scenarios 1 to 3, the whitebelt would be urbanized. As a result, the length of impacted HDFs, assuming no mitigation, increases from zero kilometres (km) under current conditions to 50.7 km under Scenario 1, 43.2 km under Scenario 2, and 33.8 km under Scenario 3. Under Scenario 4, HDFs would face minor impacts since there is no urban expansion. It is particularly important to note that up to 11.3 km of HDFs characterized as intermittent flow could be impacted by urban expansion. This equates to approximately 87% of all intermittent HDFs within the whitebelt area. If urban expansion proceeds in the whitebelt of the Etobicoke Headwaters, it will be important to ensure HDFs are protected, or any impacts mitigated, to maintain ecological and hydrological function.

2.1.1 Riparian Corridors

Riparian corridors are the transition zone between terrestrial and aquatic ecosystems around streams, which act as a buffer that contribute nutrients, shade, and filtration of contaminants from surrounding landscapes, thereby improving overall WRS feature and aquatic habitat quality. The riparian corridor refers to the area within 30 m of each side of a stream feature. Currently, approximately 51% of the riparian corridor consists of natural cover (same as Scenario 1). The amount of natural cover within the riparian corridor increases to 64% under Scenario 2, and 68% under Scenarios 3 and 4 (see **Figure 20**). This is still below the 75% target of natural cover in the riparian corridors that is recommended to help ensure healthy and sustainable natural features. It is important to note that although riparian cover is important for aquatic habitat quality, it cannot fully mitigate the impacts of broad landscape level changes including impervious cover. The Etobicoke Creek watershed is a highly urbanized watershed so opportunities to increase riparian cover in urbanized areas are limited (there have been limited to no gains since the previous Etobicoke Creek Watershed Plan).

2.1.2 In-stream Barriers

In-stream barriers represent structures or natural blockages that prevent the movement of fish species upstream or downstream. Current in-stream barriers have been assessed and priority barriers for removal identified. Eleven of the 134 in-stream barriers were selected as priority for removal based on the combined Dendritic Connectivity Index (DCI) score, which considers the passability of a structure to migratory and non-migratory fish, and habitat quality of the connectivity.

The top two priority barriers for removal are in the Headwaters subwatershed, which would provide the greatest improvement to connectivity in the watershed. Removal of these barriers would allow fish species to access habitat in the Headwaters where there is less impervious cover, greater habitat quality, and where cold and coolwater tributaries occur. The third highest priority barrier is located near the mouth of Etobicoke Creek and its removal would create improved connectivity between the creek and Lake Ontario. The remaining barriers that have been assessed as priority for removal are located in the central section of the stream network, but they were in fair-poor to poor habitat. Overall, the removal of these priority barriers would create a positive impact on in-stream connectivity and allow for easier migration and access to higher quality habitats for fish species that are likely to be impacted by future development. Barrier removals also help with sediment transport, in stream temperature, and overall water quality.

2.1.3 Fish Community Health

Impacts to the fish community were qualitatively assessed based on trends observed in fish community composition and the fish community Index of Biotic Integrity (IBI). Currently, the overall IBI score for the watershed is ‘fair’, with the Headwaters in ‘good’ condition. Given that future urban expansion is possible in the Headwaters, the IBI score would likely go down. It is expected that with the impacts of continued urban expansion, fish species replacement will occur, where sensitive species are lost (e.g., blacknose shiner and blackchin shiner) and replaced with species that are more tolerant to disturbance (e.g., creek chub, blacknose dace). This trend can be hard to detect using only the IBI score because the score will either remain the same or increase with the increased biomass of more tolerant species in the watershed. Further, with higher in-stream temperatures that are expected because of development (via runoff from impervious surfaces) and climate change, it is also predicted that there will be a loss of coldwater and coolwater reaches (and associated fish species) that currently occur in the Headwaters. As a result of development, the fish community will also have to adapt to a changing flow regime (likely higher flows with more abrupt changes to flow intensity), and changes in water quality (likely poorer water quality). These effects and the interaction between changes in water temperature, flow, and water quality will all likely negatively impact the health of the fish community and its diversity.

2.1.4 Benthic Community Health

A well-balanced and functioning biological community is a good indicator of a healthy aquatic system. Benthic macroinvertebrates (BMI), bottom-dwelling organisms including aquatic insects, crustaceans, molluscs, and worms, provide an important ecological link between microorganisms and fish communities. Impacts to the BMI community were qualitatively assessed based on trends observed in community distribution, composition, and Family Biotic Index (FBI). Currently, the overall FBI score for the watershed is “poor”. The Headwaters is currently in ‘fairly poor’ quality based on the FBI score. This score indicates that the Headwaters are already experiencing pollution impacts and any additional contaminants due to urban expansion would exacerbate these conditions.

The composition of BMI communities is expected to shift towards more pollution tolerant (worm and midge species) and fewer sensitive species (mayflies, stoneflies, and caddisflies). This is expected due to changes in water quality, sediment regime, and the hydrology within the watershed. For example, the creation of more roads and highways in the Headwaters would likely increase the usage of road salt, which is ultimately washed into streams and increases chloride concentrations. Development often results in an increase in fine sediment (i.e. silt or sand) within the aquatic system which acts to limit interstitial spaces often used by more sensitive BMI taxa. Further, changes to the hydrology of the headwaters through the addition of more stormwater management will alter the sediment composition of streams, which changes the availability of habitat for certain BMI species. Thus, as changes to water quality, sediment, and hydrology occur, the distribution and composition of BMI communities within the watershed will also change. Lastly, it is important to note that because BMI assemblages are not assessed at the species-level, it is difficult to see declines in sensitive species as they happen; this usually is not apparent until a system has already flipped to a more tolerant system.

2.1.5 Aquatic Habitat Quality

As natural surfaces are converted into impervious surfaces, water does not infiltrate soils and instead flows over these surfaces and directly into streams affecting natural flow, temperature, and water quality regimes. This subsequently impacts aquatic species and ecosystems through changes in aquatic habitat quality.

The percent impervious cover within the watershed under the four future management scenarios is summarized at three spatial scales, including the watershed, subwatershed, and Reach Contributing Areas (RCAs). Habitat quality was determined based on percent impervious cover results and was given one of four classes: sensitive (<10%), urbanizing (10-25%), non-supporting (25-60%), and urban drainage (>60%).

Overall, impervious surfaces are expected to increase, with a decline in watershed conditions under Scenarios 1 to 3. The impacts of increased impervious surfaces are concentrated in the Headwaters where percent impervious cover increases by more than double in Scenarios 1 and 2 (See Table 6). Several RCAs with sensitive habitat quality in the Headwaters become classified as urbanizing or non-supporting in Scenario 1. Further, Scenario 1 shows the largest percentage of RCAs classified as urban drainage (31/87 RCAs, 9,183.8 ha). Scenarios 2 and 3 also show deterioration in the Headwaters however, some improvements occur in the middle section of the watershed with some urban drainage RCAs becoming non-supporting. Under Scenario 4, the current sensitive RCAs are maintained and the improvements to the middle portion of the watershed also occurs. See Table 6 for maps showing the change in habitat quality for RCAs.

Table 6 - Percent Impervious Cover by Future Management Scenario

Subwatershed	Current Conditions (%)	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)	Scenario 4 (%)
Headwaters	14%	29%	30%	24%	13%
Watershed	**48%**	**52%**	**52%**	**50%**	**47%**

Subwatershed	Current Conditions (%)	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)	Scenario 4 (%)

Note: the percent impervious cover in the other subwatersheds across the four future management scenarios is insignificant since they are already urbanized, and are thus not shown in this table.

2.1.6 Groundwater Conditions

The modelling conducted provides an estimate of the assumed long-term average groundwater discharge to streams and wetlands, and groundwater recharge, under current climate conditions[13]. Rates of change in groundwater discharge is consistent with recharge, suggesting that the watershed is well contained and does not appear to be gaining or losing groundwater to neighbouring watersheds. **Table 7** shows the change in recharge and discharge for each subwatershed associated with the future management scenarios.

Table 7 - Groundwater Quantity Conditions by Subwatershed and Future Management Scenario

Subwatershed	Groundwater Component	Current Conditions (mm/yr)	Scenario 1 (% change from current)	Scenario 2 (% change from Scenario 1)	Scenario 3 (% change from Scenario 1)	Scenario 4 (% change from Scenario 1)
Headwaters	Recharge	202	-25%	6%	19%	43%
	Discharge	168	-24%	5%	19%	41%
Spring Creek	Recharge	105	-1%	2%	3%	4%
	Discharge	83	-1%	4%	4%	4%
West Branch	Recharge	116	0%	3%	3%	3%
	Discharge	136	0%	3%	2%	2%
Tributary 3	Recharge	117	0%	5%	3%	3%
	Discharge	45	0%	13%	7%	7%
Tributary 4	Recharge	112	0%	4%	2%	2%
	Discharge	14	0%	7%	7%	7%
Main Branch	Recharge	103	0%	4%	1%	1%
	Discharge	168	0%	2%	1%	1%
Little Etobicoke	Recharge	92	0%	5%	2%	2%
	Discharge	70	0%	4%	1%	1%

[13] Future climate change projections were not incorporated into the groundwater modelling exercise due to resource and time constraints.

Subwatershed	Groundwater Component	Current Conditions (mm/yr)	Scenario 1 (% change from current)	Scenario 2 (% change from Scenario 1)	Scenario 3 (% change from Scenario 1)	Scenario 4 (% change from Scenario 1)
Lower Etobicoke	Recharge	113	0%	3%	2%	2%
	Discharge	131	0%	2%	2%	2%

The results in Table 7 demonstrate that groundwater recharge and discharge would be negatively affected under Scenario 1 in the Headwaters, with gradual improvements in recharge and discharge potential with additional enhancements in Scenarios 2, 3 and 4. For the other already urban subwatersheds, the change in recharge and discharge potential with additional enhancements is insignificant, with the exception of discharge in Tributary 3 where a particular significant amount of naturalization is occurring.

From a groundwater quality perspective, quantitative assessments cannot be made for each future management scenario. Instead, qualitative assessments of chlorides were conducted. The only way to differentiate the chloride contributions from deep groundwater system interactions and the application of road salt is to examine the chlorine isotope fractions. Such data is not available currently. It is worth noting that baseflow water quality indicated that Tributary 3 and Little Etobicoke Creek on average were approaching brackish (>500 mg/L) whereas other subbasins on average were much fresher (<500 mg/L). The future scenario analysis for surface water (see Section 2.3 Water Quality) concluded that under Scenarios 1, 3 and 4 climate change resulted in a decrease in chloride concentration due to fewer snow fall events, and that under Scenario 2 the decrease was not as large due to the proposed GTA West highway and the additional expected road salting in the winter months. It is reasonable to assume that similar trends would be observed for groundwater but significantly delayed due to historical salt loading and long transport times. Further, it is worth noting that sodium would be even more delayed than chloride with cation exchange of calcium for sodium depleting, retarding, and storing the sodium pulse in the subsurface.

2.1.7 Thermal Classification

Land use change results in potential changes to thermal classification of streams through the loss of natural cover and increases to the amount of imperviousness within catchments (i.e. causing warmer streams). Consequently, these impacts to aquatic ecosystems should be considered in the face of climate change. Using modelled temperature data that assesses thermal stability and maximum weekly average temperature, the location of the reaches and how they would be affected under the scenarios was assessed. Water temperature monitored in the watershed from 2019 and 2020 was also assessed to support estimated thermal classification of reaches (i.e. field-based maximum weekly average temperature).

Table 8 presents the thermal classification of RCAs by future management scenario. Under Scenario 1, several RCAs are at risk within the Headwaters with urban expansion, since all current coldwater and coolwater RCAs are in this subwatershed. These reaches would decrease in maximum weekly thermal stability and increase in maximum temperature. Under Scenario 2, the increase in natural cover due to restoration opportunities in potential natural cover compensate for the conversion to impervious surfaces in the Headwaters subwatershed, thus increasing the number of coolwater, coldwater, and stable RCAs. Under Scenario 3, the coldwater potential is only restored leading to similar conditions to Scenario 2. Finally, in Scenario 4, the general increase in natural cover allows for a further increase in potential coolwater, coldwater, and stable RCAs.

Table 8 - Thermal Classification of Reach Contributing Areas by Future Management Scenario

Thermal Classification	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Modelled Maximum Weekly Average Temperature	1 coldwater RCA	0 coldwater RCA	1 coldwater RCA	1 coldwater RCA	> 1 coldwater RCA
Modelled Thermal Stability	14 thermally stable RCAs	7 thermally stable RCAs	< 14 thermally stable RCAs	< 14 thermally stable RCAs	> 14 thermally stable RCAs
Field-based Maximum Weekly Average Temperature (2019 – 2020)	3 coldwater and 3 coolwater RCAs	0 coldwater and 0 coolwater RCAs	< 3 coldwater and < 3 coolwater RCAs	< 3 coldwater and < 3 coolwater RCAs	> 3 coldwater RCAs and > 3 coolwater RCAs

2.1.8 Climate Change and Aquatic Systems

Since future management scenario analysis is about assessing future watershed conditions, incorporating climate change into assumptions and analyses is a necessity. Figure 4 identifies how climate change is expected to affect aquatic systems using the 'If-Then-So' method which is a qualitative approach consistent with traditional risk-based assessment. These 'If-Then-So' statements can generate a narrative of how future climate change can impact watershed components:

- ***If*** changes in the future climate were to occur based on trends in various climate parameters (e.g. mean/maximum/minimum temperature (°C), extreme heat/cold (days/year), total and extreme precipitation, dry days (days/year), growing season, agricultural variables and ice/snow)
- ***Then*** outcomes/impacts can be identified
- ***So*** consequences of those outcomes/impacts can be provided

Climate Change Analysis – Aquatic Systems		
If (climate stressor)	**Then (outcome)**	**So (consequence)**
Increase in average temperature **Increase in the intensity and frequency of precipitation events**	Warmer stream temperatures Increased runoff from roads and urban / rural lands	Loss of cold/cool water fish habitat Decreases to stream habitat quality from runoff and temperature changes Loss of ecosystem goods and services

Increase in the intensity and frequency of extreme weather events	Damage to riparian corridors (i.e. trees and other vegetation)	

Figure 4 - Climate Change and Aquatic Systems

2.2 Natural Heritage System and Urban Forest

The NHS is made up of natural features and areas (e.g. forests, meadows, wetlands), and linkages to provide habitat connectivity and support natural processes, which are necessary to maintain biodiversity, natural functions, and ecosystems. The urban forest is made up of trees and woody shrubs on all public and private property within the watershed, including urbanized spaces (e.g. along roads) and in natural areas (e.g. forests). Understanding the state of natural cover, habitat quality (i.e. terrestrial ecosystems) and the urban forest is important for watershed management due to the many ecosystem benefits that terrestrial features like forests, meadows and street trees provide, including supporting biodiversity, water retention and filtration, and cleaner air. Healthy terrestrial ecosystems are vital for sustaining plant and animal populations. In general, scenarios that maximize the amount of natural cover have the most positive benefits for the terrestrial ecosystem.

For the future management scenarios, habitat quantity, habitat quality, biodiversity, connectivity, climate vulnerability, and the urban forest were assessed.

Impacts of Urbanization and Intensification on Biodiversity and Ecosystem Health

The scientific literature demonstrates that urbanization negatively affects biodiversity and ecosystem functions. Yet the Greater Toronto Area is one of the fastest growing regions in North America. With these recognized impacts and needs, research has been conducted to understand different patterns of urbanization. Urban expansion is a form of land development typically characterized by low-density single-family homes in previously unbuilt natural or rural areas. Intensification focuses on increasing population density in already built-up areas. Several studies have shown that compact high-density developments over a smaller area result in fewer extinctions and maintain bird species distributions. Additionally compact development was shown to have fewer detrimental impacts on forest-dwelling mammals than dispersed urban expansion, while also maintaining habitat connectivity better. This literature suggests that if the urban footprint needs to expand that high density forms and a minimal footprint are more beneficial from a terrestrial ecosystem perspective.

2.2.1 Habitat Quantity

Habitat loss and degradation is a significant threat to biodiversity and the primary cause of species extinctions in Canada. Increasing urbanization has converted natural and agricultural lands to impermeable (i.e. paved) built surfaces.

As noted in **Table 5** the amount of natural cover (i.e. habitat quantity) increases by 59% under Scenario 2 and 95% under Scenarios 3 and 4, representing approximately 18% and 23% of the watershed area respectively. This is achieved through the identification of potential natural cover through NHS planning (see **Subsection 3.2.1 Habitat Quantity** for more information).

Even with the urbanized nature of this watershed, there are opportunities to increase natural cover across the subwatersheds (see **Figure 23**). Based on the enhancement assumptions used in the future management scenarios, the type of natural cover (i.e. habitat type) fluctuates as demonstrated in **Table 9**.

Table 9 - Natural Cover Type by Future Management Scenario

Natural Cover Type	Area (ha or %)	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Forest	Area (ha)	882	1,001	2,102	3,175	3,175
	Area (%)	4%	5%	9%	14%	14%
Wetland	Area (ha)	509	509	578	732	732
	Area (%)	2%	2%	3%	3%	3%
Meadow	Area (ha)	1,106	1,106	976	1,091	1,091
	Area (%)	5%	5%	4%	5%	5%
Unclassified (areas of natural cover that did not have a natural cover class designated, example open space or water)	Area (ha)	0	0	495	108	108
	Area (%)	N/A	N/A	2%	1%	1%

Note: 119 ha of successional forest was left out of current conditions since it is assumed under the future scenarios that successional forest will have matured into forest.

Environment and Climate Change Canada's *How Much Habitat is Enough?* was developed to provide science-based guidance for the conservation and restoration of habitat. These guidelines are intended as minimum ecological requirements with the conservation of existing habitat as the first priority. Based on these guidelines, a minimum of 30% forest cover and 10% wetland cover is recommended at the watershed-scale. Meadow guidelines suggest conserving all existing meadow, but also recommend creating at least one 100 ha patch, or having an average meadow patch size of 50 ha. In a heavily urbanized watershed like Etobicoke Creek, creating these larger patches is likely not possible; however, a combination of best management practices for hay crops and strategic restoration of meadows is important. Even under the optimal enhancements in Scenarios 3 and 4, forest cover only reaches 14%, wetland cover 3%, and the average meadow patch size is approximately 1 ha. These results show that Etobicoke Creek watershed remains below recommended guidelines, although the natural cover optimal enhancements are a significant improvement.

The importance of the matrix influence (i.e. influence of surrounding land uses) (see **Section 2.2.2 Habitat Quality** for more information) is also stressed in guidelines since the type of matrix can greatly affect species composition in adjacent patches. For example, an urban matrix affects nearby habitat patches more negatively than a rural matrix. Considering both the amount of natural cover and matrix influences, Scenario 4 results in a watershed with a total amount of natural cover and matrix influences closer to achieving recommended habitat conditions.

Figure 5 – Bobolink and Eastern Meadowlark. Threatened grassland bird species in the Etobicoke Creek watershed

2.2.2 Habitat Quality

For terrestrial ecosystems and habitats to function, it is important to manage habitat quality and quantity. Habitat quality represents how functional the habitat is in terms of meeting the reproductive, foraging, or sheltering needs of individual species. From a landscape ecology perspective, higher quality habitat patches are generally larger in size (i.e. able to support more species or larger populations), more circular in shape (i.e. experiencing fewer negative influences from adjacent land cover), and surrounded by a hospitable matrix (i.e. type of land cover next to the habitat patch). Natural cover (e.g. forests, wetlands, and meadows) also helps maintain ecosystem functions and services such as habitat provisioning, nutrient cycling, flood attenuation, and regulating surface temperatures.

Changes in habitat quality under each scenario reflect changes in the amount of urban expansion and the level of natural cover enhancements. For Scenario 1, the average habitat quality decreases due to the matrix influences from urban expansion, even though the amount of natural cover does not change. For Scenario 2, average habitat quality decreases at a less substantial rate than Scenario 1. For Scenario 3, average habitat quality improves due to optimal enhancements. For Scenario 4, average habitat quality improves slightly more than Scenario 3 due to optimal enhancements and lack of urban expansion.

Changes across the watershed reflect where natural cover enhancements are focused based on potential improvements. For example, in the Headwaters many habitat patches improve under Scenarios 3 and 4, with Scenario 4 having a greater area of higher quality habitat patches. Under Scenarios 3 and 4, two large higher quality habitat patches are created near the Heart Lake Conservation Area, further supporting connectivity restoration efforts in the area. In the lower portions of the watershed, some poor-quality habitat patches show improvements under Scenarios 3 and 4, demonstrating the watershed-wide benefits of the optimal enhancements.

2.2.3 Terrestrial Biodiversity

Natural landscapes provide habitat for numerous wildlife and vegetation communities. To estimate the impact of the future management scenarios, species data was overlaid with each scenario to assess expected broad-scale changes.

In Scenarios 1, 2, and 3, if agricultural lands are converted to urban land use there will be a direct loss of habitat for numerous species currently using these areas. Etobicoke Creek is currently home to at least eight terrestrial species listed as threatened or endangered under Ontario's *Endangered Species Act*. These species include Bank Swallow (*Riparia riparia*), Barn Swallow (*Hirundo rustica*), Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), Chimney Swift (*Chaetura pelagica*), Least Bittern (*Ixobrychus exilis*), and spike blazing-star (*Liatris spicata*) which are listed as threatened along with butternut (*Juglans cinerea*) listed as endangered. Species listed as endangered are facing imminent extinction or extirpation. Species listed as threatened are likely to become endangered unless steps are taken to address factors causing population declines. While the addition of natural cover in Scenarios 2 and 3 may provide benefits such as larger patch sizes and improved connectivity, the negative matrix influences associated with urban areas may offset the gains from natural cover enhancements. It is likely that any potential gains of area-sensitive species in Scenarios 2 and 3 will be greatly minimized with development in adjacent areas. Animal species in urban areas are affected by more abundant predator communities, parasites, urban noise affecting communication, and fragmentation affecting distribution and mortality.

It is difficult to determine how existing vegetation communities will change under each future management scenario. However, some general changes will likely occur based on current knowledge in the scientific literature related to development and restoration. Plant communities in urban areas generally consist of more non-native species and fewer sensitive species. Urban areas can also limit seed dispersal, increase trampling from recreation pressures, and cause changes in environmental variables (e.g. temperature, chemistry, hydrology) affecting species occurrence. These expected changes would be similar in all scenarios with urban expansion (i.e. Scenarios 1, 2, and 3). But, in Scenarios 2 and 3 where natural cover is enhanced, the addition of potential natural cover could help to buffer some of the negative influences of urban areas on vegetation communities.

2.2.4 Habitat Connectivity

Maintaining and improving landscape connectivity, both at local and regional scales, is crucial for wildlife movements. Landscape connectivity at the local scale ensures that wildlife is able to move to appropriate habitat patches to maintain their short-term life history processes (e.g. seasonal movement between breeding, foraging, and overwintering areas). Regional scale landscape connectivity ensures that longer-term ecological processes (e.g. metapopulation dynamics, gene flow, and dispersal) are maintained in the face of climate change and land use changes.

The amount of high connectivity priority areas overlapping with areas of natural cover increases with an increased level of natural cover enhancements (see **Table 10**). Most of the regional connectivity priorities are in the Headwaters and near Heart Lake Conservation Area. These areas are most enhanced with natural cover under Scenarios 3 and 4. A smaller amount of important areas for watershed connectivity occurs in the lower portions of the watershed. Assumed enhancements under Scenarios 2, 3, and 4 will help buffer these important corridors from the surrounding urban landscape.

Under Scenario 2, the amount of high priority connectivity areas within areas of natural cover increased (8-44%) due to assumed enhancements. Under Scenarios 3 and 4, the amount of high priority connectivity areas within areas of natural cover increased more than under Scenario 2 (25-106%) due to assumed enhancements.

Under Scenario 2, the proposed GTA West Highway (i.e. Highway 413) will have a substantial impact on habitat connectivity, amongst other potential environmental impacts. This includes losses in the number, form, and function of natural features and species. There will be significant fragmentation of valleylands. If this highway is constructed, efforts should be made to maintain habitat connectivity through proper planning and design (e.g. through the use of eco-passages, fencing, and other mitigation measures) in early stages using TRCA's Crossings Guideline for Valley and Stream Corridors (2015) and detailed site-level assessments.

Table 10 shows the habitat connectivity priorities overlapping with NHS areas in the Etobicoke Creek watershed for each of the future management scenarios. The changes in the amount of high priority connectivity areas within the NHS under each future management scenario reflects the level of natural cover enhancements.

Table 10 - Habitat Connectivity by Future Management Scenario

Habitat Connectivity	**Current Conditions** (Area in ha within natural cover land use)	**Scenario 1** (% change from current)	**Scenario 2** (% change from scenario 1)	**Scenario 3** (% change from scenario 1)	**Scenario 4** (% change from scenario 1)
Regional	459	0%	8%	25%	25%
Watershed	1,832	0%	44%	106%	106%
Local – forest to forest	1,463	0%	21%	42%	42%
Local – forest to wetland	439	0%	13%	23%	23%

Note: the area amounts for current conditions differ from the ECWP Characterization Report, since for the purposes of future management scenario analysis, connectivity was assessed only for areas within the natural cover land use layer rather than the entire watershed.

2.2.5 Climate Vulnerabilities

TRCA has completed a climate change vulnerability assessment of the terrestrial system for its entire jurisdiction. There are five vulnerability indicators used in this assessment: habitat patch quality, wetland hydrological vulnerability, climate sensitive vegetation communities, soil drainage, and ground surface temperature. Changes in the amount of highly vulnerable areas (i.e. the five indicators) within the NHS under each scenario has been assessed. For Scenario 1, there is no change in the amount of high vulnerability areas within the NHS compared to current conditions. For Scenario 2, 3, and 4 there is an increase in the amount of high vulnerability areas within the NHS compared to Scenario 1.

It is important to note that while there was no change between current conditions and Scenario 1, additional high vulnerability areas would be created due to urbanization in the Headwaters. For example, ground surface temperatures would increase due to the urban heat island effect, habitat patch quality would decline to urban matrix influences, and as surfaces become impervious, soil drainage would decrease leading to increased vulnerability.

As the amount of natural cover enhancements increase, more highly vulnerable vegetation communities overlap with areas of existing and potential natural cover. In general, as climate vulnerable areas are incorporated into the NHS they are likely to be more resilient to the impacts of climate change. Small differences occur in wetlands overlapping areas of existing or potential natural cover between Scenarios 2, 3, and 4 due to minor variation in the boundary of the NHS used for Scenario 2 compared to Scenarios 3 and 4. The amount of highly vulnerable soils overlapping areas of natural cover increases under each scenario due to the increasing level of natural cover enhancements.

Changes in the amount of highly vulnerable habitat patches reflect the degree of natural cover enhancements; however, Scenarios 3 and 4 had a smaller increase than expected based on the level of natural cover enhancements. This is due to methodological changes[14] in natural cover layers used to conduct the vulnerability assessment, and between the NHS for Scenario 2 and Scenarios 3 and 4. For example, many meadow habitat patches in urban areas from the NHS used for Scenario 2 were not included in the NHS used for Scenarios 3 and 4, resulting in an apparent decrease in the amount of highly vulnerable patches within areas of natural cover.

Similar changes in the amount of highly vulnerable ground surface temperature areas occurred with an increase in Scenario 2 followed by a decrease in Scenarios 3 and 4. This is again due to methodological differences between the Scenarios and were primarily in urban areas. Improvements in Scenario 2 largely reflect potential natural cover targeting urban areas where ground surface temperatures are high. Additional natural cover in Scenarios 3 and 4 further enhance highly vulnerable temperature areas within the urban zone although increases in this indicator were not as substantial as in the Headwaters due to limited opportunities in urban areas.

Areas identified through the climate change vulnerability assessment are not all within existing natural cover and, with an enhanced NHS (including potential natural cover and contributing areas), these areas will be better supported and likely better able to adapt to climate change.

Table 11 outlines the area for each vulnerability indicator and the percent change across future management scenarios.

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[14] Different datasets were used for the climate vulnerability assessment and the watershed refined NHS, resulting in slight discrepancies.

Table 11 - Climate Vulnerability Indicators by Future Management Scenario

Vulnerability Indicator	Area Within Natural Cover (ha) and % Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Habitat patch quality	Area (ha)	1,103	1,103	1,452	1,279	1,279
	% change	N/A	0	32%	16%	16%
Wetlands	Area (ha)	69.7	69.7	72.4	72.1	72.1
	% change	N/A	0	4%	3%	3%
Climate sensitive vegetation communities	Area (ha)	2.5	2.5	2.6	2.6	2.6
	% change	N/A	0	2%	3%	3%
Soil drainage	Area (ha)	1,451	1,451	2,088	2,208	2,208
	% change	N/A	0	44%	52%	52%
Ground surface temperature	Area (ha)	618	618	1,055	900	900
	% change	N/A	0	71%	46%	46%

Note: the area amounts for current conditions differ from the ECWP Characterization Report, since for the purposes of future management scenario analysis, climate vulnerability was assessed only for areas within natural cover land use layer rather than the entire watershed.

The climate in TRCA's jurisdiction by 2050 under Representative Concentration Pathway (RCP 8.5) is expected to be warmer, with more extreme heat days, wetter, with more extreme precipitation events, and have a longer growing season. Since climate is the main predictor of the geographic distribution of species and communities, climate change will have profound impacts on species, communities, and ecosystem function. It is also predicted to magnify the impacts of other existing stressors such as habitat loss and fragmentation, and invasive species. Expected impacts to terrestrial ecosystems due to climate change are outlined in **Figure 6** below.

Climate Change Analysis – Terrestrial Systems		
If (climate stressor)	**Then (outcome)**	**So (consequence)**
Increase in average temperature	Species movement to areas with suitable climate (i.e. range expansion)	Potential species extinction if unable to adapt to climatic changes
Increase in distribution and severity of pests and diseases	Increase prevalence and magnitude of disease impacts	Species become susceptible to pests and diseases
Increase in extreme weather events	Localized changes in species distribution Storm impacts to ecosystem health	Ecosystems can take longer to recover from storm events

Increase in invasive species prevalence	Both native and invasive species are expected to shift ranges, but invasive species will likely be successful due to adaptability, high growth rates and ability to infest disturbed areas	Additional stress on native species populations from non-native competitors

Figure 6 - Climate Change and Terrestrial Systems

2.2.6 Urban Forest

Since most of the watershed is urbanized, the changes and impacts to the urban forest will be largely caused by further urbanization and intensification. Urban intensification has been shown to have an adverse impact on urban forests, contributing to tree removal, canopy reduction, and the reduction of available planting space. Infill development projects often result in larger building footprints and more impervious surface thereby reducing the amount of available space for trees.

In the assessment of urban forest across the future management scenarios, there are some interesting findings. There is no real change in urban forest quantity from current conditions to Scenario 1 since the currently rural Headwaters already has a low canopy cover percentage. Urban expansion would result in tree planting, but not significantly enough to increase overall canopy cover across the watershed. Canopy cover does increase by approximately 32% from Scenario 1 to Scenario 2, but still represents less than 20% of the entire watershed area. This is because planting only occurs in the contributing areas of the NHS, which are only a small portion of the watershed, much of which is unplantable. Scenarios 3 and 4 represent ambitious planting objectives, in which trees would be planted across the watershed in most available pervious spaces and some impervious spaces, such as parking lots (although at a much lower density). Under these ambitious scenarios, canopy cover increases by approximately 80% compared to Scenario 1 and represents about 27% of the watershed area.

Based on the urban forest enhancement assumptions made in the future management scenarios and the assessment of potential plantable spaces by land uses, there is significant potential to increase the urban forest canopy within all subwatersheds. **Table 12** demonstrates the area percentage of each subwatershed that could potentially consist of urban forest canopy cover by future management scenario.

Table 12 - Canopy Cover Area Percentage by Subwatershed and Future Management Scenarios

Subwatershed	Current Conditions (area %)	Scenario 1 (area %)	Scenario 2 (area %)	Scenario 3 (area %)	Scenario 4 (area %)
Headwaters	13%	13%	20%	25%	29%
Spring Creek	15%	15%	20%	27%	27%
West Branch	18%	18%	22%	29%	29%
Tributary 3	7%	7%	13%	21%	21%
Tributary 4	13%	13%	18%	23%	23%
Main Branch	14%	14%	16%	22%	22%

Subwatershed	Current Conditions (area %)	Scenario 1 (area %)	Scenario 2 (area %)	Scenario 3 (area %)	Scenario 4 (area %)
Little Etobicoke	14%	14%	16%	24%	24%
Lower Etobicoke	23%	23%	25%	33%	33%
Watershed	**15%**	**15%**	**19%**	**27%**	**27%**

A healthy and expansive urban forest is important for watershed health due to the numerous ecosystem services provided by trees, such as improved water and air quality, stormwater interception, carbon storage and sequestration, moderating extreme heat, and providing habitat.

The range of services and benefits provided by the urban forest can support communities to adapt to climate change, however urban trees are already exposed to environmental stressors that are expected to be exacerbated by climate change. Based on the projected climatic conditions under the RCP 8.5 scenario, the urban forest across the Etobicoke Creek watershed is expected to be vulnerable to increased average temperatures, heat events, drought, and altered precipitation patterns. Additionally, pests and diseases are expected to be more pervasive because of the increased average temperatures and shorter, warmer winters. These stressors directly affect the ability of urban trees to become established and survive. Figure 7 identifies how climate change is expected to affect the urban forest.

Climate Change Analysis – Urban Forest		
If (climate stressor)	**Then (outcome)**	**So (consequence)**
Increase in the frequency / intensity of extreme heat events	Increased stress responses, such as loss of leaves and reduced tree growth Increased tree death Increased risk of pests and diseases	Loss of ecosystem goods and services provided by trees Decreased shade from loss of canopy cover Increased heat island effect in urban areas
Increase in average temperature and hot days over 30 °C	Increased damage to trees and more tree deaths Disrupts seed production Change in the types of species (some species fare well with higher temperatures and drier conditions, others don't)	More pests and diseases Loss of biodiversity (i.e. amount and type of species) Increased maintenance and tree replacement costs
Increased and changing precipitation patterns	Shifting ecosystem types for plants and animals	

Figure 7 - Climate Change and the Urban Forest

2.3 Water Quality

Maintaining good water quality is essential for healthy ecosystems and their functions and services. The Etobicoke Creek watershed generally has poor water quality compared to the rest of TRCA's jurisdiction; however, water quality tends to be worse in existing urban areas and better in more rural and natural areas of the watershed. This variation provides an opportunity to compare the outcomes of varying future land use and natural cover and stormwater enhancement scenarios to inform watershed management decisions. In order to compare these outcomes, two water quality parameters were assessed, chloride (e.g. from road salt) and TSS (e.g. the amount of particulate matter in water such as silt, clay, etc.), using a watershed model.

TSS was chosen as a surrogate to represent the impacts of other parameters of concern noted in the characterization of the Etobicoke Creek watershed. TSS had strong positive correlations with total phosphorus (r = 0.87), copper (r = 0.62), iron (r = 0.82), and zinc (r = 0.59) using water quality data from over the past two decades. These strong correlations suggest that changes in these parameters under each future management scenario would be like those predicted by the model for TSS. *Escherichia coli* (*E. coli*) is another parameter of concern in this watershed, but is not strongly correlated with TSS (r = 0.33). Future management scenarios that include stormwater enhancements, such as eliminating cross connections, or retrofitting combined sewers, would help improve *E. coli* counts. In addition to *E. coli*, there are several other existing water quality concerns in the watershed such as spills, microplastics, and chemicals of emerging concern. In general, future management scenarios with additional urban areas or roads will increase the likelihood of spills (such as diesel), chemicals of emerging concern, and microplastics (such as rubber from tire wear) entering waterways.

Overall, predicted changes in chloride and TSS reflect the level of urbanization, and natural cover and stormwater enhancements in each future management scenario. The magnitude of the predicted change varied across the watershed showing the strongest impacts in areas close to anticipated urban or road development. Even though proximity was an important factor, these changes were so pronounced that they also occurred downstream but to a lesser degree. Climate change led to, on average, lower percent changes in chloride due to fewer snow events; however, maximum values were higher than current conditions and were the highest in Scenario 2 containing the proposed GTA West highway.

2.3.1 Chlorides

On average, chloride concentrations decreased under the future management scenarios (See **Figure 8**). Several factors affect chloride including climate change, land use change, and stormwater and natural cover enhancements. Less snow is predicted with climate change resulting in lower road salt use in general (the model only uses snow events to consider road salt application and does not account for other types of precipitation such as freezing rain that might also initiate road salt application). It is important to note that although climate models suggest less snow fall due to higher daily temperatures, there may be a change to freeze/thaw cycles necessitating the use of road salts. This finding is consistent with chloride modelling in New York State from 2018. This study found that stream chloride concentrations are anticipated to rise for the next several decades followed by declines starting between 2040 and 2069 due to decreased snowfall and reduced salt application. Land uses such as urbanization and road construction result in higher chloride concentrations due to salt application. Both stormwater and natural cover enhancements increase the retention of chloride, delaying its release into streams.

Even though concentrations decreased overall, the magnitude of the decrease varied among future management scenarios, especially in the winter season.

- Scenario 1, there is a decrease in chloride concentration suggesting that climate change is largely the cause since there is urban expansion with minimal stormwater enhancements.
- Scenario 2, the decrease was not as large due to the proposed GTA West highway and the additional expected road salting in winter months.
- Scenarios 3 and 4 are similar suggesting again impacts of climate change. Climate change impacts appear to be so large that comparisons related to land use change are not distinguishable.

Even though climate change seems to be driving a decrease in chloride concentrations in the watershed, concentrations are already high, affecting aquatic life. Legacy chloride retained in various locations (e.g. groundwater, stormwater, and soils) will likely increase in the WRS over the next several decades, stressing an already impacted system.

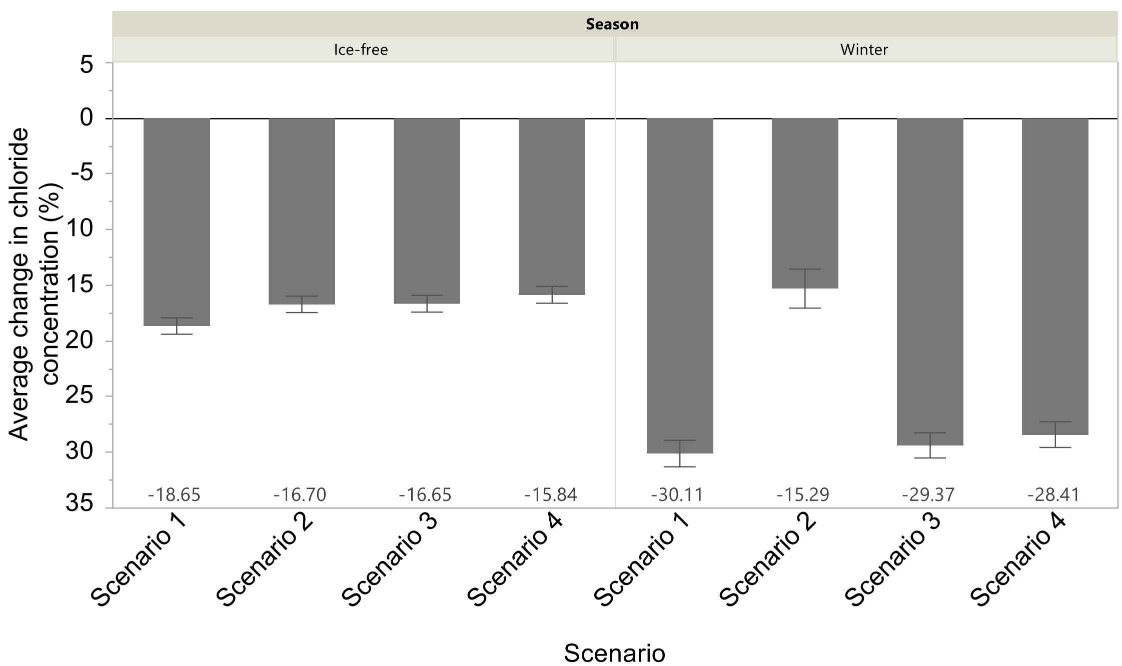

Figure 8 - Average Percent Change in Chloride Concentrations of All Stream Segments Combined

Figure 8 shows the relative change in expected concentrations between the future management scenarios and should not be considered the same as the percent change outlined in **Table 5**. In other words, since absolute concentration values are not being reported due to the nature of the water quality model, the average change in concentration is being used to interpret relative increases or decreases in chloride concentrations amongst future management scenarios.

The maximum percent change predicted by the model was also analyzed to determine where the greatest increases in chloride concentrations occurred (See **Figure 9**). The greatest percentage increase is expected under

Scenario 2 during the winter season in stream segments in the upper portion of the watershed. Maximum percent change in chloride was lower for Scenarios 3 and 4, demonstrating the benefits of the optimal stormwater and natural cover enhancements.

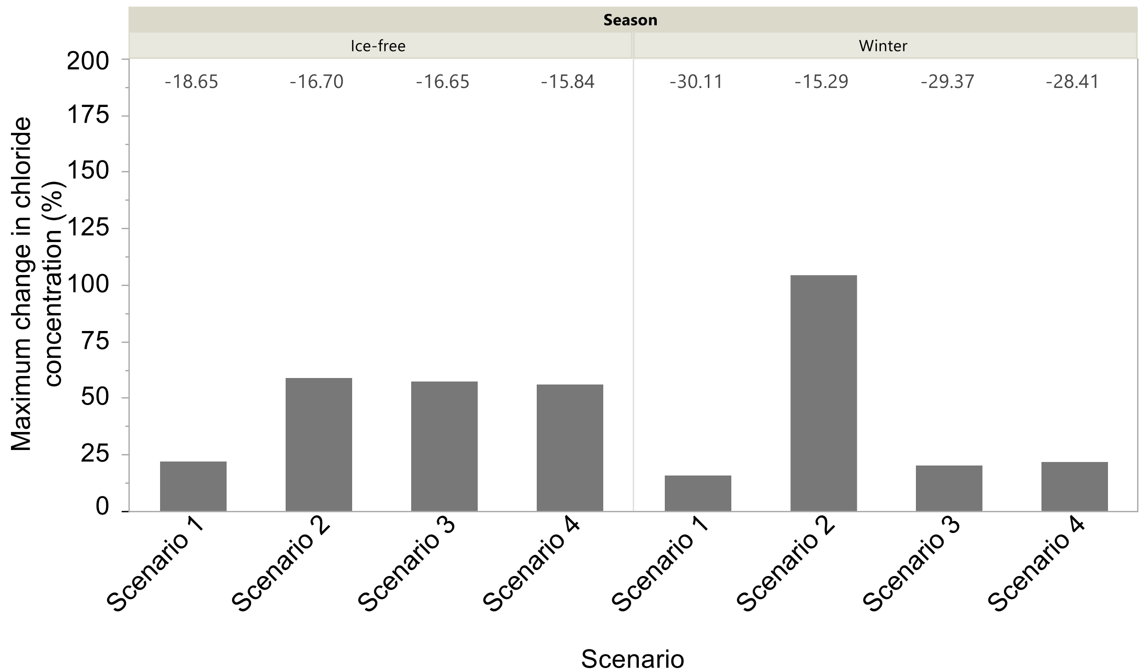

Figure 9 - Maximum Percent Change in Chloride Concentrations for All Stream Segments Combined

If changes at different points in the watershed are examined, there are some noticeable patterns for the maximum percent change in chloride concentrations for each future management scenario. The Mayfield water quality station located in the Headwaters shows the highest maximum change in chloride concentrations for the winter season under Scenario 2 due to its close proximity to the proposed GTA West highway. This pattern also applies to several other stations downstream. See **Figure 10** for the maximum change in chloride concentrations for the eight water quality stations. **Figure 24** can be used as a reference for the location of these water quality stations within the watershed.

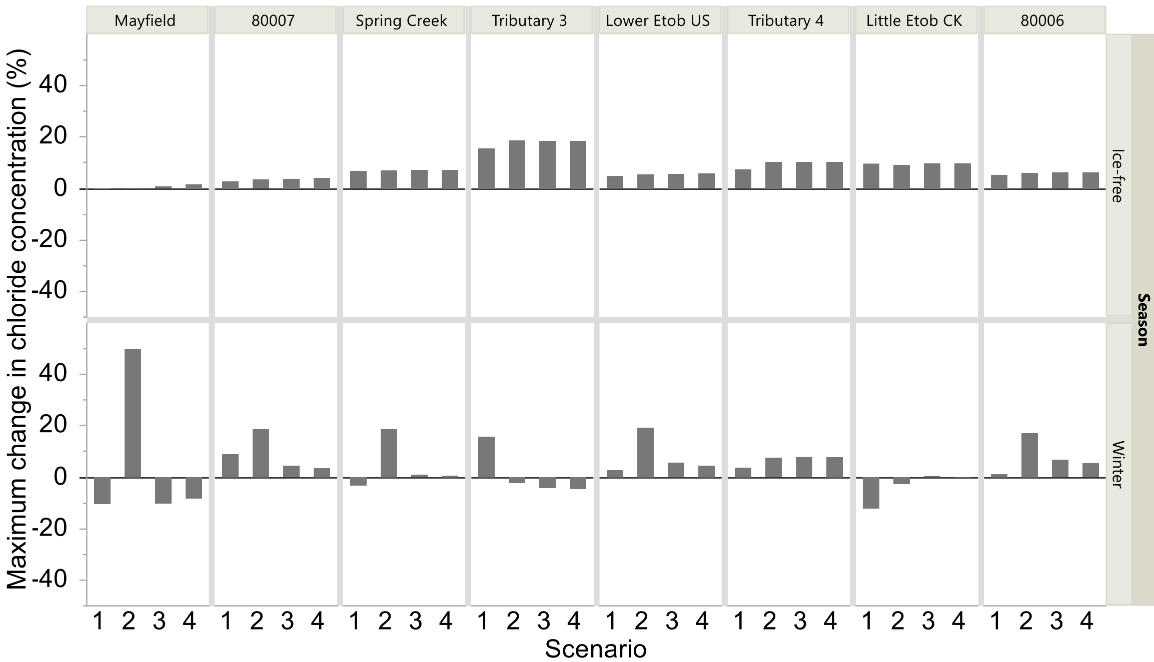

Figure 10 - Maximum Percent Change in Chloride Concentrations by Water Quality Station

2.3.2 Total Suspended Solids

TSS concentrations were affected by climate change, changes in land use, and stormwater and natural cover enhancements. Climate change is expected to increase the amount of precipitation resulting in more run-off from land and subsequently increasing TSS in streams. Land use changes that result in more impervious surfaces also result in more run-off increasing TSS in streams. Both stormwater and natural cover enhancements decrease the amount of TSS entering streams by stabilizing soils and retaining sediments.

Average percent change in TSS concentration differed under each future management scenario (See **Figure 11**).

- Scenario 1 resulted in higher TSS concentrations than current conditions due to urban expansion, minimal stormwater enhancements, and no enhancement of the NHS.
- Scenario 2 resulted in higher TSS concentrations than current conditions but demonstrates the improvement in TSS due to additional natural cover and stormwater enhancements.
- Average TSS concentrations decreased by the greatest percentage under Scenarios 3 and 4 where NHS and stormwater enhancements are maximized.

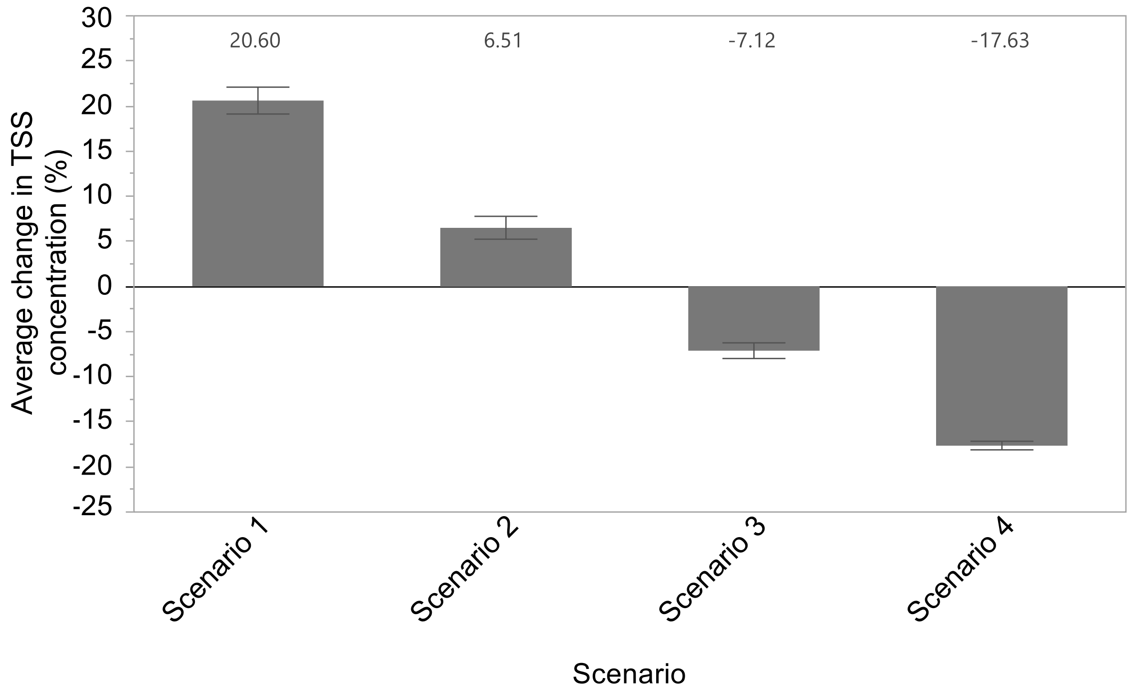

Figure 11 - Average Percent Change in TSS Concentrations for All Stream Segments Combined

Figure 11 shows the relative change in expected concentrations between the future management scenarios and should not be considered the same as the percent change outlined in **Table 5**. In other words, since absolute concentration values are not being reported due to the nature of the water quality model, the average change in concentration is being used to interpret relative increases or decreases in TSS concentrations amongst future management scenarios.

The maximum percent change in TSS concentrations predicted by the model (see **Figure 12**) shows lower levels of maximum TSS concentrations with the increasing number of enhancements associated with the future management scenarios (i.e. highest for Scenario 1, lowest for Scenario 4).

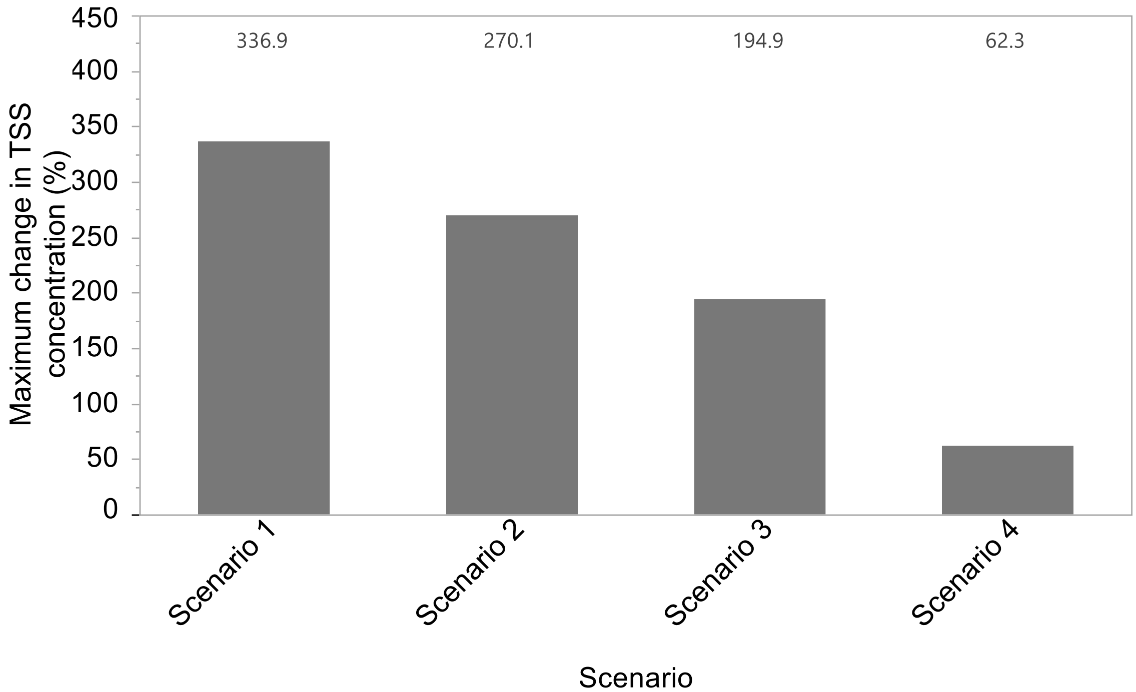

Figure 12 - Maximum Percent Change in TSS Concentrations for All Stream Segments Combined

If changes at different points in the watershed are examined, there are some noticeable patterns for the maximum percent change in TSS concentrations for each future management scenario. The greatest increases were at the Mayfield station in the Headwaters for Scenario 1, 2, and 3. This is expected due to the urban expansion and the link between construction, imperviousness, and TSS concentrations. The maximum TSS concentrations at Mayfield are lower for Scenarios 2 and 3 with the increasing number of enhancements. A similar pattern exists for the other water quality stations, with Scenarios 3 and 4 having the lowest maximum TSS concentrations. See **Figure 13** for the maximum percent change in TSS concentrations by water quality station. **Figure 24** can be used as a reference for the location of these water quality stations within the watershed.

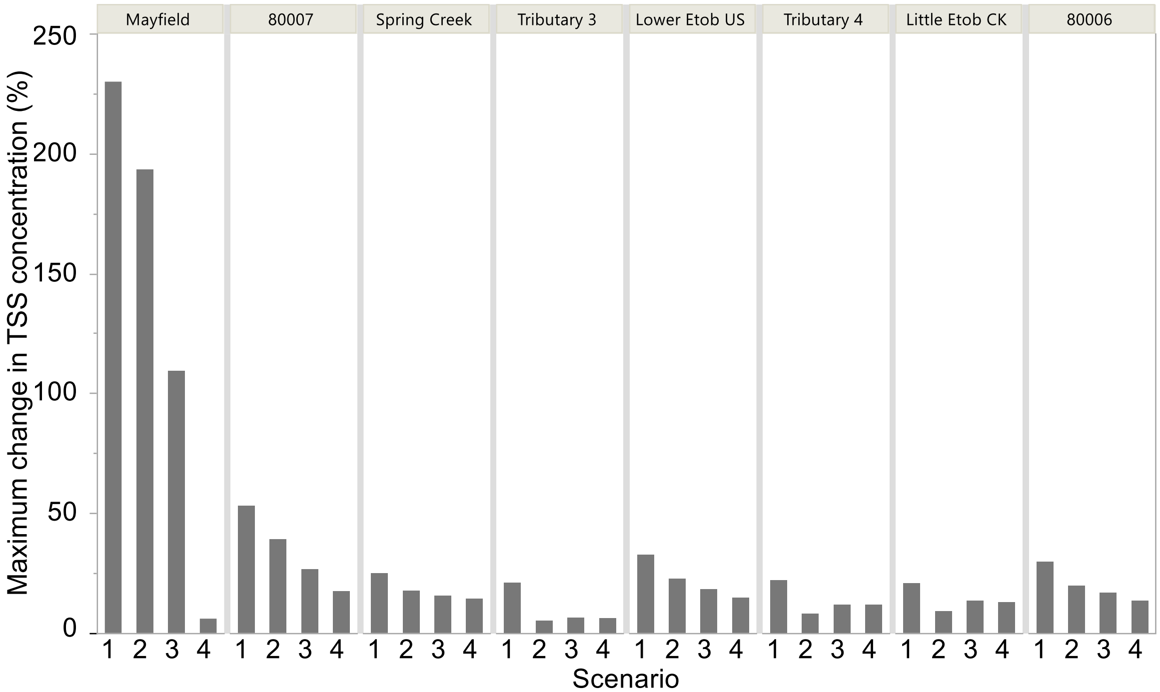

Figure 13 - Maximum Percent Change in TSS Concentrations by Water Quality Station

Expected impacts to water quality due to climate change are outlined in **Figure 14** below. Future warming is predicted to lead to increases in the intensity and frequency of rainfall events. Changes in hydrologic processes (such as precipitation leading to greater stream flow) affect how pollutants are mobilized and transported to water bodies. Changes in hydrology related to climate change are predicted to generally lead to a greater risk of water quality degradation.

Climate Change Analysis – Water Quality		
If (climate stressor)	**Then (outcome)**	**So (consequence)**
Increase in the intensity and frequency of precipitation events	Increased runoff from urban and agricultural areas	Decrease in surface water quality
Increase in the intensity and frequency of extreme weather events	Increased risk of spills	

Figure 14 - Climate Change and Water Quality

2.4 Natural Hazards

One of the main responsibilities of TRCA is to protect life and property from natural hazards (i.e. riverine and shoreline flooding and erosion risks).

The increase in intensity and frequency of precipitation events associated with a changing climate is expected to result in increased flooding and erosion. Expected impacts to natural hazards (including flooding and erosion) due to climate change are outlined in **Figure 15** below.

Climate Change Analysis – Natural Hazards		
If (climate stressor)	**Then (outcome)**	**So (consequence)**
Increase in the intensity and frequency of precipitation events	Increased flooding Increased erosion of valley and stream corridors and shorelines	Increased risk to infrastructure and property Increased risk to public health and safety Increased risk to ecosystems and their ability to adapt

Figure 15 - Climate Change and Natural Hazards

2.4.1 Flooding

Riverine flooding occurs when the capacity of a stream is exceeded, causing water to overtop the banks, affecting the surrounding areas. Historically, flood risk has generally increased due to urbanization, which alters the volume, intensity, and timing of runoff to streams. This is especially true for areas that were built without stormwater management controls in place, such as stormwater management ponds. Within the Etobicoke Creek watershed there are six identified FVCs where urban areas are at an elevated risk of flooding. As part of the future management scenarios analysis, hydrologic modelling was completed to understand changes to flow into the FVCs. Each future management scenario was run with and without climate change, with results for each of the six FVCs and design storms[15] from the 2 to 100-year return period and the Regional storm (i.e. Hurricane Hazel).

In Scenario 1, design storm inflows to FVCs are comparable to current conditions. Scenarios 2, 3, and 4 show design storm peak flow reductions below current conditions at all FVCs. Under the Regional storm, Scenarios 1, 2, and 3 significantly increase peak flows from the Headwaters into the West Branch, with further downstream effects seen at Longbranch FVC near the Creek mouth at Lake Ontario. Scenario 4 showed a minor increase from the Headwaters into the West Branch, but effects further downstream are comparable to current conditions. When climate change adjusted design storms are applied to each of the future management scenarios,

[15] Design storms are based on statistical analysis of rainfall over a period of record. For example, the Regional storm (i.e. Hurricane Hazel) is a 12-hour event with 212 mm of rainfall, which assumes completely saturated soils. The 5-year storm means there is a one in five probability of flow being exceeded in any one year, one in 50 probability for the 50-year storm, and so forth.

stormwater infrastructure continues to provide most of the runoff mitigation, but not as effectively. The 100-year level of service is not achieved for climate change adjusted design storms based on current standards.

The inflow locations to the six FVCs were chosen as observation points for changes in flood risk because these areas experience riverine flood conditions under less extreme events than the regulatory storm (whichever is greater of the Regional storm (Hurricane Hazel) or the 100-year storm), and are therefore sensitive to upstream development and management interventions. Brampton Central is the most upstream FVC and would therefore exhibit the effects of urban expansion in the Headwaters and the proposed enhancements most clearly from a modelling perspective. It is noted that the City of Brampton is working towards flood mitigation in this area and some increases to inflow may not correspond to increased flood risk as solutions are implemented.

The proposed enhancements associated with Scenarios 2, 3, and 4, intercept a portion of the rainfall landing on a catchment before it becomes runoff, thereby reducing the volume of water and lowering peak flows. The mid-range enhancements in Scenario 2 and optimal enhancements in Scenarios 3 and 4 are expected to progressively increase system storage and reduce FVC inflows to levels below current conditions and Scenario 1. Inflows to FVCs in Scenarios 3 and 4 are not expected to be significantly different from each other since the conceptual stormwater infrastructure that control outflows from urban expansion would hypothetically minimize downstream impacts and generate similar flows to Scenario 4.

Results for the 100-year, 50-year, 5-year, and Regional design storms are presented in the following tables. Through the hydrologic modelling, the 25-year, 10-year, and 2-year design storms were also run, but are not presented here. Generally, the results for these design storms showed a similar pattern to the results in the tables below. Table 13 shows the relevant design storms for each of the FVCs without climate change factored in. In other words, the results only account for land use in the future management scenarios. Table 14 shows the relevant design storms for each of the FVCs with climate change factored in. So, the results account for climate change and land use in the future management scenarios. Table 15 shows the Regional storm (i.e. Hurricane Hazel) modelling results for each of the FVCs. All tables represent the percent change in peak flows as positive values since a reduction in peak flow means flood risk decreases. Figure 25 shows a map of the inflows to the FVCs discussed in the following tables.

Table 13 - Design Storms at FVCs without Climate Change

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
100-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	78.8	71.7	67.4	59.3	61.8
	% change	N/A	9%	6%	17%	14%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	23.5	23.2	23.1	22.5	22.5
	% change	N/A	1%	0%	3%	3%

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	29.8	26.1	24.6	22.4	22.5
	% change	N/A	12%	6%	14%	14%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	37.1	37.4	37.2	36.1	36
	% change	N/A	-1%	1%	4%	4%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	106.9	108.4	105.7	91.3	91.3
	% change	N/A	-1%	3%	16%	16%
Longbranch FVC Inflow	Peak flows (m^3/s)	359.0	359.4	323.1	276.9	275.4
	% change	N/A	0%	10%	23%	23%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	304.7	304.6	276.6	240.6	239.7
	% change	N/A	0%	9%	21%	21%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	36.5	37.1	36.4	33.8	33.9
	% change	N/A	-2%	2%	9%	9%
50-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	69.9	63.7	59.2	51.2	51.9
	% change	N/A	9%	7%	20%	19%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	21.3	21	21	20.5	20.5
	% change	N/A	1%	0%	3%	3%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	26.8	23.4	22	19.3	19.5
	% change	N/A	12%	6%	18%	17%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	33.8	34.1	33.8	32.4	32.4
	% change	N/A	-1%	1%	5%	5%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	96.8	98.1	95.3	80.2	80.2
	% change	N/A	-1%	3%	18%	18%

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Longbranch FVC Inflow	Peak flows (m^3/s)	314.9	315.1	280.6	236.1	235
	% change	N/A	0%	11%	25%	25%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	269.6	270.1	243	207	206
	% change	N/A	0%	10%	23%	24%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	33.1	33.6	32.9	29.9	30
	% change	N/A	-2%	2%	11%	11%
5-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	41.2	37.6	32.8	24.6	25.9
	% change	N/A	9%	13%	35%	31%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	13.7	13.5	13.2	12.7	12.7
	% change	N/A	2%	2%	6%	6%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	14.4	10.1	8.5	6.6	6.6
	% change	N/A	30%	16%	34%	35%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	22.5	22.5	22.4	17.5	17.5
	% change	N/A	0%	1%	22%	22%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	63.1	63.8	58.6	41.9	41.9
	% change	N/A	-1%	8%	34%	34%
Longbranch FVC Inflow	Peak flows (m^3/s)	182.5	182	151.3	118	117.7
	% change	N/A	0%	17%	35%	35%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	160.7	160.7	134.9	104	103.7
	% change	N/A	0%	16%	35%	36%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	21.6	21.9	21.1	16.4	16.5
	% change	N/A	-2%	4%	25%	25%

Adjusted rainfall volumes for each of the design storms are higher, based on the current and adjusted intensity-duration-frequency (IDF) parameters for climate projections. While none of the future management scenarios specifically test climate change adjusted design storms, land use, and each enhancement independently of each other, the closest comparison is for the FVC peak flows with and without climate change for Scenarios 3 and 4. Comparing Scenario 3 and 4 without climate change can assess the impact of land use, since Scenario 4 does not include the urban expansion in the Headwaters. The hydrology modelling results show that stormwater infrastructure based on relevant criteria can manage peak flows from the land use change comparable to Scenario 4 levels. Urban expansion areas in the models are assumed to conform with TRCA stormwater management quantity criteria for the Etobicoke Creek Headwaters, so conceptual ponds were included to control outflows to 60% of existing conditions flow. This is a stricter standard than the typical “post- to pre-development" approach, but it was developed to prevent the off-site impacts of urban expansion in the Headwaters. Comparing Scenario 4 with and without climate change can assess the relative impact of climate change. Generally, it is observed that the capacity of stormwater infrastructure designed for current standards is exceeded around the adjusted 50-year design storm. In other words, the Scenario 4 climate change adjusted 50-year peak flows are higher than the Scenario 4 100-year peak flows at all FVCs without climate change.

Table 14 - Design Storms at FVCs with Climate Change

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
100-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	78.8	93	88.1	80.6	90.2
	% change	N/A	-18%	5%	13%	3%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	23.5	29	28.9	28.1	28.1
	% change	N/A	-23%	0%	3%	3%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	29.8	32.7	31.3	28.8	28.9
	% change	N/A	-10%	4%	12%	12%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	37.1	45.7	45.5	44.7	44.7
	% change	N/A	-23%	1%	2%	2%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	106.9	134.2	132.3	120.7	120.6
	% change	N/A	-26%	1%	10%	10%
Longbranch FVC Inflow	Peak flows (m^3/s)	359	474.2	437.7	388.1	385.5
	% change	N/A	-32%	8%	18%	18%

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	304.7	394	367.2	328.2	326.2
	% change	N/A	-29%	7%	17%	17%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	36.5	45.8	45.1	43.3	43.5
	% change	N/A	-25%	2%	5%	5%
50-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	69.9	77.9	73.4	65.6	70.2
	% change	N/A	-12%	6%	16%	10%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	21.3	24.9	24.8	24	24
	% change	N/A	-17%	0%	4%	4%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	26.8	28.1	26.6	24.3	24.4
	% change	N/A	-5%	6%	14%	13%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	33.8	39.9	39.7	38.7	38.6
	% change	N/A	-18%	1%	3%	3%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	96.8	116	113.5	99.8	99.8
	% change	N/A	-20%	2%	14%	14%
Longbranch FVC Inflow	Peak flows (m^3/s)	314.9	392.8	356	308.2	306.3
	% change	N/A	-25%	9%	22%	22%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	269.6	331.6	303.3	264.9	263.7
	% change	N/A	-23%	9%	20%	21%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	33.1	39.7	39	36.7	36.8
	% change	N/A	-20%	2%	8%	7%
5-year Design Storm						
Brampton Central FVC Inflow	Peak flows (m^3/s)	41.2	41.1	36.1	28.1	29.1
	% change	N/A	0%	12%	32%	29%

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	13.7	14.5	14.3	14.2	14.2
	% change	N/A	-5%	1%	2%	2%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	14.4	12.1	9.4	7.2	7.2
	% change	N/A	16%	23%	40%	41%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	22.5	24.3	24	19.9	19.9
	% change	N/A	-8%	1%	18%	18%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	63.1	68.4	63.5	46.9	46.9
	% change	N/A	-9%	7%	31%	31%
Longbranch FVC Inflow	Peak flows (m^3/s)	182.5	199	167.2	131.1	130.7
	% change	N/A	-9%	16%	34%	34%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	160.7	174.5	149	116.1	115.7
	% change	N/A	-9%	15%	34%	34%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	21.6	23.5	22.7	18.4	18.4
	% change	N/A	-9%	3%	22%	22%

As per industry standard for simulation of the Regional storm, all stormwater management facilities, including any LID on-site retention, were removed from the model (i.e. assumed to be at capacity with no additional retention ability) and soil parameters were adjusted to reflect saturated conditions, which lowered the capacity of any enhancements to the NHS and urban forest.

Scenarios 1 to 3 significantly increase peaks flows at the Brampton Central FVC, while peak flows to the West Mall and Longbranch FVCs increase moderately, with Scenario 3 providing only partial benefits to these areas. Under the Regional storm, the enhancements to the NHS and urban forest are not expected to significantly offset the runoff potential of the urban expansion.

Table 15 - Regional Storm Peak Flow Results

Flood Vulnerable Cluster Inflow	Peak flows (m^3/s) and Percent Change	Current Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Regional Storm (i.e. Hurricane Hazel)						
Brampton Central FVC Inflow	Peak flows (m^3/s)	284.7	325.8	324.9	321.2	288.5
	% change	N/A	-14%	0%	1%	11%
Avondale FVC West Tributary Inflow	Peak flows (m^3/s)	35	35	34.9	34.9	34.9
	% change	N/A	0%	0%	0%	0%
Avondale FVC East Tributary Inflow	Peak flows (m^3/s)	159.7	152.9	154.2	152.2	151.3
	% change	N/A	4%	-1%	1%	1%
Little Etobicoke FVC Inflow	Peak flows (m^3/s)	74.7	74.9	74.9	74.7	73
	% change	N/A	0%	0%	0%	3%
Dixie/Dundas FVC Inflow	Peak flows (m^3/s)	200.1	201	201	200.2	198.9
	% change	N/A	-1%	0%	0%	1%
Longbranch FVC Inflow	Peak flows (m^3/s)	898.4	915.2	913.7	907.7	891.1
	% change	N/A	-2%	0%	1%	3%
West Mall FVC West Tributary Inflow	Peak flows (m^3/s)	739.5	760	759.5	752.9	736.6
	% change	N/A	-3%	0%	1%	3%
West Mall FVC East Tributary Inflow	Peak flows (m^3/s)	61.8	62.4	62.3	62.2	62.2
	% change	N/A	-1%	0%	0%	0%

To help understand the benefits of the different types of enhancements, a comparison of LID implementation and pervious enhancements (i.e. NHS and urban forest) on the urbanized portions of the watershed is useful. The effects of the NHS and urban forest enhancements cannot be separated from each other since they were lumped together into the overall pervious component parameters. However, comparing the change in storage of pervious areas from the future management scenarios is a reasonable estimate of how natural cover enhancements affect storage quantities. A general LID implementation of simple on-site retention was used, which only affects impervious area storage. Table 16 shows the average runoff volume stored by LID onsite retention and pervious areas (i.e. natural cover) per hectare of urbanized catchment for the 2 to 100-year design storms.

The natural cover enhancements from Scenario 1 to Scenario 2 increase the average storage in urban pervious areas by 3 to 4.1 m^3/ha for the 2 to 100-year design storms respectively. For Scenario 2 to Scenario 3/4, the natural cover enhancements increase the average storage in urban pervious areas by 13.3 to 18.1 m^3/ha for the 2 to 100-year design storms respectively. In all scenarios, the storage provided by LID onsite retention is exceeded by the design storms. By implementing on-site retention as a function of the amount of impervious area in a particular catchment, a trend emerges that suggests a minimal storage depth where certain land uses can start to see benefits. For example, in Scenario 1 where 5 mm of onsite retention is prescribed to the Headwaters urban expansion areas, onsite retention volumes were comparable to pervious area storage where imperviousness exceeded 90% (e.g. similar to commercial and industrial land use). For Scenario 2, in which 12.5 mm of onsite retention is assumed for urbanized catchments across the watershed, onsite retention begins to approach pervious area storage volumes for catchments with around 67% imperviousness (e.g. similar to medium to high density residential land use). For Scenario 3 and 4, in which 25 mm of onsite retention is assumed for urbanized catchments across the watershed, onsite retention begins to approach pervious area storage volumes for catchments with around 49% imperviousness.

Table 16 - Average Storage Provided by LID and Natural Cover on Urbanized Catchments

Design Storm	**Scenario 1**		**Scenario 2**		**Scenario 3 and 4**	
	LID (m^3/ha)	**Natural Cover (m^3/ha)**	**LID (m^3/ha)**	**Natural Cover (m^3/ha)**	**LID (m^3/ha)**	**Natural Cover (m^3/ha)**
2-year	11.2	108.5	68.3	111.5	130.3	124.8
5-year	11.2	122.3	68.3	125.7	130.3	141.7
10-year	11.2	129.7	68.3	133.3	130.3	151
25-year	11.2	137.5	68.3	141.4	130.3	160.8
50-year	11.2	142.5	68.3	146.5	130.3	167.1
100-year	11.2	146.9	68.3	151	130.3	172.7

2.4.2 Erosion Risk

In-stream erosion occurs when particles forming the stream channel boundary get dislodged and transported. The forces that cause erosion are related to the volume and rate at which sediment and water are delivered to the stream. In urban settings, previous studies have shown that as urbanization progresses, changes occur in channel morphology and sediment transport due to the changes in the watershed hydrology. As the percentage of imperviousness in a watershed increases, the impacts to the stream such as in-stream erosion also increase. Stream channels have a certain capacity to respond to change without any negative impacts. This ability to accept increased stream discharges without negative erosion impacts is based on a threshold determined by the specific characteristics of a stream reach.

For each of the four future management scenarios, the potential in-stream erosion was determined at the reaches represented by the fluvial monitoring sites (at which erosion thresholds were identified) using an erosion threshold assessment approach which involved the use of two indicators: cumulative effective work index (CEW) and the time of exceedance (TOE). CEW provides a measure of the energy expended by the channel above the threshold discharge, or critical shear stress value. Larger values of CEW imply greater potential for erosion of the median grain size of the channel material. TOE provides a measure of the total amount of time over which the threshold or critical flow is exceeded in the channel. Larger values of TOE suggests a larger total time period during which the channel could erode.

A comparison of the CEW and TOE across the four different future management scenarios shows the following:

- Scenario 1 has a much larger potential for erosion than current conditions for all subwatersheds, with the exception of Little Etobicoke and Tributary 4.
- The Headwaters subwatershed shows the largest increase in erosion for Scenario 1.
- All subwatersheds show progressively lower amounts of erosion in Scenarios 2, 3, and 4 compared to Scenario 1 with increased enhancements.

It is evident that a larger urban footprint without enhancements results in greater erosion impacts. **Table 17** shows the results of the average values for CEW and TOE on a subwatershed basis. **Figure 26** shows a map of the average change in CEW across the watershed, while **Figure 27** shows the average change in TOE across the watershed. A negative percent change indicates more erosion, while a positive change means less erosion when compared to current conditions or Scenario 1.

Table 17 - CEW and TOE by Subwatershed and Future Management Scenarios

Subwatershed	Current Conditions	Scenario 1 (% change)	Scenario 2 (% change)	Scenario 3 (% change)	Scenario 4 (% change)
CEW: Cumulative Effective Work Index (N/m* for current conditions)					
Headwaters	9,238,494	-128%	18%	35%	58%
Spring Creek	556,488,257	-11%	29%	45%	47%
West Branch	279,882,341	-49%	30%	42%	57%
Tributary 4	1,412,573,672	-1%	38%	48%	48%
Main Branch	465,512,369	-18%	34%	46%	53%
Little Etobicoke	926,783,569	-1%	40%	53%	53%
Lower Etobicoke	6,105,756,983	-13%	35%	48%	53%

Subwatershed	Current Conditions	Scenario 1 (% change)	Scenario 2 (% change)	Scenario 3 (% change)	Scenario 4 (% change)
TOE: Time of Exceedance (hr for current conditions)					
Headwaters	312	-104%	17%	32%	48%
Spring Creek	3,888	-136%	25%	44%	48%
West Branch	1,296	-24%	24%	42%	51%
Tributary 4	1,176	-1%	38%	51%	51%
Main Branch	1,019	-4%	31%	49%	50%
Little Etobicoke	1,797	-1%	41%	54%	54%
Lower Etobicoke	3,256	-8%	36%	51%	54%

Notes:

* N/m stands for newtons / metre

** Tributary 3 is not included in this analysis as there is no fluvial geomorphology monitoring station in this subwatershed at which erosion risk could be assessed.

3. METHODOLOGY

This section provides an overview of the methods and approaches that were used to characterize each of the technical components.

3.1 Water Resource System

To begin the analysis of impacts to the WRS, ArcGIS software was used to clip each KHF and KHA layer three separate times to the natural, rural, and urban land use areas for each of the four future management scenarios. This allowed the amount of each feature or area within each land use type to be separated and quantified in either kilometers or hectares under each scenario. This was done by subtracting the current quantity of each feature or area (TA_C) within each land use type from the total area quantity (TA_{S1}) to determine the difference. This difference was then divided by the current quantity to determine the percentage change (equations 1 and 2). The net change in the quantity of each KHF and KHA in natural and rural areas for each scenario was determined by summing the differences in the quantities of the feature within natural and rural land use and then dividing this by the total quantity of the feature in natural and rural areas (equations 3 and 4).

Equation 1: Scenario 1 % change = $(TA_{s1} - TA_C) / TA_C$

Equation 2: Scenarios 2-4 % change = $(TA_{S2,3,4} – TA_{S1}) / TA_{S1}$

Net change in natural and rural land use:

Equation 3: Scenario 1 % change = $(TA_{s1} - TA_C)_N + (TA_{s1} - TA_C)_R / (TA_C)_N + (TA_C)_R$

Equation 4: Scenarios 2-4 % change = $(TA_{S2-4} – TA_{S1})_N + (TA_{s1} - TA_C)_R / (TA_{S1})_N + (TA_{S1})_R$

Where, TA_C is the total area of a KHF or KHA under current conditions, TA_{S1} is the total area in Scenario 1, $TA_{S2,3,4}$ is the total area under Scenarios 2-4, and sub-script N and R indicates within natural and rural areas, respectively.

3.1.1 Riparian Corridors

Channel width was used as measured by the Regional Watershed Monitoring Program (RWMP) with data from 2001 to 2019 to determine the average width of the Strahler stream order in the watershed. A 30-m riparian buffer was determined by accounting for the stream width (using half the stream width + 30-m buffer) and the amount of natural cover was summarized within this buffer for each RCA. Natural cover was based on successional forest and forest combined, beach/bluffs, meadow, and wetland habitat using the refined 2019 natural cover layer for Etobicoke Creek.

3.1.2 In-stream Barriers

There are 134 barriers that have been surveyed within Etobicoke Creek (87 barriers with no passage and 47 that are passable for jumping species only). This data set was updated to remove barriers that were mitigated by TRCA Restoration and Infrastructure (4 barriers were removed), and natural barriers were not considered. To prioritize future barrier mitigation projects, a 'take-one-out' procedure was devised for each barrier to calculate the improved overall connectivity within the watershed. Further, barrier priorities were weighted based on the combined DCI score and habitat quality of the connectivity (the percent imperviousness of RCAs was a proxy for habitat quality). The resulting removal-priority DCI scores determined the rank of the top 11 barriers that were identified as having the largest value for connecting high value habitat.

3.1.3 Fish Community Health

Impacts to the fish community were qualitatively assessed based on observed trends in fish species diversity, based on RWMP data and IBI. These trends were compared to previous and expected changes to impervious cover, hydrology, and water quality to determine likely relationships between these factors and fish community health.

3.1.4 Benthic Community Health

Impacts to the benthic macroinvertebrate community were qualitatively assessed based on observed trends in species diversity, based on RWMP data and FBI scores. These trends were compared to previous and expected changes to impervious cover, hydrology, and water quality to determine likely relationships between these factors and benthic macroinvertebrate community health.

3.1.5 Aquatic Habitat Quality

To complete the analysis of impacts from changes in impervious cover, ArcGIS software was used to calculate total impervious cover, in hectares, and the percent impervious cover (%IC) at three spatial scales (watershed, subwatershed, and RCA). This was completed four times to assess changes to %IC under the four future management scenarios.

Equation 1: $\text{Scenario 1 \%change} = (\%IC_{S1} - \%IC_{C}) / \%IC_{C}$

Equation 2: $\text{Scenarios 2-4 \%change} = (\%IC_{S2,3,4} - \%IC_{S1}) / \%IC_{S1}$

Where $\%IC_C$ is the percent impervious cover under current conditions, $\%IC_{S1}$ is the percent impervious cover in Scenario 1, and $\%IC_{S2,3,4}$ is the total area under Scenarios 2-4.

Habitat quality was determined based on %IC results and was given one of four classes, including: sensitive (<10%), urbanizing (10-25%), non-supporting (25-60%), and urban drainage (>60%).

3.1.6 Groundwater Conditions

For groundwater quantity, the York Tier-3 steady state groundwater flow model was used to simulate groundwater/surface water interactions within the watershed for each future land use compared to current conditions. For each scenario, the distribution of groundwater recharge was estimated by translating local recharge estimates classified by land use type and surficial geology. Rates of groundwater recharge are an input to the model and are dependent on three factors: land use, percolation rates of surficial deposits, and local topography. An overlay analysis of estimated recharge was conducted over the existing model and recharge values were extrapolated to the expanded areas based on mapped land use and surficial geology. Long term groundwater discharge to streams is assumed to reflect baseflow. Baseflow has also been estimated from total measured streamflow at gauged stations by using automated hydrograph separation techniques. Steady-state (i.e. long-term average) groundwater potentials obtained from the numerical model match well to the observed water levels from wells in the watershed.

For groundwater quality, data was used from five TRCA groundwater monitoring stations and two Provincial Groundwater Monitoring Network stations. Data from 2016 – 2020 was used for the qualitative assessment.

3.1.7 Thermal Classification

To complete thermal classification, the stream reaches were classified based on field and modelled temperature data. Thermal regimes from field data were assessed based on July 1-21 maximum weekly average temperatures collected from loggers between 2019 and 2020 in 14 RCAs. Fish community classification for field-based data was determined using three main temperature categories: cold (<19°C), cool (19 to 21°C), or warm (>21°C). Stream temperature classification for modelled data was based on predicted modelled weekly average temperature across the jurisdiction. Stream reach classification for model-based data was determined using three main temperature categories: cold (<21°C), cool (21 to 25°C), or warm (>25°C). Thermal stability was determined using three temperature fluctuation categories: stable (<8.5°C), moderate (8.5 to 11°C), or very unstable (>11°C).

3.2 Natural Heritage System and Urban Forest

This subsection outlines methods associated with habitat quantity, habitat quality, terrestrial biodiversity, climate vulnerabilities, and the urban forest.

3.2.1 Habitat Quantity

As outlined in **Table 2**, each future management scenario assumed a different level of natural cover. Scenario 1 was consistent with current conditions. Scenario 2 used the 2018 Conservation Authority NHS. This 2018 NHS focused on terrestrial criteria and areas for improvements to habitat connectivity and enhancements to climate vulnerable habitats by identifying existing and potential natural cover. Scenarios 3 and 4 used the 2021 watershed refined enhanced NHS, which incorporated terrestrial and aquatic criteria to identify priority areas for protection and enhancement. Using these criteria, an equally weighted scoring exercise was conducted to run an overlay and multiple hit analysis with the highest scoring areas being identified as priorities for inclusion in the enhanced NHS.

The 2018 Conservation Authority NHS is the result of integration of TRCA and Credit Valley Conservation natural heritage systems for the Region of Peel. For this work, data from respective jurisdictions was integrated and aligned with municipal NHS mapping.

The 2021 watershed refined enhanced NHS builds on this systems approach to ensure the target NHS remains current and relevant to achieve TRCA and municipal partner natural heritage objectives within the broader context of changing land use and climate. It identifies strategic areas to improve both terrestrial and aquatic ecosystem health and resiliency.

These 2021 areas were refined further by overlaying restoration opportunities polygons and the high criteria scores. The restoration opportunities polygons were also used to assume natural cover type for the areas identified as potential natural cover (i.e. forest, wetland, meadow, etc.).

3.2.2 Habitat Quality

The LAM evaluates individual habitat patches and ranks them from “very poor” to “excellent” quality based on size, shape, and matrix influence (TRCA 2007). Patch scores range from 1 to 5 with the total LAM score (ranging from 0 to 15) weighted according to habitat type and patch size. The total LAM score can be interpreted as a local rank (L-rank) ranging from L1 (excellent quality patch) to L5 (very poor quality patch). In general, patches with a higher total score are larger in size, more circular in shape, and have few matrix influences.

3.2.3 Terrestrial Biodiversity

The Terrestrial Inventories & Monitoring Program collects data on flora, fauna, and vegetation communities using both inventory surveys (annual surveys covering larger areas of land at various geographic locations) and long-term monitoring plots (point locations monitored annually across the watershed).

3.2.4 Habitat Connectivity

The habitat connectivity analysis results completed for TRCA’s *Crossing Guidelines for Valley and Stream Corridors* were used for the future management scenarios. Regional connectivity refers broadly to connectivity among all high-quality habitat patches in a particular region. Local connectivity was mapped using the concept of “habitat networks”, which reflects the areas where potential wildlife movements within their general daily and seasonal movement capacity are more likely. Two specific groups of species were focused on that move between wetlands and forests (includes most amphibians), and forests (includes most small mammals and salamanders). The resulting habitat network layers were identified as priority areas for local connectivity.

3.2.5 Climate Vulnerabilities

TRCA, in partnership with the Ontario Climate Consortium and the Region of Peel, developed a framework to assess the vulnerabilities of existing natural systems to climate change impacts and to identify priority areas for adaptation for the Region of Peel. An adapted version of this vulnerability assessment was applied to the terrestrial system for the entire TRCA jurisdiction. The TRCA terrestrial system climate change vulnerability assessment uses five vulnerability indicators: habitat patch quality, climate sensitive ELC vegetation community types, wetland hydrological vulnerability, mid-afternoon ground surface temperature, and soil drainage.

3.2.6 Urban Forest

For each scenario, the potential for urban forest enhancement was based on some assumptions about where targeted planting might occur based on land use, land cover, and proximity to the NHS. In Scenario 1, canopy cover percent was assumed to remain the same across each land use, with the exception of assuming urban expansion achieved canopy cover consistent with residential land uses. For Scenario 2, enhancements were assumed to only occur in contributing areas of the enhanced NHS. For Scenarios 3 and 4, enhancements occurred across the watershed.

The potential enhanced canopy cover for each scenario was based on potential impervious and pervious plantable space, determined by land cover type (paved surfaces, which were not roads or buildings and bare ground or low shrub/herbaceous) as well as land use type (e.g. residential, commercial, industrial, etc.). Planting densities were specified for each land use–land cover combination (see **Table 18**).

Table 18 - Urban Forest Planting Assumptions

Land Use Type / Impervious or Pervious Potential	Scenario 1	Scenario 2 (inside contributing areas)	Scenarios 3 & 4
Industrial Pervious	No enhancement	1 tree planted every 10 m x 10 m	1 tree planted every 10 m x 10 m
Industrial Impervious	No enhancement	No enhancement	No enhancement
Commercial Pervious	No enhancement	1 tree planted every 10 m x 10 m	1 tree planted every 10 m x 10 m
Commercial Impervious	No enhancement	No enhancement	No enhancement
Agriculture	No enhancement	None	None
Cemetery Pervious	No enhancement	1 tree planted every 10 m x 10 m	1 tree planted every 10 m x 10 m
Cemetery Impervious	No enhancement	None	None
Golf Course Pervious & Impervious	No enhancement	None	None
Institutional Pervious	No enhancement	1 tree planted every 10 m x 10 m	1 tree planted every 10 m x 10 m
Institutional Impervious	No enhancement	1 tree planted every 20 m x 30 m	1 tree planted every 20 m x 30 m
Recreational/Open Space Pervious	No enhancement	1 tree planted every 20 m x 20 m	1 tree planted every 20 m x 20 m
Recreational/Open Impervious (parking lots)	No enhancement	1 tree every 20 m x 30 m on impervious surface	1 tree every 20 m x 30 m on impervious surface
Residential (all types residential) Pervious	No enhancement	1 tree planted every 10 m x 10 m	1 tree planted every 10 m x 10 m
Residential Impervious	No enhancement	None	None
Roads (in Residential Areas) Pervious	No enhancement	1 tree 10 m x 10 m	1 tree 10 m x 10 m
Roads (in Residential Areas) Impervious	No enhancement	None	None
Railway	No enhancement	None	None
Forest/Successional Forest	No enhancement	No Enhancement	No enhancement
Meadow in NHS	No enhancement	No Enhancement	No enhancement
Meadow outside of NHS	No enhancement	1 tree planted 10 m x 20 m	1 tree planted 10 m x 20 m
Riverine/Lacustrine	No enhancement	No enhancement	No enhancement
Wetland	No enhancement	No enhancement	No enhancement
Beach/Bluff	No enhancement	No enhancement	No enhancement

Potential canopy cover enhancements were calculated at the sub-watershed level and aggregated to examine and compare urban forest expansion between the four future management scenarios developed for the Etobicoke Creek Watershed (see **Appendix A**). The calculated enhancements assumed that all the identified potential plantable space would eventually have trees. Therefore, the increase in tree canopy cover represents the maximum possible amount that the canopy could increase (which likely is not fully achievable). The feasibility of implementing these enhancements depends heavily on uptake on private property. This approach provides a framework to inform priority planting areas in the eventual watershed plan.

3.3 Water Quality

A process-based watershed model is needed to account for hydrologic inputs (i.e. groundwater) and future climate to investigate how stream water quality responds to changes in land use and management. For this exercise, the Stormwater Management Model (SWMM) by the US Environmental Protection Agency was selected for modelling chlorides and TSS. Although SWMM has largely been used for plot-scale, event-based models, it was selected for offering the following options:

- Key hydrological processes for modelling long-term continuous streamflow
- Build up wash-off functions for water quality
- A snow-only buildup function that can be used to capture the seasonality of chlorides from road salts
- Ability to represent overall stormwater retention and detention

The current conditions model was created using data from 2016 to 2020. The following is a summary of the inputs used in the continuous streamflow and water quality model:

- **Elevations:** a Digital Elevation Model (DEM) of 10 m x 10 m resolution from 2011
- **Stream network:** a network consisting of 129 links and nodes was created from the Etobicoke Creek drainage layer. Small first order and / or seasonal tributaries not clearly visible in the DEM were removed. All stream cross-sections were computed from the DEM (with 400 m long transects spaced every 100 m on streams), and averaged along the length of stream segment. The number of links (stream segments) and nodes (junctions) were determined by the program based on stream curvature and variability in cross-sections, then simplified to reduce model runtime.
- **Subcatchments:** 18 subcatchment boundaries (see Figure 24) were extracted from the DEM to represent each tributary draining into Etobicoke Creek, with sizes varying according to the contributing area around a tributary. While model results for flow (m^3/s) and water quality concentrations (mg/L) were available for all 129 links and nodes, these subcatchments provided a summary of total runoff and water quality loads at each tributary. The scale of subcatchments were determined based on the overall watershed area (213 km^2), number of Etobicoke Creek subwatershed divisions in TRCA, areas of highest land use change in future (headwaters), and locations of existing TRCA water quality monitoring stations.
- **Climate:** precipitation records (sub-hourly) were taken from all season gauge HY046. These were converted to daily total rainfall (mm) for consistency with future climate data. Similarly, sub-hourly temperature records taken from HY033 were converted to daily maximum and minimum temperatures (^{0}C).
- **Land use:** current land use (2019) and the corresponding standard engineering percentages of total and directly connected impervious areas, used for hydrology modelling in TRCA, were area-weighted over each subcatchment for modelling streamflow and routing water quality. Standard Manning's N values and depression storage for pervious and impervious areas were assigned based on comparison with other hydrology models and literature.
- **Soil and groundwater:** soil types from the Ontario Ministry of Agriculture, Food, and Rural Affairs soil survey complex were aggregated to four main classes based on those found in the watershed: sandy

loam, loam, clay, and clay loam. Soil parameters were collected and area-weighted over each subcatchment to calculate infiltration in the model using the Green-Amp equation. Groundwater parameters from the soil properties (including porosity, field capacity, wilting point, hydraulic conductivity, suction head, initial deficit) were averaged to one aquifer for all subcatchments. For each subcatchment, groundwater was routed to the same node as streamflow, and the surface and bottom elevations of the aquifer were assigned based on the node elevation and an aquifer thickness of 20 m. Baseflow was modelled using the lateral groundwater flow equation and assuming an overall loss of 0.0 2mm/hr to deep groundwater recharge when the aquifer is fully saturated.

- **Streamflow:** daily flow (m^3/s) observations from five monitoring stations were used for visual comparison and conceptual understanding of ranges and patterns in the hydrology parameterization.
- **Water quality:** stream concentrations (mg/L, continuous) and subcatchment loads (kg, total for modelling period) of TSS were simulated based on a simplified Event Mean Concentration method, assuming 150 mg/L assigned to all urban land use polygons, and 50 mg/L for all rural and open green spaces. A groundwater concentration of 4 mg/L was assumed for TSS based on overall baseflow observations throughout the watershed. Chloride was simulated based on buildup and washoff model from all roads, with a small amount of buildup in all other impervious surfaces. This model assumes buildup of chloride only during snow events, with stream chloride in warmer months coming from groundwater flow. A groundwater concentration of 150 mg/L was assumed for chloride based on overall baseflow observations throughout the watershed.

The future management scenarios were set up to represent a five-year time period between 2047 and 2051. Scenarios 1 to 4 were set up in the model based on the assumptions outlined in **Subsection 1.2 Overview of the Future Management Scenarios**.

While the model captures the overall patterns of flow and water quality, it does not accurately represent specific rainfall/snow events, or subwatershed responses. Sufficient continuous data for water quality was not available for calibration and subcatchment responses. This means that the magnitudes of modelled water quality concentrations (sub-hourly) by themselves are not representative of the currently observed (monthly) datasets that are available. However, the modelled physical processes sufficiently represent the current watershed conditions and surface runoff. In the absence of sufficient monitored data for water quality calibration and validation, results from such models can be used to compare relative effects of changes, despite uncertainty in parameter magnitudes (i.e. actual values of predicted concentrations).

Additionally, these types of models, particularly for chlorides, do not account well for the movement of chlorides through soils and groundwater potentially leading to legacy chlorides continuing to build-up in the watershed. Also, the models are not able to predict accurately the amount of road salts that would get applied to roads during any event. So, it is important to recognize these limitations for the chloride results.

Streamflow (daily) at the watershed outlet for 2020 was calibrated and validated for 2016 – 2019 (see **Figure 16**). Parameterization of water quality based on visual comparison of overall patterns of range and seasonality observed in monthly chloride and TSS concentrations for the watershed was also completed. The percent change (increase/decrease) was calculated for all streams as the indicator of water quality for the future management scenarios. To avoid comparison of particularly dry or wet years, a 5-year monthly mean was calculated for each month of in-stream flow (m^3/s), TSS (mg/L) and chlorides (mg/L), first from modelled current conditions (2016-2020), and then from modelled future scenarios (2047-2051).

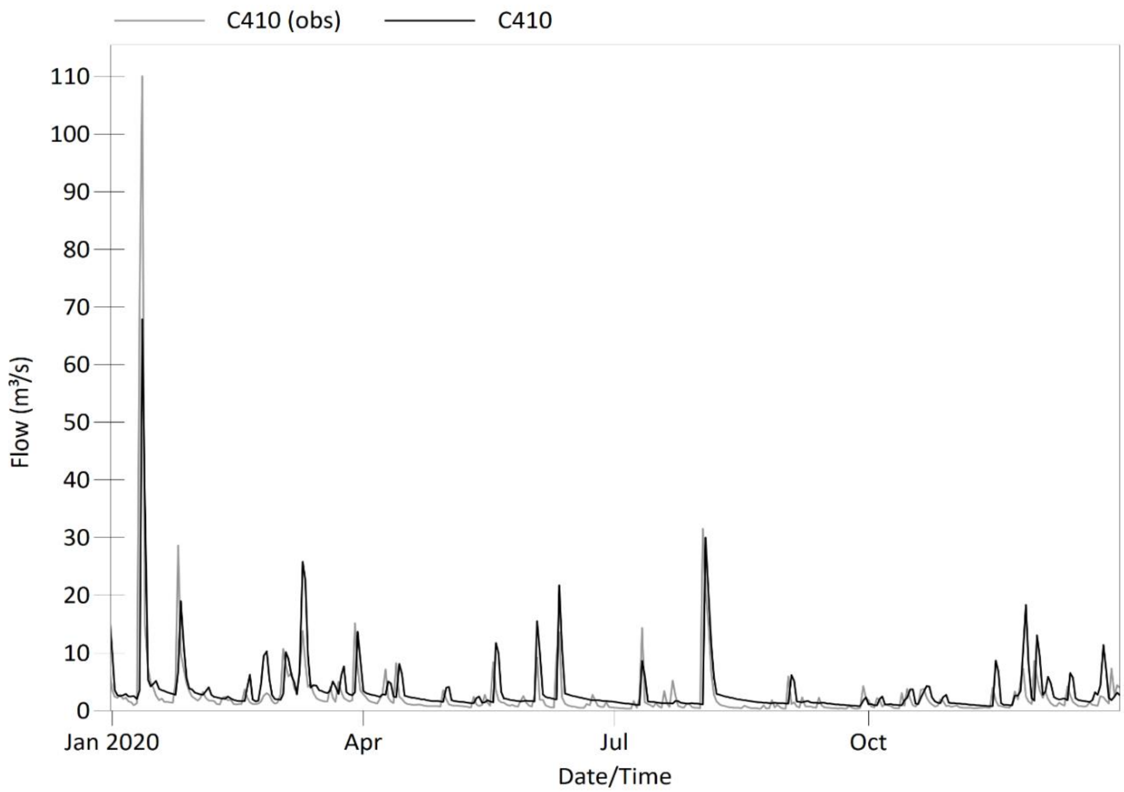

Figure 16 - Comparison of Modelled (Black) and Observed (Grey) Daily Flow at Queen Elizabeth Way (QEW) in 2020

Flow calibration showed satisfactory model performance with a Nash-Sutcliffe Efficiency score of 0.45 and R^2 of 0.46 in 2020. Modelled chloride was compared to 15-minute time interval observations at a continuous water quality monitoring sensor installed in 2021. This sensor monitors specific conductivity and turbidity. While conductivity highly correlates with chlorides ($R^2 = 0.99$) in this urban watershed, turbidity and TSS relationships were more difficult to ascertain due to errors in the turbidity observations. The comparison of conductivity and chlorides through a regression equation shows that the model effectively captured the range and duration of chloride peaks at a sub-hourly scale, although it missed the exact timing of the peaks. The modelled chloride also showed an Integral Square Error score of 1.26 from January to May, 2021, which is rated as “excellent” for planning and design purposes.

3.4 Natural Hazards

This subsection outlines methods associated with flooding and erosion risk.

3.4.1 Flooding

The Visual OTTHYMO (VO) model platform was used to assess the watershed hydrology.

A total of 46 conceptual stormwater management ponds were sized for the urban expansion area, based on TRCA stormwater management criteria for the Etobicoke Creek headwaters (i.e., 60% of existing conditions). After applying the expansion area parameters (with no interventions applied) to the model catchments, a Route Reservoir command is connected between each new urbanized catchment (STANDHYD command) and the nearest hydrologic node (ADDHYD command); a storage-discharge curve is then needed to define the pond function. An initial estimate of storage volumes needed to achieve target release rates for each catchment can be obtained using the unitary equations in the 2013 Etobicoke Creek Hydrology Update, or by taking 60% of existing conditions peak flows (e.g., from a current conditions scenario) and using the Ministry of Environment's Stormwater Management Planning and Design manual. The initial Route Reservoirs are then tested by simulating the design storms again, noting if and where storage volumes are exceeded in the detailed model output file, and adjusting storage volumes. The process is repeated until the conceptual ponds provide sufficient storage for each design storm target release rate. It should be noted that in practice, the function of each of these conceptual ponds would likely be distributed among several stormwater management ponds servicing smaller drainage areas.

LID implementation is conceptualized as on-site retention for impervious areas by increasing the impervious area depression storage parameter (DPSI) on STANDHYD commands. This approach was chosen because the DPSI roughly approximates the goal of treating stormwater before it reaches stormwater ponds, and the specific suites of implementable technologies is not necessarily of interest for analyses at this scale, but rather what the effect on stormwater would be under ideal operational conditions. In summary:

- Scenario 1: Increased DPSI 5mm on STANDHYD commands representing the urban expansion areas only
- Scenario 2: Increased DPSI 12.5mm on STANDHYD commands across the watershed
- Scenario 3: Increased DPSI 25mm on STANDHYD commands across the watershed
- Scenario 4: Same as Scenario 3, except there is no Headwaters urban expansion

Urban canopy cover (area value) in each future management scenario was estimated on a catchment basis; however, the specific locations of the coverage were not determined (i.e. no shape file of the urban forest itself). In concept, improvements to urban forest would increase initial abstraction, which can be estimated by modifying the soil parameters (Curve Number, method) for the pervious component of STANDHYD commands to reflect forested land cover values. The approach taken to estimate the effect of urban forest improvements was to calculate the soil parameters for the watershed if it was entirely forested (i.e., catchment-averaged soil parameters for forested land cover), subtract the estimated canopy cover from the total impervious area of each STANDHYD, apply the forested catchment parameters to the canopy area only, and aggregate this new pervious area into the rest of the STANDHYD pervious component to create a set of average pervious area soil parameters for the STANDHYD.

The model future management scenarios were built by updating the future conditions scenario of the 2013 model with corresponding land use shape files; in some instances, the land use shape file was missing some areas covered by the hydrologic model, so these were manually backfilled based on the nearest land use that would reasonably form a contiguous feature. Development areas that are in an Official Plan, but not in the current conditions, were verified and included for drainage area, hydrologic parameters, and stormwater management based on reports submitted to TRCA for permitting. This resulted in some refinement of the future conditions catchment shape file. Using GIS tools, the land use, underlying soils, and catchment delineations were intersected to create parameter grids for each catchment. Catchment-averaged parameters were then calculated using the parameter grids and look-up tables.

The climate projections that were used for this modelling were based on RCP 8.5 (i.e. high emission, continual increase scenario) using the relevant IDF curve (i.e. Bloor Street gauge) from the University of Western Ontario IDF_CC Tool. The volume of rainfall for each design storm was adjusted accordingly as shown in **Table 19**. Note that there is no adjusted IDF for the Regional storm as this is a historic event.

Table 19 - Rainfall Depths for Current and Adjusted Design Storms

Design Storm	Volume (mm)	
	Current IDF	Adjust IDF
2-year	42	44.07
5-year	54.38	57.96
10-year	62.71	67.77
25-year	73.1	82.01
50-year	80.82	94.16
100-year	88.54	107.47

3.4.2 Erosion Risk

To undertake an erosion threshold assessment, continuous hydrologic modelling is required. The event-based model (VO6) discussed in the preceding section for flood risk was converted to a continuous model.

Continuous precipitation data from TRCA's Heart Lake gauge (HY033) was used for the period between 2011 and 2016. Data was available at a five-minute time step, which was then transformed to an hourly time step. The model was also tested at five-minute intervals; however, during the testing phase this interval caused some model stability issues for the six-year time period. Hourly data input was determined to be optimal for model performance for a six-year long data set. A quality control check was also performed on the data set. Any data points with recorded tags "ICE", "EST NO", "EQ MALF", "EQ FAIL", "EST POOR", "POOR", were removed from the final dataset since these tags correspond to ice conditions that affect records, estimated data with no confidence, equipment malfunction, equipment failure, estimated data with poor confidence and poor data, respectively.

Additionally, it should be noted that the Heart Lake gauge is a three-season gauge that is decommissioned during the cold months when the precipitation may have a snow component. Due to this limitation, no precipitation was modelled for the late Fall to early Spring months.

Data for the soil layers was based on Soil Survey Complex data. This dataset was first trimmed for the Etobicoke Creek watershed. GIS spatial analysis was then undertaken to determine the soil types within each subcatchment. Since there were some differences in the boundaries of the subcatchment for the different future management scenarios, the spatial analysis was undertaken for each scenario. Since the model uses a lumped approach in the parametrization of the catchments, the soil type data was aggregated using a weighted area approach for each subcatchment for each future management scenario.

All other subcatchment routing parameters used were the same parameters as those in the event-based model used for the flood hazard scenario analysis.

The continuous model was built from a calibrated event-based model. However, this continuous model itself was not calibrated. Multiple precipitation gauges with detailed long-term records would need to be used for a proper calibration. Additionally, observed flows at all subwatersheds (if available) would need to be used. A model calibration of this magnitude was out of the scope for this analysis. Although no calibration was undertaken, modeled flows for a test scenario (current conditions with 2012 landuse) were compared against observed flows. For the purposes of model testing and verification, the model was first run using precipitation inputs for the period from 2010 to 2019. Hydrograph results for a location in Lower Etobicoke by the QEW were compared against those observed at the same location (Water Survey of Canada Gauge, 02HC030). **Figure 17** shows the results for the year 2010. In general, the timings of the peak for the modelled and observed datasets matched well.

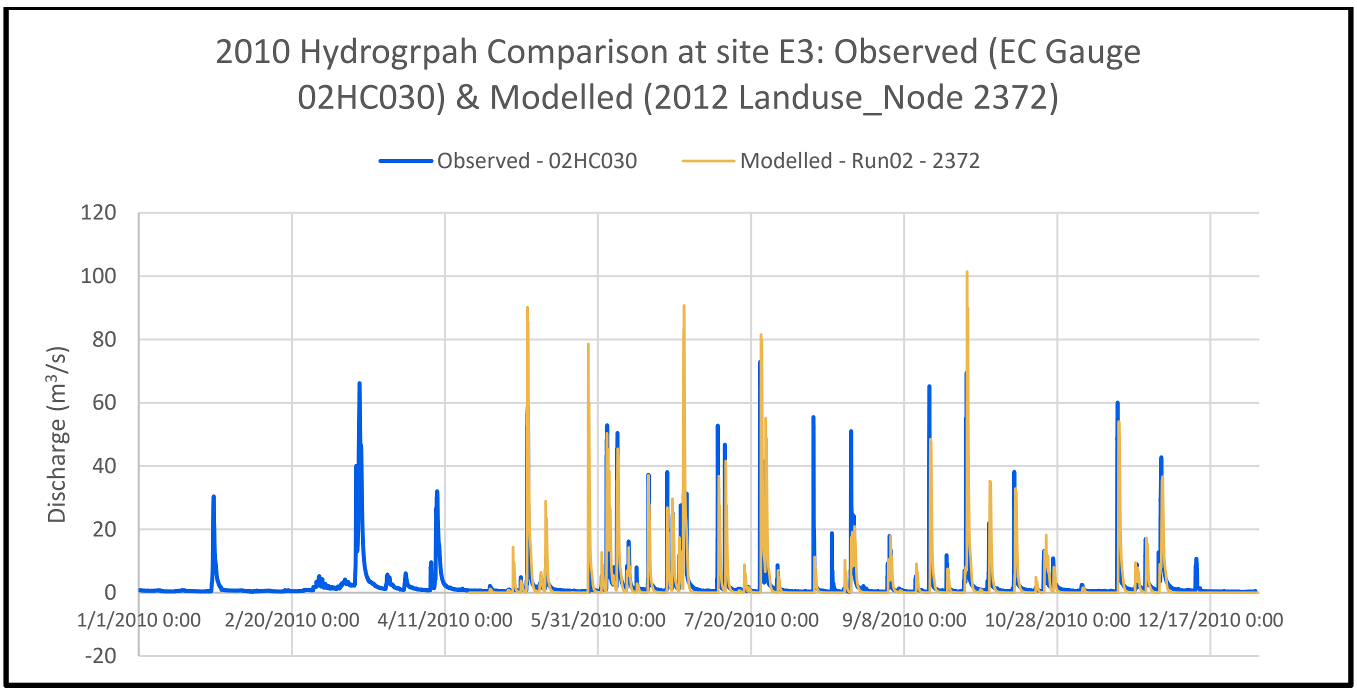

Figure 17 - Observed and Modelled Flows at QEW

However, there are some discrepancies in the magnitude of the peaks. In some cases of high flows, the WSC gauge ceased recording. However, this is not a sufficient explanation for other cases when the peaks of the observed and modelled data do not match. The reliance on one rain gauge and the assumption that this singular rain gauge is representative of the entire watershed is likely the reason for discrepancy in the magnitudes of the peaks. Since no precipitation was inputted for the cold months, the modelled hydrograph did not show any flow for these months. Additionally, no groundwater inputs were included in the model.

Model performance was also evaluated by calculating the Nash-Sutcliffe Efficiency (NSE), which was ranged from -0.01 to 0.72 for the years between 2010 and 2019. Negative values indicate that estimated error variance in the modelled data is greater than the variance in the observed data. An NSE value of 1 indicates a perfect model where it matches the observed flow perfectly. Finally, a six-year data set was used for the continuous modelling. This decision was based on a selection of consecutive years that produced the best NSE results: 2011 to 2016 during which the NSE ranged from 0.26 to 0.76.

The CEW Index was determined using the in-built tool in the VO6 software which requires the input of the Critical Shear Stress at a given “Route Channel” location (i.e. a model element that represents the river reach). To determine the TOE, the hydrograph results were first extracted at the various nodes corresponding to the fluvial sites at which thresholds were established. TOE was then determined to be the number of hours during which the discharge exceeded the threshold (or the critical) flow at that location.

4. MAPS

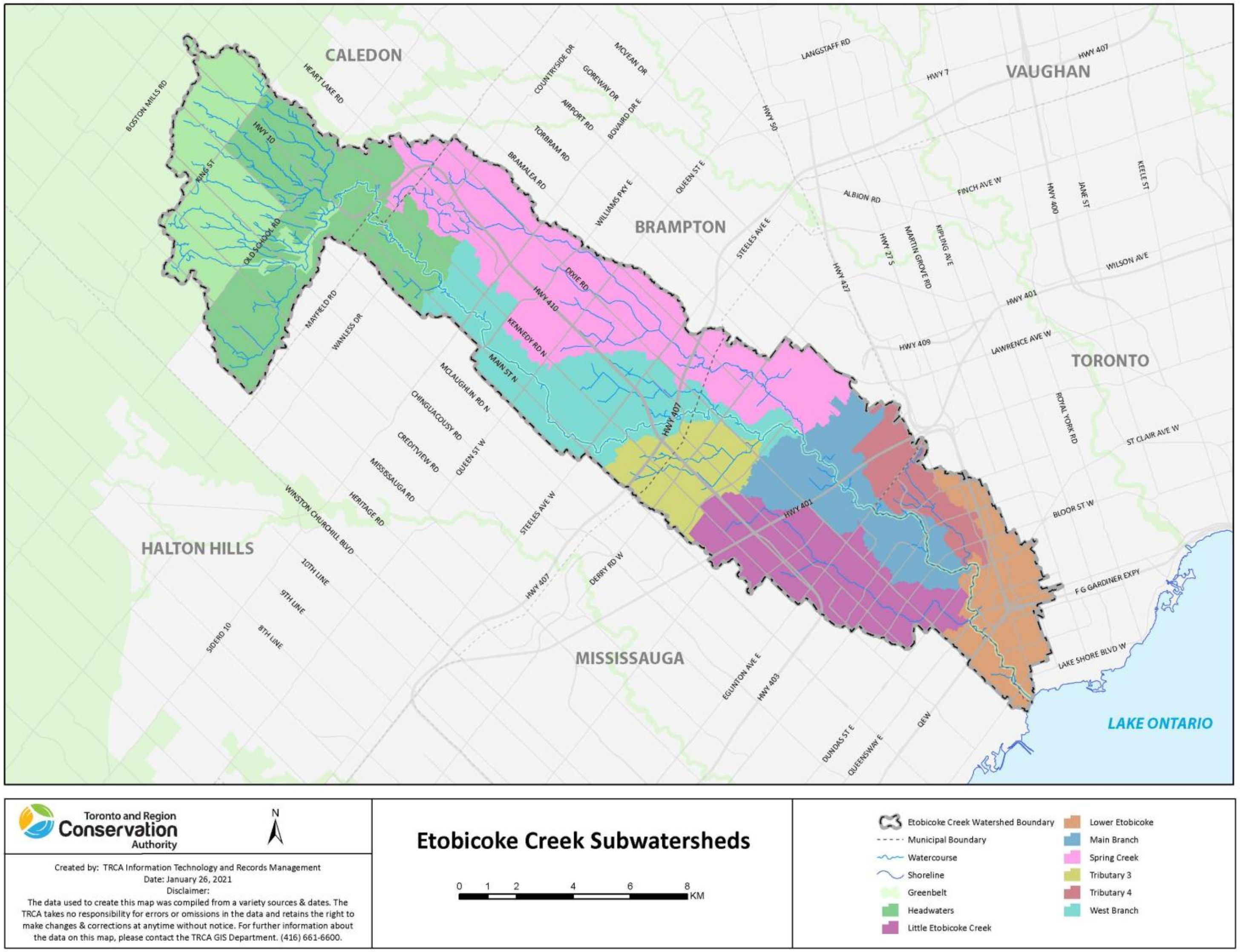

Figure 18 - Etobicoke Creek Subwatersheds

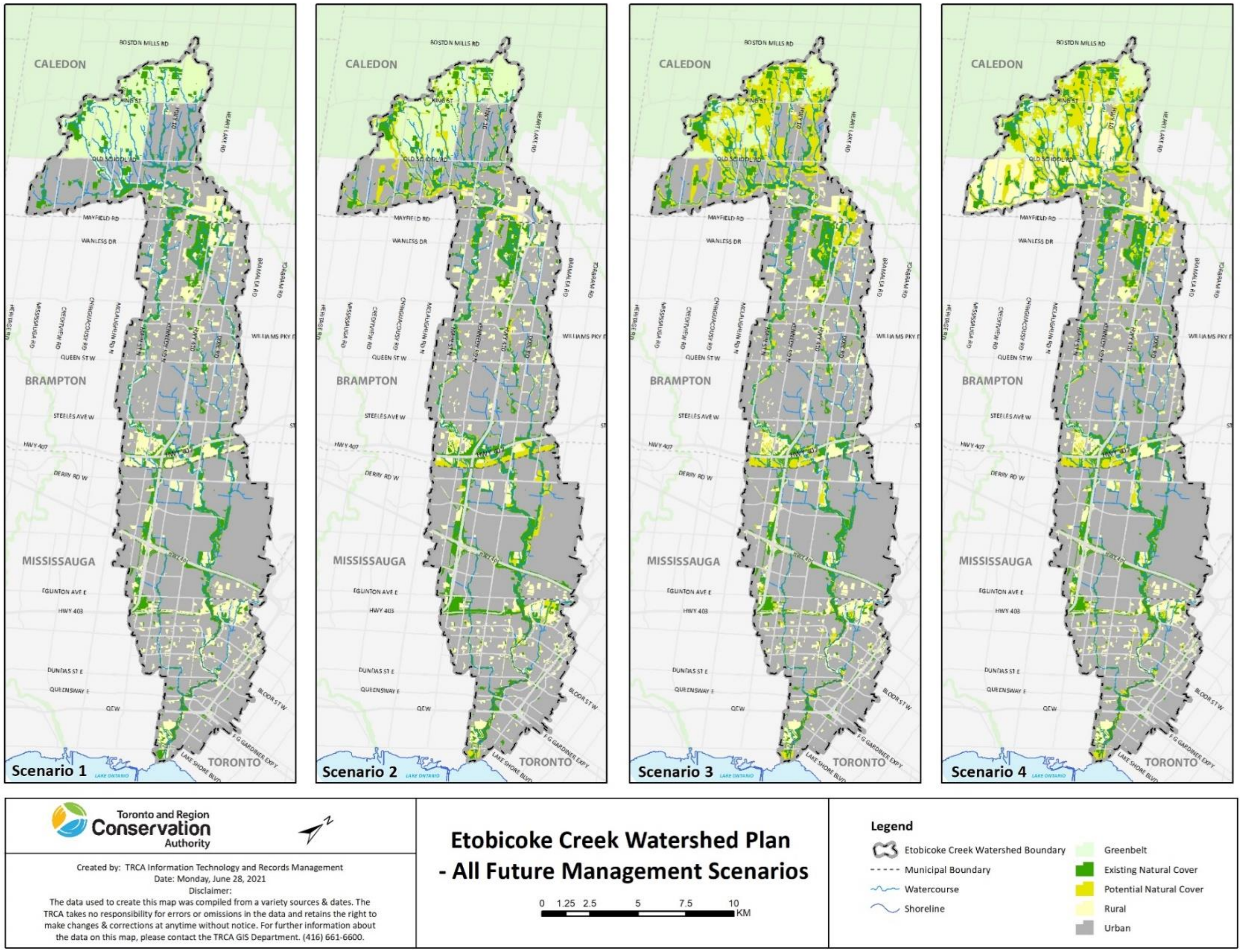

Figure 19 – Land Use of Future Management Scenarios

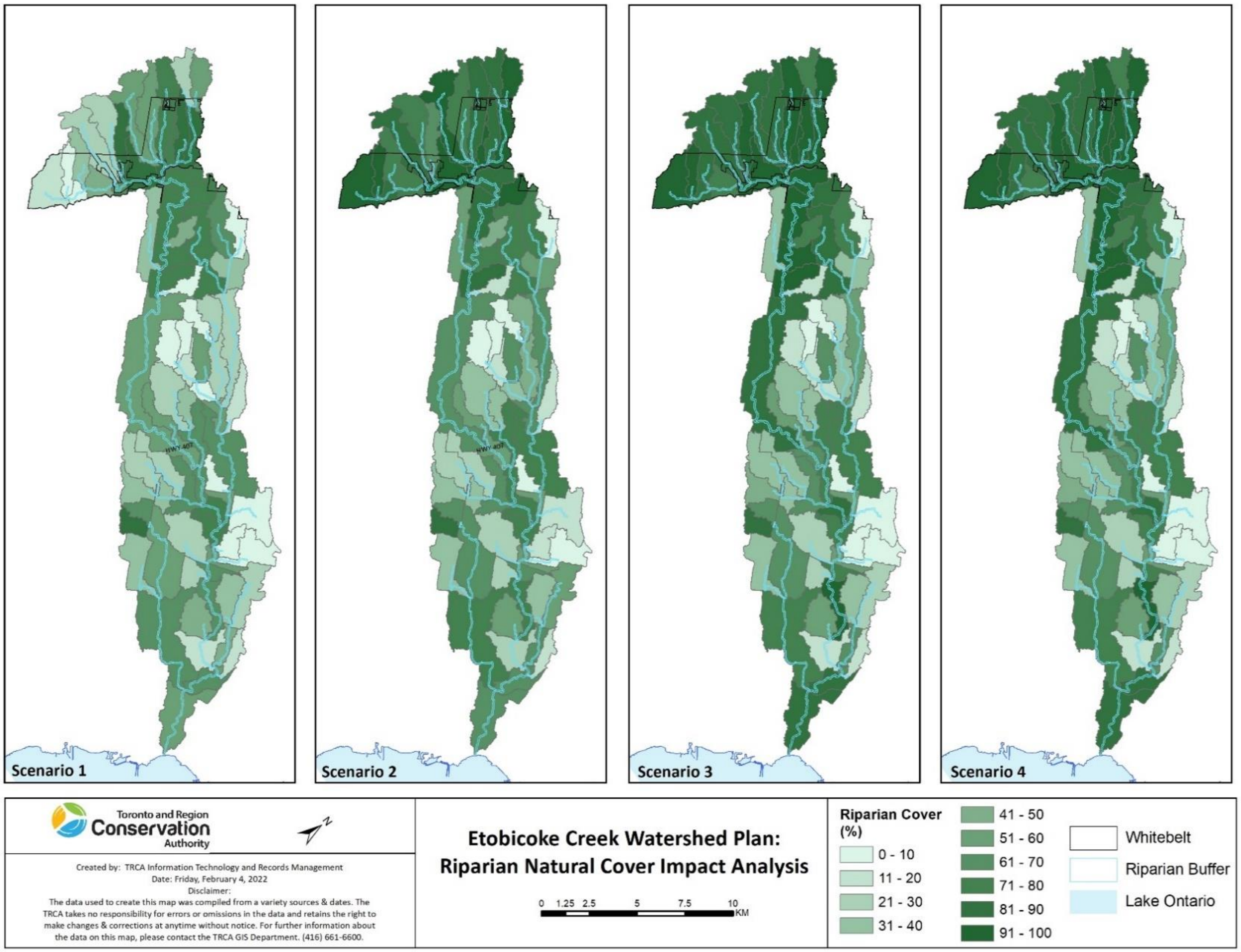

Figure 20 - Riparian Cover of Reach Contributing Areas by Future Management Scenario

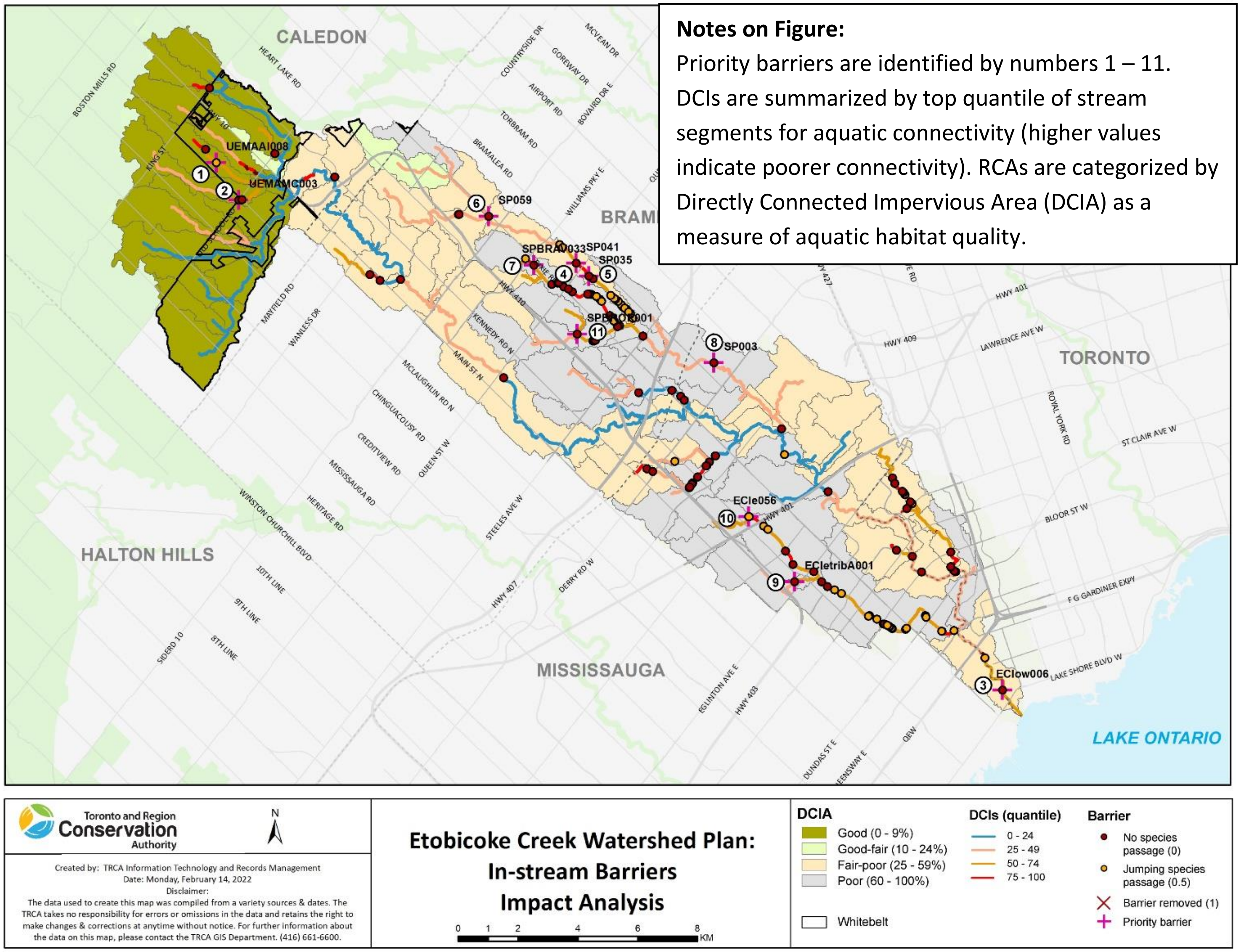

Figure 21 - Instream Barriers and Aquatic Connectivity

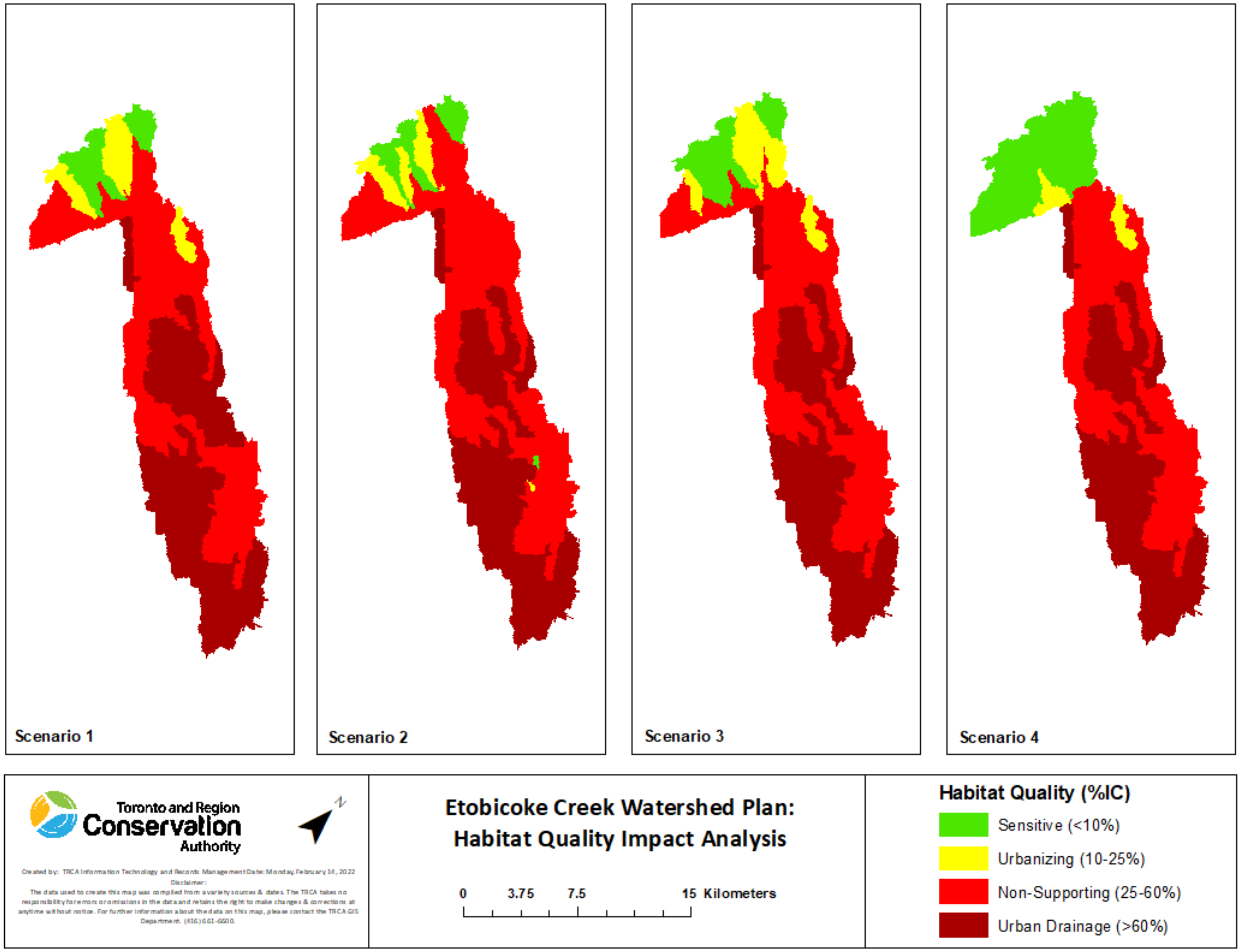

Figure 22 - Aquatic Habitat Quality by Future Management Scenario

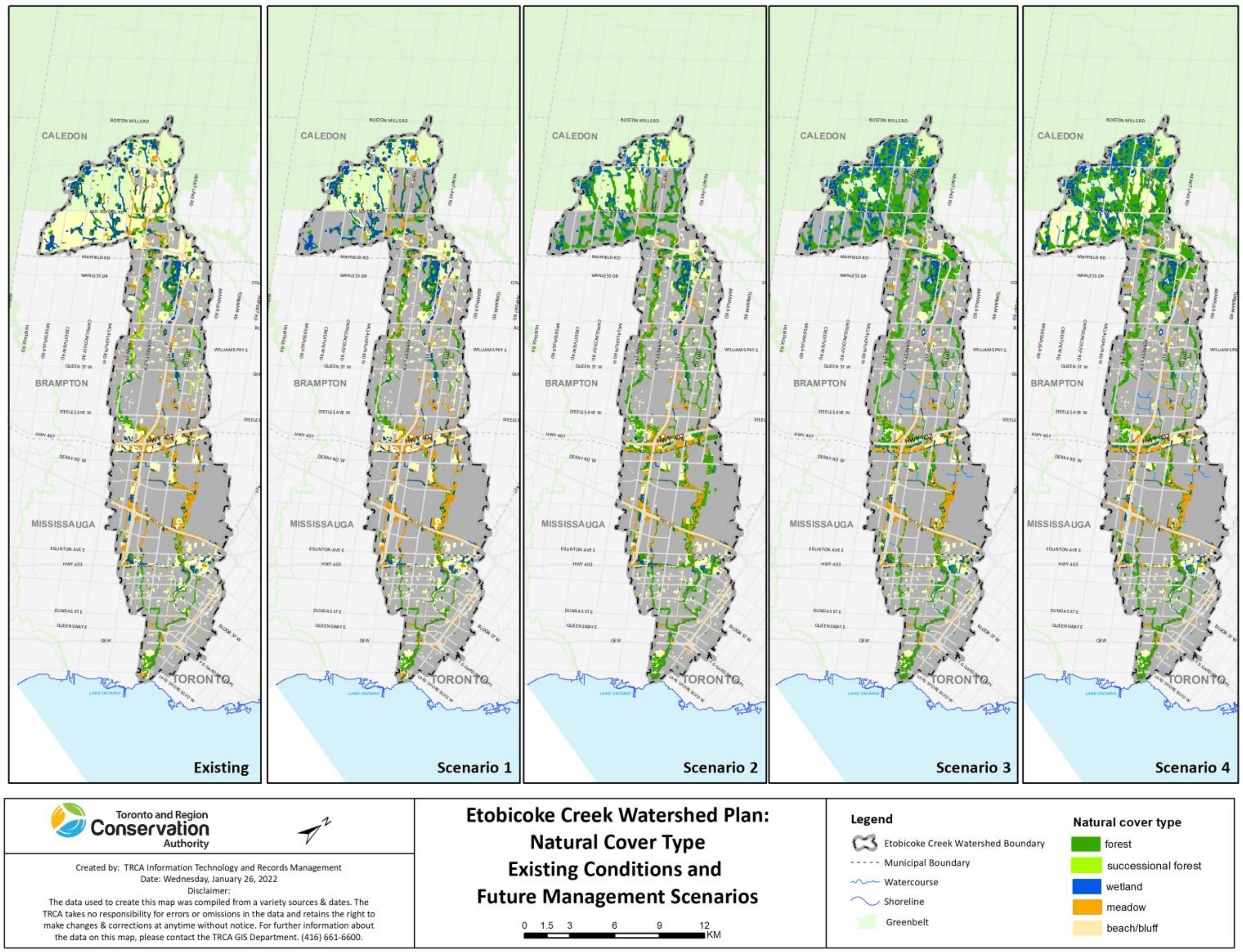

Figure 23 - Natural Cover by Future Management Scenario

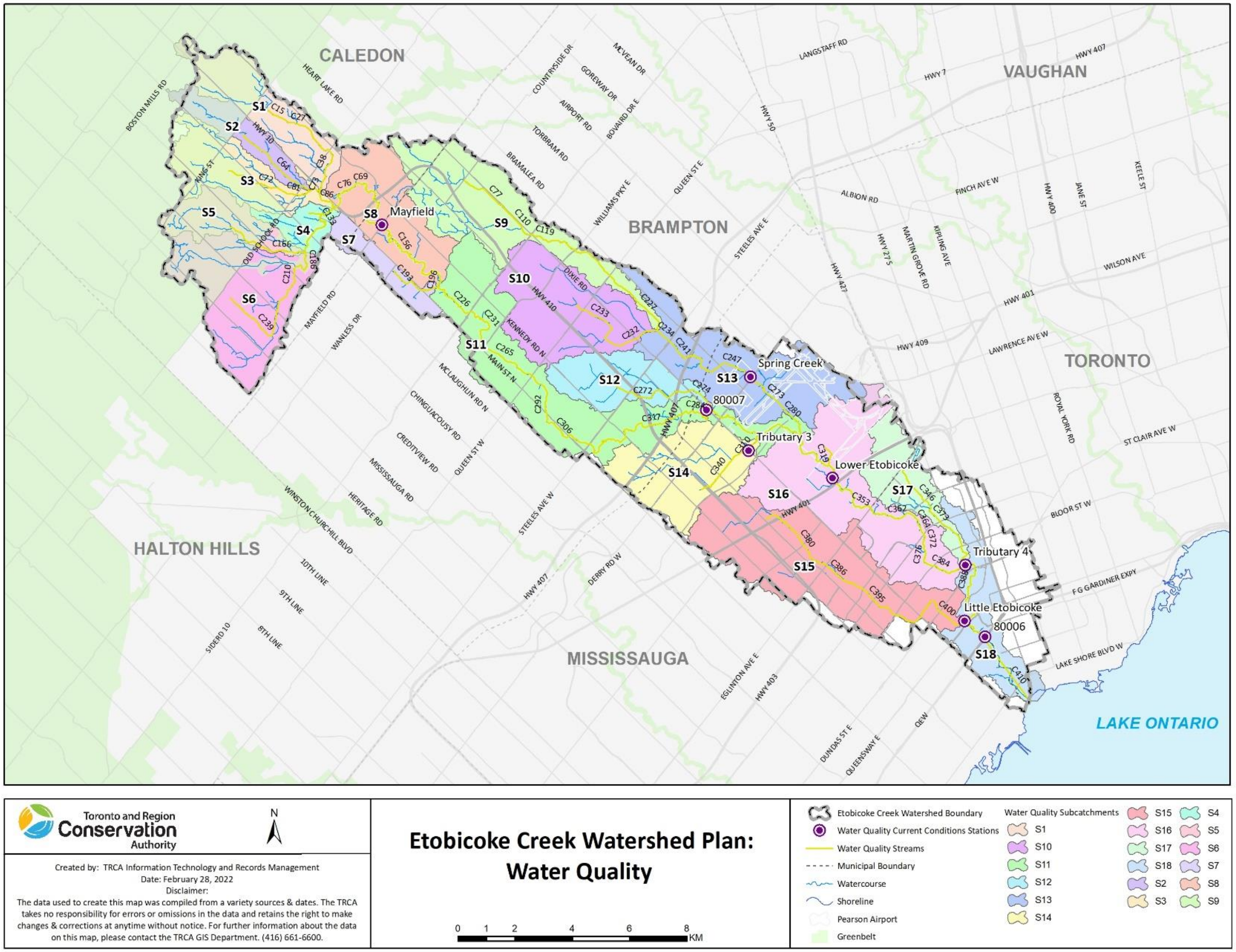

Figure 24 - Water Quality Subcatchments and Stations

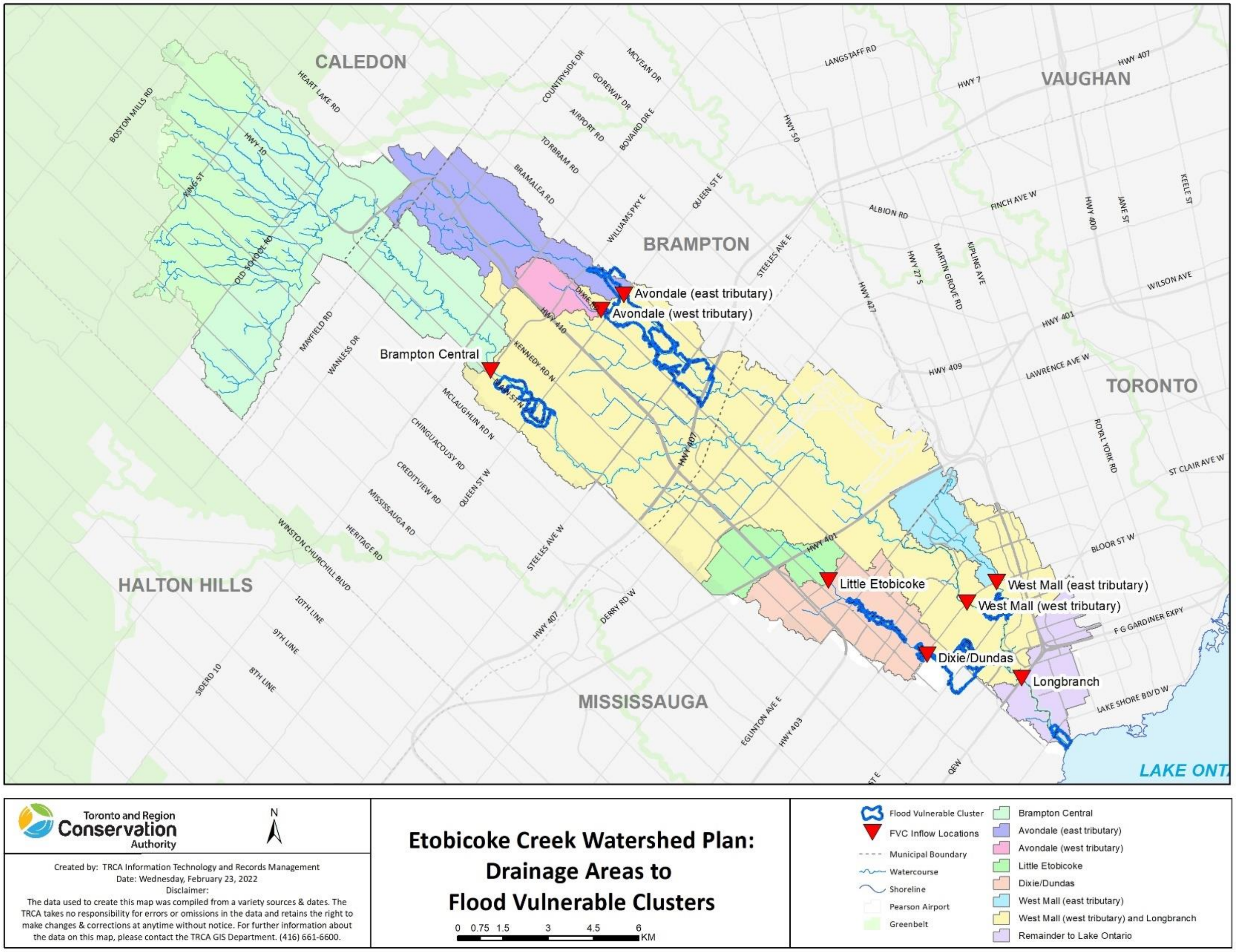

Figure 25 - Drainage Areas to Flood Vulnerable Clusters

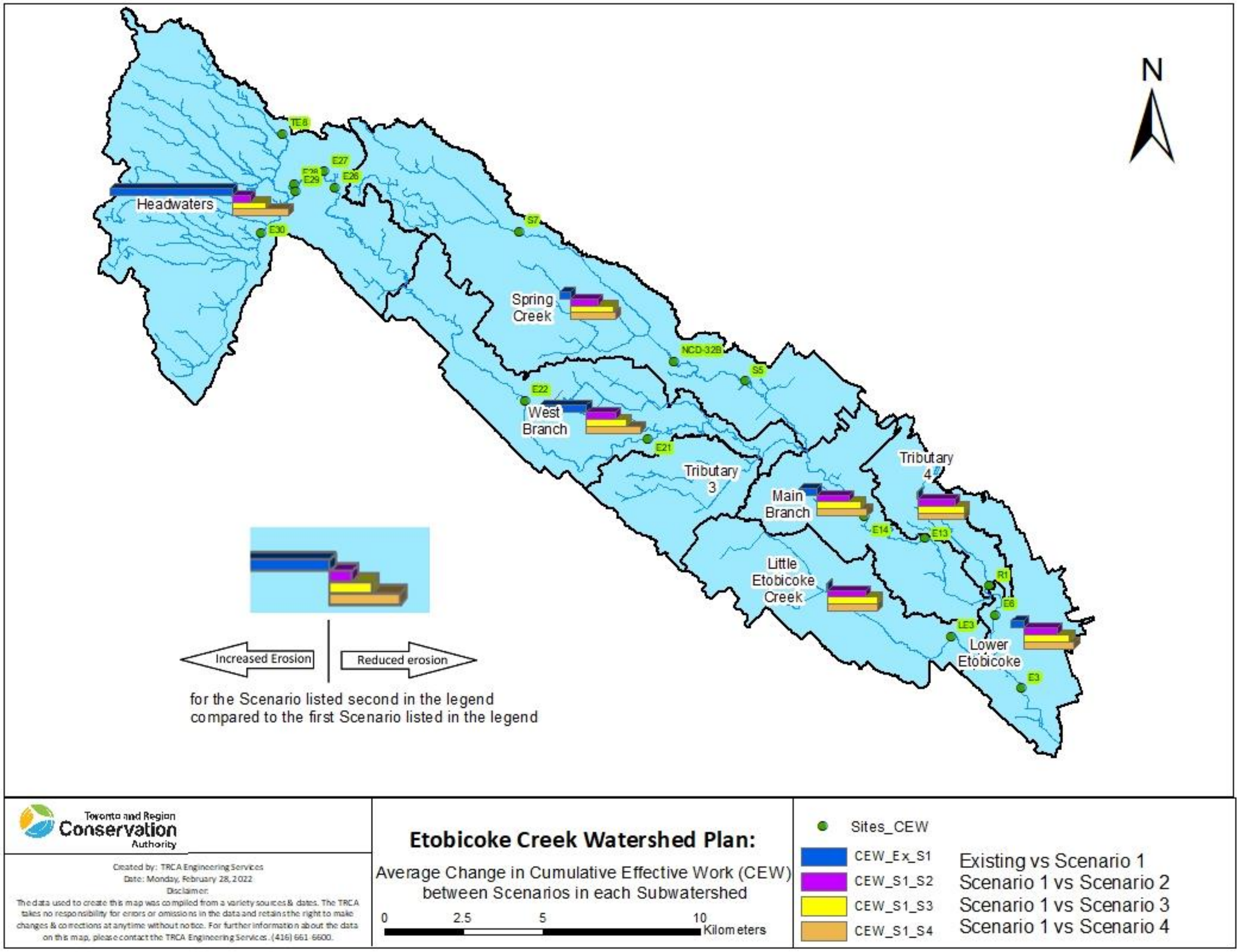

Figure 26 - Average Change in CEW between Future Management Scenarios

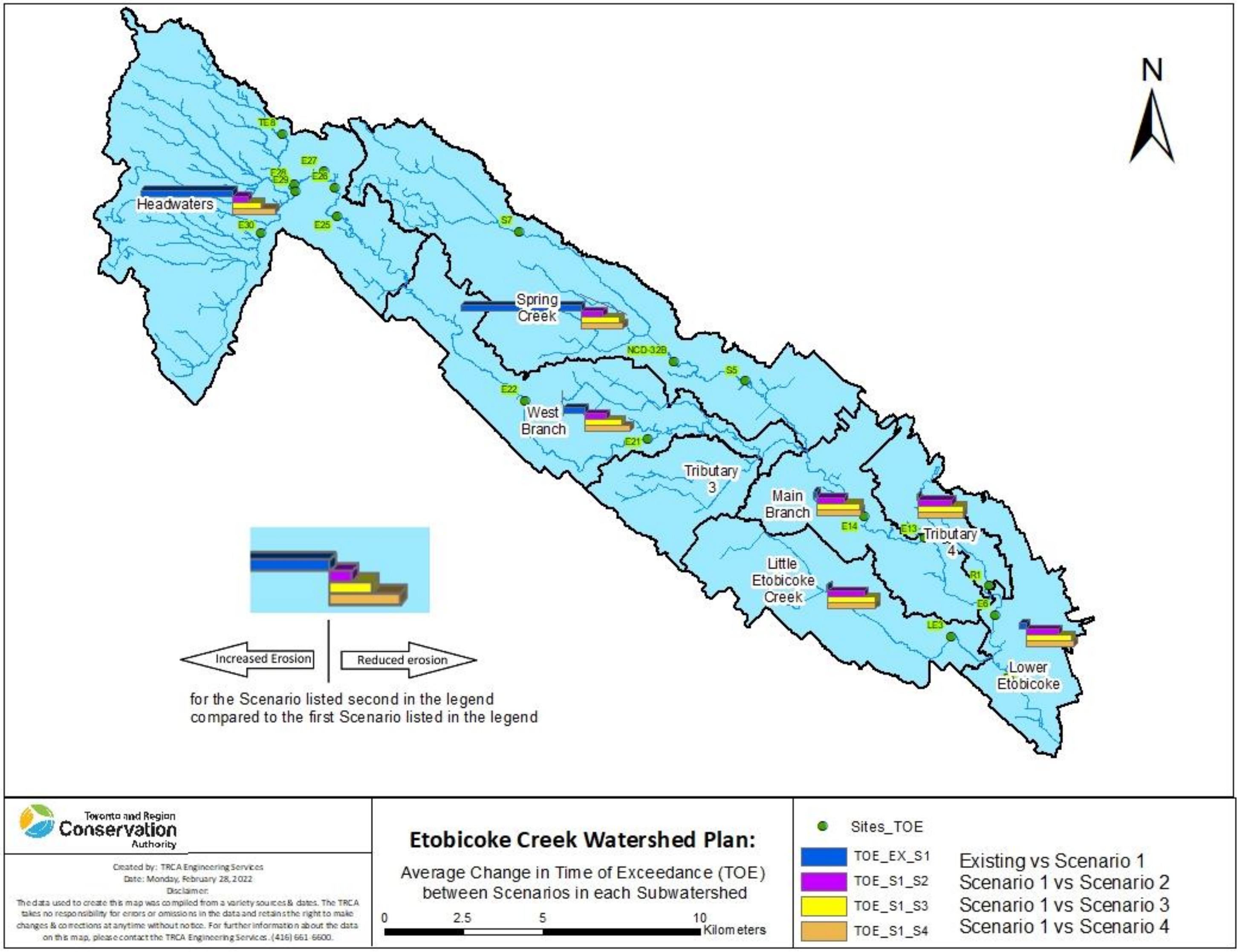

Figure 27 - Average Change in TOE between Future Management Scenarios

5. GLOSSARY

Biodiversity
The variability among organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species and ecosystems.

Ecological Function
The natural processes, products, or services that living and non-living environments provide or perform within or between species, ecosystems, and landscapes, including hydrologic functions and biological, physical, chemical and socio-economic interactions.

Headwater Drainage Features
Ill-defined, non-permanently flowing drainage features that may not have defined beds and banks.

Highly Vulnerable Aquifer
Aquifers, including lands above the aquifers, on which external sources have or are likely to have a significant adverse effect.

Hydrologic Function
The functions of the hydrologic cycle that include the occurrence, circulation, distribution, and chemical and physical properties of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere, and water's interaction with the environment including its relation to living things.

Key Hydrologic Areas
Significant groundwater recharge areas, highly vulnerable aquifers, and significant surface water contribution areas that are necessary for the ecological and hydrologic integrity of a watershed.

Key Hydrologic Features
Permanent streams, intermittent streams, inland lakes and their littoral zones, seepage areas and springs, and wetlands.

Low Impact Development
An approach to stormwater management that seeks to manage rain and other precipitation as close as possible to where it falls to mitigate the impacts of increased runoff and stormwater pollution. It typically includes a set of site design strategies and distributed, small-scale structural practices to mimic the natural hydrology to the greatest extent possible through infiltration, evapotranspiration, harvesting, filtration, and detention of stormwater. Low impact development can include, for example: bio-swales, vegetated areas at the edge of paved surfaces, permeable pavement, rain gardens, green roofs, and exfiltration systems. Low impact development often employs vegetation and soil in its design, however, that does not always have to be the case and the specific form may vary considering local conditions and community character.

Natural Heritage System

A system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. The system can include key natural heritage features, key hydrologic features, federal and provincial parks and conservation reserves, other natural heritage features and areas, lands that have been restored or have the potential to be restored to a natural state, associated areas that support hydrologic functions, and working landscapes that enable ecological functions to continue.

Riparian

The areas adjacent to water bodies such as streams, wetlands, and shorelines. Riparian areas form transitional zones between aquatic and terrestrial ecosystems.

Urban Forest

All trees, shrubs, and understorey plants, as well as the soils that sustain them, occurring on public and private property in natural, urban, and rural areas.

Water Resource System

A system consisting of ground water features and areas and surface water features (including shoreline areas), and hydrologic functions, which provide the water resources necessary to sustain healthy aquatic and terrestrial ecosystems and human water consumption. The water resource system will comprise key hydrologic features and key hydrologic areas.

Whitebelt

Refers to lands between the built boundary of urban settlement areas and the boundary of the Greenbelt Plan Area.

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APPENDIX A

Based on the assumptions outlined in **Subsection 1.2 Overview of the Future Management Scenarios**, the amount of natural and urban tree canopy cover varies for each future management scenario. **Table 20** provides the statistics for natural cover enhancements (both existing and potential natural cover, if applicable) at the subwatershed-scale. **Table 21** provides the statistics for urban tree canopy cover enhancements at the subwatershed-scale.

Table 20 - Natural Cover Enhancements by Future Management Scenario

Natural Cover	**Current Conditions (2019)**	**Scenario 1:** Urban Expansion with Minimal Enhancements	**Scenario 2:** Urban Expansion with Mid-range Enhancements	**Scenario 3:** Urban Expansion with Optimal Enhancements	**Scenario 4:** Existing Urban Boundary with Optimal Enhancements
Entire Watershed (22,404.4 ha)					
Existing[16]	12.3%	12.4%	12.3%	11.7%	11.7%
Potential	N/A	N/A	6.2%	11.1%	11.1%
Headwaters (6,135.5 ha)					
Existing (within whitebelt)	4.6%	4.6%	3.4%	3.6%	3.6%
Potential (within whitebelt)	N/A	N/A	4.7%	10.6%	10.6%
Existing (within Greenbelt)	8.4%	8.4%	7.0%	8.2%	8.2%
Potential (within Greenbelt)	N/A	N/A	7.4%	17.2%	17.2%
Spring Creek (4,965.7 ha)					
Existing	12.3%	12.3%	11.2%	11.7%	11.7%
Potential	N/A	N/A	5.3%	5.6%	5.6%
West Branch (2,999.4 ha)					
Existing	12.3%	12.3%	14.0%	12.0%	12.0%
Potential	N/A	N/A	3.2%	4.5%	4.5%

[16] The slight variations in existing natural cover across the different scenarios, particularly at the subwatershed scale, is due to how different types of features are classified. For example, the NHS used in Scenario 2 defines some areas as meadows that are not considered existing meadows in the watershed refined NHS used for Scenario 3 and 4. Additionally, streams are considered existing natural cover in Scenario 2, but potential natural cover for Scenarios 3 and 4. This is to identify potential restoration opportunities.

Natural Cover	Current Conditions (2019)	Scenario 1: Urban Expansion with Minimal Enhancements	Scenario 2: Urban Expansion with Mid-range Enhancements	Scenario 3: Urban Expansion with Optimal Enhancements	Scenario 4: Existing Urban Boundary with Optimal Enhancements
Tributary 3 (1,250.7 ha)					
Existing	10.5%	10.5%	13.6%	10.4%	10.4%
Potential	N/A	N/A	7.6%	9.8%	9.8%
Tributary 4 (955.4 ha)					
Existing	6.8%	6.8%	8.1%	6.8%	6.8%
Potential	N/A	N/A	5.5%	3.7%	3.7%
Main Branch (2,025.0 ha)					
Existing	10.8%	10.8%	12.5%	10.7%	10.7%
Potential	N/A	N/A	2.5%	1.9%	1.9%
Little Etobicoke (2,396.3 ha)					
Existing	10.7%	10.7%	14.1%	10.7%	10.7%
Potential	N/A	N/A	0.6%	1.7%	1.7%
Lower Etobicoke (1,676.6 ha)					
Existing	10%	10.0%	10.4%	9.0%	9.0%
Potential	N/A	N/A	2.5%	3.2%	3.2%

Table 21 - Urban Tree Canopy Cover Enhancements by Future Management Scenario

Urban Tree Canopy Cover	Existing Conditions (2019)	Scenario 1: Urban Expansion with Minimal Enhancements	Scenario 2: Urban Expansion with Mid-range Enhancements	Scenario 3: Urban Expansion with Optimal Enhancements	Scenario 4: Existing Urban Boundary with Optimal Enhancements
Watershed	**14.7%**	**14.7%**	**18.8%**	**26.5%**	**26.7%**
Headwaters	12.9%	13.3%	20.2%	25.4%	28.7%
Spring Creek	14.5%	14.5%	19.9%	26.3%	26.3%
West Branch	17.9%	17.9%	21.5%	29.2%	29.2%
Tributary 3	6.5%	6.5%	12.5%	20.6%	20.6%
Tributary 4	13.3%	13.3%	18.1%	23.3%	23.3%
Main Branch	14.2%	14.2%	16.3%	21.7%	21.7%
Little Etobicoke	14.0%	14.0%	15.9%	23.5%	23.5%
Lower Etobicoke	22.9%	22.9%	25.3%	33.4%	33.4%

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