



Humber River Watershed Characterization Report

Prepared by Toronto and Region Conservation Authority

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EXECUTIVE SUMMARY

Watershed planning provides a systematic and comprehensive framework for ensuring healthy watersheds. Watershed planning helps to characterize current watershed conditions, assess future implications under potential future land use and climate conditions, and identify measures to protect, restore, and enhance the health of the watershed and build resiliency to land use and climate changes. Watershed characterization is one of the preliminary stages of the watershed planning process.

Watershed plans do not make land use and infrastructure planning decisions. Rather, they are intended to help municipalities make informed decisions on where and how to grow in a way that minimizes and/or mitigates impacts to watershed health. Watershed plans also help inform other initiatives including ecosystem restoration and management, land management and acquisition, best practices for rural land uses, low impact development and green infrastructure implementation, and climate adaptation.

The last watershed plan for the Humber River (Humber River Watershed Plan - Pathways to a Healthy Humber) and its accompanying Implementation Guide were published in June 2008. It is important to regularly update watershed plans to review progress from previous plans, reflect current conditions, incorporate the latest watershed science, policies, and best practices, and adjust management approaches.

This Watershed Characterization Report presents the findings from extensive monitoring and technical analyses and is organized as follows:

1. **Introduction** – provides an overview of watershed planning, the geographic context for the Humber River watershed, and land use change since 2002.
2. **Existing Watershed Conditions** – identifies the findings and results of watershed characterization 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. **Historical Climate Trends** - provides a summary of historical climate trends, climate-related impacts in the Humber River watershed, and municipal climate emergency declarations, action plans/strategies, and targets.
4. **Policy Inventory** – provides an overview of existing municipal policies as they relate to watershed planning broadly and the Humber River watershed specifically, as well as a comparison of single-tier and upper-tier municipal Natural Heritage Systems as identified in Official Plans (as of June 2022) to TRCA's recently updated Regional Target Natural Heritage System (2022).
5. **Cultural Heritage Inventory** – provides an overview of the cultural heritage conditions and trends in the watershed.
6. **Methodology** – provides an overview of the technical methodologies used to complete the analyses for each technical component outlined in [Section 2.0 Existing Watershed Conditions](#) and [Section 5.0 Cultural Heritage Inventory](#).
7. **Maps** – contains the technical maps referenced throughout the report.

8. **Glossary** – contains a list of terms or words found throughout the report.
9. **References** – contains all the references used in the preparation of each of the technical reports that were completed in support of this Watershed Characterization Report.

At 90,258 hectares in size, the Humber River watershed is the largest watershed in TRCA's jurisdiction and spans from its headwaters on the Niagara Escarpment and Oak Ridges Moraine (and in the provincial Greenbelt) to the river's mouth at Lake Ontario. The watershed lies within the municipal boundaries of one single-tier municipality (City of Toronto), four upper-tier municipalities (Peel Region, York Region, Dufferin County, and Simcoe County), and nine lower-tier municipalities (Town of Caledon, City of Brampton, City of Mississauga, Township of King, Town of Aurora, City of Vaughan, City of Richmond Hill, Town of Mono, and Township of Adjala-Tosorontio).

The Humber River was designated as a Canadian Heritage River in 1999 based on its outstanding human heritage and recreational values and was officially included in the Canadian Heritage River System (CHRS), Canada's national river conservation program. The CHRS program is a federal-provincial-territorial managed program which works with river managers across Canada to conserve and promote the natural, cultural, and recreational values of designated rivers. The Humber River is the only Canadian Heritage River in the Greater Toronto Area and is one of only 40 designated heritage rivers in the country.

As of 2020, urban land uses represent 26.7% of the watershed, up from 20.7% in 2002. Approximately 32.7% of the watershed is natural cover (as of 2020), down from 34% in 2002. There are issues related to flooding and erosion, water quality, low natural cover, and varying qualities of terrestrial and aquatic habitat, mostly due to the urbanized nature of the watershed (especially in the middle and lower portions).

Municipalities within the Humber River watershed have varying Official Plan policies to address these watershed issues, with many of the municipalities incorporating policies to protect the Water Resource System as part of the on-going Official Plan updates through the Municipal Comprehensive Review process. The effectiveness of existing policies will be considered as the watershed planning process unfolds to identify the best management actions to improve existing conditions and mitigate potential future impacts.

The information contained in this report will inform the next stage of the watershed planning process: future management scenarios. In this stage, different potential future land use and climate change scenarios will be examined to determine whether watershed conditions are expected to improve, stay the same, or deteriorate. Based on the results from the watershed characterization and future management scenarios stages, a management framework will be developed to help inform land use and infrastructure planning with the goal of improving watershed conditions. An updated watershed plan can be used to assist TRCA and its municipal partners in ensuring a cleaner, healthier, and more sustainable and resilient Humber River watershed.



Figure 1 - Humber River

Watershed Vision

Humber River watershed is protected, restored, and enhanced to sustain a more resilient, healthy, clean, and biodiverse ecosystem where we live in harmony with nature and celebrate the Humber River's unique Indigenous history and cultural heritage.

In the fall of 2022, TRCA engaged watershed stakeholders, residents, and members of the public on what they would like to see in a watershed vision using an online engagement survey and interactive polling during two virtual webinars on October 12 and 13, 2022. The survey asked respondents to select up to five words that should be a vital part of the vision statement for the Humber River watershed. The top five selected words were biodiversity, ecosystems, sustainable, protected, and resilient. The survey also asked respondents to identify any other key words that should be part of the vision statement. The three words identified most often were Indigenous, non-motorized, and flooding/floodplain/manage flood risks. The webinar polling asked participants what word they would use to describe the kind of Humber River watershed they would like to see in the future. The top words included clean, healthy, biodiverse, natural (native species), sustainable, and flood-free.

The Steering Committee for the new Humber River Watershed Plan (consisting of Mississaugas of the Credit First Nation, TRCA, the municipalities within the watershed) also provided input to the vision statement. Top vision statement words selected by the Steering Committee included: ecosystems/environment, natural/naturalized/native species, restoration, biodiverse, healthy, resilient, heritage/cultural heritage, and connected. Variations of a vision based on these results were presented to the Steering Committee for input. The vision for the Humber River watershed noted above reflects engagement and Steering Committee feedback.

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Acronyms

BMI	Benthic macroinvertebrates	NHIC	Natural Heritage Information Centre
CAs	Contributing Areas	NHS	Natural Heritage System
CHRS	Canadian Heritage Rivers System	ORMGP	Oak Ridges Moraine Groundwater Program
COSEWIC	Committee on the Status of Endangered Wildlife in Canada	PCBs	PolyChlorinated Biphenyls
COSSARO	Committee on the Status of Species at Risk in Ontario	PCMs	Polycyclic Musks
CWQG	Canadian Water Quality Guideline	PFASs	Perfluoroalkyl Substances
DBH	Diameter at Breast Height	PFCA	Perfluorocarboxylic Acid
DCIA	Directly Connected Impervious Cover/Area	PFOS	Perfluorooctane Sulfonate
DEM	Digital Elevation Model	PFSA	Perfluorosulfonic Acid
DFO	Department of Fisheries and Oceans Canada	PGMN	Provincial Groundwater Monitoring Network
ECCC	Environment and Climate Change Canada	PNC	Potential Natural Cover
ELC	Ecological Land Classification	PRMS	Precipitation-Runoff Modelling System
ENC	Existing Natural Cover	PTTW	Permit to Take Water
ESGRAs	Ecologically Significant Groundwater Recharge Areas	PWQMN	Provincial Water Quality Monitoring Network
FBI	Family Biotic Index	PWQO	Provincial Water Quality Objective
FVC	Flood Vulnerable Cluster	RCA	Reach Contributing Area
HDF	Headwater Drainage Feature	RGA	Rapid Geomorphic Assessment
HRWP	Humber River Watershed Plan	RWMP	Regional Watershed Monitoring Program
HVAs	Highly Vulnerable Aquifer	SGRAs	Significant Groundwater Recharge Areas
IBI	Index of Biotic Integrity	SPIN	Stream Power Index for Networks
IHA	Indicators of Hydrological Alteration	SSP	Specific Stream Power
IRP	Integrated Restoration Prioritization	SSPR	Specific Stream Power Ratio
KBA	Key Biodiversity Area	SSWCAs	Significant Surface Water Contribution Areas
KHA	Key Hydrologic Area	SWM	Stormwater Management
KHF	Key Hydrologic Feature	SSWCAs	Significant Surface Water Contribution Areas
LAM	Landscape Analysis Model	TIMP	Total Imperviousness
LTMP	Long-Term Monitoring Program	TRCA	Toronto and Region Conservation Authority
MBW	Meander Belt Width	WRS	Water Resource System
MECP	Ministry of the Environment, Conservation and Parks	WSC	Water Survey of Canada
MNRF	Ministry of Natural Resources and Forestry	XIMP	Total imperviousness that is directly connected to a drainage system
MTO	Ministry of Transportation		

1.0 INTRODUCTION

This report provides an overview of the current conditions of the Humber River watershed and compares trends since the last watershed plan, Humber River Watershed Plan – Pathways to a Healthy Humber, which was released, along with the Humber River Watershed Plan Implementation Guide, in June 2008.

Many of the key issues noted in the 2008 Humber River Watershed Plan (HRWP) and subsequent watershed report cards are still relevant. Additionally, like all watersheds in TRCA's jurisdiction, the Humber River watershed faces significant urban growth pressure. Climate change is another key stressor on watershed health. Beyond urbanization and climate change, other key issues (i.e., drivers) within the Humber River watershed include:

- In-stream aquatic barriers prevent the movement of fish species.
- Although the fish community is in relatively good health at the watershed scale, there are large differences at the subwatershed scale between the northern rural areas and the southern urbanized areas of the watershed.
- There is declining quality, distribution, and quantity of natural cover (with higher quality habitats in the Main Humber and East Humber subwatersheds in the northern part of the watershed).
- There is uneven distribution of urban forest canopy cover among the subwatersheds.
- Surface water quality is variable throughout the watershed with poorest conditions often in the lower watershed.
- There are increasing stormwater runoff, flooding, and erosion issues.



Figure 2 - Bank Erosion on Scarlett Road, Toronto.

In some instances, the 2008 HRWP established targets. Where applicable, [Section 2.0 Existing Watershed Conditions](#) reports on current conditions and progress made relative to those targets. Additionally, trends are generally assessed relative to two, ten-year time periods: 2012–2021 (current conditions) and 2002–2011 (baseline conditions). Historical data is included pre-2002 where data was available. The two time periods were chosen to present updated technical information and fill data gaps from the 2008 HRWP. Using these two time periods for the characterization analysis allows for the assessment of trends over time and for reporting on progress related to watershed conditions from the previous watershed plan. Finally, this Watershed Characterization Report uses the latest science and updated data compared to the previous analyses.

1.1 Watershed Planning Context

Watershed planning helps to characterize current watershed conditions, assess future implications under potential future land use and climate conditions, and identify measures to protect, restore, and enhance the health of the watershed and build resiliency to land use and climate changes. Watershed characterization is one of the preliminary stages of the watershed planning process (see [Figure 3](#)).

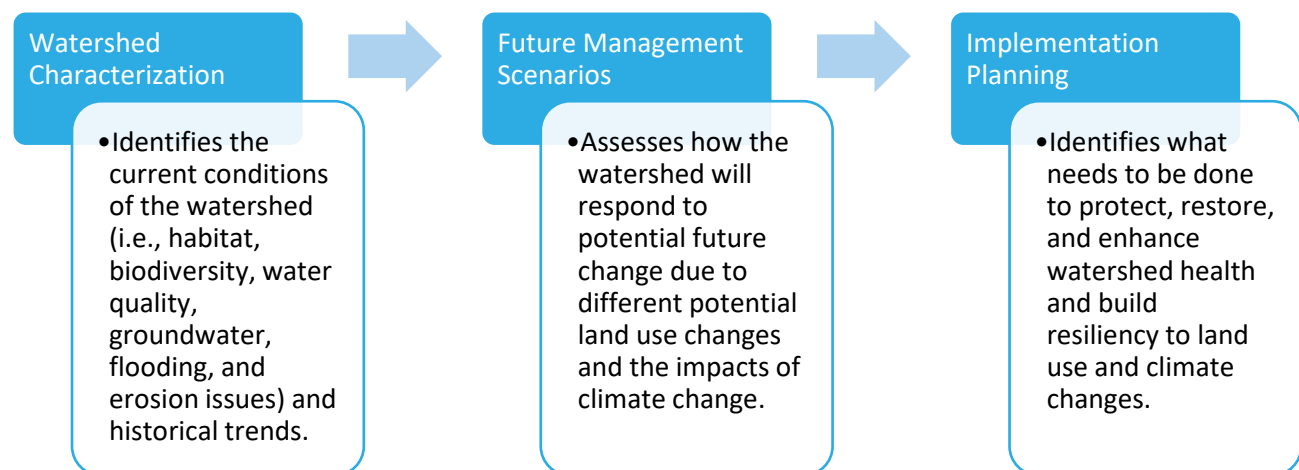


Figure 3 - Overview of the Watershed Planning Process

The development of a watershed plan is a multi-year, multi-partner, collaborative exercise. For the purposes of the HRWP, the main partners involved in plan development are Toronto and Region Conservation Authority (TRCA), Mississaugas of the Credit First Nation, City of Toronto, Peel Region, York Region, Dufferin County, Simcoe County, Town of Caledon, City of Brampton, Township of King, Town of Aurora, City of Vaughan, City of Richmond Hill, Town of Mono, and Township of Adjala-Tosorontio.

Engagement with First Nations and Indigenous communities as well as broader engagement with watershed stakeholders, residents, and members of the public will play an important role in the development of the watershed plan to ensure it reflects the perspectives of First Nations and Indigenous communities as well as watershed stakeholders, residents, landowners, and the public. Engagement that has taken place during the watershed characterization stage is outlined in the Humber Engagement Summary 1 which is available on the [project website](#).

Ultimately, the characterization stage of the watershed planning process sets the context of the current state of the watershed, which will inform subsequent stages in plan development.

Provincial policies recognize the watershed as the ecologically meaningful scale for long-term and integrated planning. Additionally, provincial policy directions currently require/encourage municipalities to undertake watershed planning to ensure the protection, enhancement, or restoration of the quality and quantity of water, to inform decisions on the allocation of growth, and to plan water, wastewater, and stormwater infrastructure.

1.2 Geographic Context

At 90,258 hectares in size, the Humber River watershed is the largest watershed in TRCA's jurisdiction. The upper portions of the watershed are largely rural and are part of the provincial Greenbelt and include portions of the Niagara Escarpment and Oak Ridges Moraine. The lower (and some of the middle portions) of the watershed are mostly urbanized. The watershed consists of five subwatersheds including Main Humber, East Humber, West Humber, Lower Humber, and Black Creek (see [Map 1](#)). [Table 1](#) shows the geographic distribution of the watershed by subwatershed and by municipality.

Table 1 - Geographic Distribution of the Watershed

Geographic Unit	Size (ha)	Proportion of Watershed Area (%)
Humber River Watershed	90,258¹	100%
Subwatersheds:		
Main Humber	35,748	39.6%
East Humber	19,607	21.7%
West Humber	20,362	22.6%
Lower Humber	8,267	9.2%
Black Creek	6,274	6.9%
Portion of Watershed by Municipality:		
City of Toronto	13,287	14.7%
Region of Peel	38,718	43.0%
• City of Mississauga	143	0.2%
• City of Brampton	7,118	7.9%
• Town of Caledon	31,457	34.9%
Region of York	34,489	38.2%
• Township of King	14,614	16.2%
• Town of Aurora	115.0	0.1%

¹ Areas throughout this report have been rounded to the nearest whole number.

Geographic Unit	Size (ha)	Proportion of Watershed Area (%)
• City of Vaughan	17,861	19.8%
• City of Richmond Hill	1,899	2.1%
County of Simcoe	2,002	2.2%
• Township of Adjala-Tosorontio	2,002	2.2%
County of Dufferin	1,759	2.0%
• Town of Mono	1,759	2.0%

1.3 Land Use Change

Assessing land use change at a watershed scale over time helps to understand how different land uses are influencing watershed conditions and provides important context. For the Humber River watershed, three time periods, 2002, 2012, and 2020, were used to understand the progression of land use change (i.e., urban, rural, natural). These years were chosen based on the availability of comprehensive land use datasets.

TRCA undertook a land use classification alignment exercise and refinement (i.e., quality assurance and quality control) of the layers to ensure as much consistency as possible between the datasets from the different time periods. Even with this refinement, the quality of the datasets from the older time periods is not as high (i.e., detailed) as the most recent datasets. Still, at the watershed scale, this comparison of land use change over time provides important context to understand the rate of urbanization in the watershed.

Table 2 provides an overview of land use change and impervious cover within the watershed. Impervious cover refers to the amount of land that is considered to have a hardened surface (e.g., pavement, building, etc.) preventing the infiltration of water into the ground. Imperviousness is an indicator of watershed health as a high proportion of impervious surfaces is associated with an increase in the severity and duration of peak flows during storm events (i.e., runoff), causing flooding, erosion, and sedimentation. Impervious cover also affects water quality and stream temperature due to runoff, which can negatively impact aquatic biodiversity.

Table 2 demonstrates that the Humber River watershed is continuing to urbanize with losses of both natural and rural land cover types. The same trend applies to many of the subwatersheds. As of 2020, impervious cover in the watershed is 23.1% (with the assumption that water is 0% impervious from an ecological perspective). Impervious cover in the subwatersheds is as follows: Main Humber (12.1%), East Humber (14.4%), West Humber (22.6%), Lower Humber (61.2%), and Black Creek (64.6%).

The more urbanized subwatersheds (Lower Humber and Black Creek) have greater than 60% impervious cover while the more rural subwatersheds (Main Humber and East Humber) have the lowest impervious cover (both less than 15%). Natural cover is quite low across the subwatersheds, with Black Creek having the lowest at 0.6% (of 7.0% total area of subwatershed) and the Main Humber having the highest at 19.1% (of 39.6% total area of subwatershed) in 2020. **Map 2** shows the progression of land use change in the watershed.

Table 2 - Land Use Change²

	Area Estimates			Change Estimates	
	2002 (area % and ha)	2012 (area % and ha)	2020 (area % and ha)	% change from 2002 to 2012 (+ or -)	% change from 2012 to 2020 (+ or -)
Urban	20.7% (18,722 ha)	24.9% (22,432 ha)	26.7% (24,100 ha)	+20.3%	+7.2%
Rural*	45.3% (40,868 ha)	41.2% (37,214 ha)	40.6% (36,613 ha)	-9.1%	-1.5%
Natural	34.0% (30,668 ha)	33.9% (30,612 ha)	32.7% (29,545 ha)	-0.3%	-3.5%
Impervious Cover ³	17.8% (16,066 ha)	21.7% (19,586 ha)	23.1% (20,849 ha)	+21.9%	+6.5%

*Rural includes land use classifications such as agriculture, golf courses, recreational/open space, and cemetery, etc. These types of land uses cannot be considered natural, nor can they be considered urban as they still have low amounts of impervious surfaces. See [Appendix A – Land Use Classifications](#) for a full list of land use classifications summarized as urban, rural, and natural.

² Percent change is calculated based on the difference between the relevant time period's land use area in hectares.

³ This calculation of impervious cover assumes that water (e.g., lakes, rivers, ponds) is 0% impervious (from an ecological perspective).

2.0 EXISTING WATERSHED CONDITIONS

As part of watershed characterization, TRCA assessed extensive monitoring, inventory, and land use datasets to provide the most up-to-date information on current conditions and determine how conditions have changed over time (i.e., trends). Technical analyses were completed for numerous watershed components as outlined in [Table 3](#).

Table 3 - List of Characterization Analyses Completed

Watershed Component	Technical Analyses Completed
Water Resource System (WRS)	<ul style="list-style-type: none"> • Delineation of key hydrologic features (e.g., permanent and intermittent streams) and areas (e.g., significant groundwater recharge areas) • Amount of cover and cover type in riparian zone (i.e., transition area between terrestrial and aquatic ecosystems found along riverbanks, ponds, and lakes) • In-stream aquatic barriers (i.e., structures that prevent fish movement) • Riverine fish community health (e.g., species diversity and abundance) • Sensitive species habitat • Estuary fish community health (i.e., lake-based fish communities) • Benthic invertebrate community health (i.e., bottom dwelling organisms such as aquatic insects, molluscs, and worms) • Freshwater mussels (i.e., filter-feeding macroinvertebrates that live on and in the sediment of the river) • Aquatic habitat quality (i.e., stream quality as it relates to impervious cover) • Ecohydrology (i.e., hydrology changes related to the aquatic ecosystem) • Groundwater conditions (e.g., groundwater quantity, quality, and contaminants of emerging concern) • Streamflow (i.e., volume of water flowing past a gauge in a watercourse)
Natural Heritage System (NHS) and Urban Forest	<ul style="list-style-type: none"> • Habitat quantity (i.e., amount of natural cover) • Habitat quality (e.g., patch size, shape, and surrounding land influences) • Terrestrial biodiversity (e.g., vegetation communities, animals, plants, invasive species, and species at risk) • Habitat connectivity (i.e., corridors for wildlife movement) • Climate vulnerabilities (i.e., habitat patches vulnerable to the effects of climate change) • Carbon storage (i.e., amount of carbon stored in various natural cover types) • Urban forest (i.e., amount of tree canopy cover)
Surface Water Quality	<ul style="list-style-type: none"> • Parameters of concern • Chemicals of emerging concern • Microplastics

Watershed Component	Technical Analyses Completed
	<ul style="list-style-type: none"> Spills
Natural Hazards (Flooding and Erosion)	<ul style="list-style-type: none"> Flood risk, including Flood Vulnerable Clusters (FVCs) Erosion risk (sensitivity and stability) and erosion hazard sites/erosion control structures
Stormwater Management	<ul style="list-style-type: none"> Inventory of existing stormwater management infrastructure
Restoration Planning / Opportunities	<ul style="list-style-type: none"> Inventory of existing restoration opportunities and completed restoration projects

The key findings of the watershed characterization analyses are organized into four main categories (WRS, NHS and urban forest, surface water quality, and natural hazards) and are presented in [Table 4](#).

Table 4 - Watershed Characterization Key Findings

Component	Key Findings
WRS (includes in-stream barriers, aquatic habitat health, groundwater conditions, streamflow etc.)	<ul style="list-style-type: none"> A large number of in-stream aquatic barriers have been documented by TRCA in the watershed (91) that prevent the movement of fish species, and there is approximately 60.3% natural cover within the riparian zone (i.e., within 30 metres of streams, ponds, and lakes). The average health rating for the fish community is 'good' suggesting that, at the watershed scale, the fish community is in good health. However, there are large differences in fish community health at the subwatershed scale between the northern rural areas and the southern urbanized areas in the watershed. The Lower Humber and Black Creek subwatersheds are rated as being in 'poor' condition and the Main and West Humber subwatersheds are rated as being in 'fair' condition. Only the East Humber subwatershed is rated as being in 'good' condition. There is approximately 4,279 ha of potentially occupied and potentially contributing habitat for Redside Dace in the Humber River and an estimated 1,058 ha of potentially occupied and potentially contributing habitat (instream and terrestrial) for Rapids Clubtail (both endangered and sensitive indicator species). The fish community of the Humber River estuary has shifted to one that is comprised largely of pollution tolerant species with fewer sensitive individuals (a total of 42 fish species detected in the current period). The average habitat health rating for benthic invertebrate communities is 'fairly poor' which suggests substantial to severe water quality impacts in the watershed. Aquatic habitat quality at the watershed scale, based on percent impervious cover, is classified as urbanizing or impacted (with 23.1%

Component	Key Findings
	<p>impervious cover in the watershed). However, there are vast differences in aquatic habitat quality across the subwatersheds, with the Black Creek and Lower Humber subwatersheds currently classified as ‘urban drainage’ (64.6% and 61.2% impervious cover, respectively).</p> <ul style="list-style-type: none"> • The average groundwater recharge for the watershed (235 mm/year) is focused within the hummocky terrain (i.e., closed depressions) and surficial sand and gravel deposits of the Oak Ridges Moraine within the Main Humber subwatershed, and this plays an important role in the recharge distribution across the watershed. • Streamflow in the watershed has increased by 20.3% from historical conditions (based on the 30-year time period which provides a more accurate streamflow representation since climatic conditions tend to be quite variable from year to year and even on decadal scale). The current average annual streamflow is 280.4 mm/year (representing 33% of the average annual precipitation). The increase in streamflow/discharge can be a result of both an increase in impervious cover between 2002 and 2020 and average annual precipitation (increase of 5% in 30-year time period between 1961-1990 and 1991-2021). • For the current 30-year time period, there is a clear trend of increasing average annual precipitation from downstream to upstream subwatersheds.
NHS / Urban Forest (includes terrestrial habitat quantity and quality, sensitive species, tree canopy etc.)	<ul style="list-style-type: none"> • Approximately 31.4%⁴ of the watershed consists of natural cover (including 16.6% forest, 2.7% successional forest, 7.1% meadow, 5% wetland, and <0.1 % beach/bluff), with terrestrial natural cover continuing to decrease (e.g., forest and meadow cover). Between 2002 and 2020, 1,289 ha of terrestrial natural cover was lost in the watershed (decrease in total amount of natural cover by 4.4%), some of which was due to urban development and associated land use changes. • The Main Humber and East Humber subwatersheds have generally higher quality habitat due to larger amounts of natural cover and reduced negative urban influences. The West Humber, Lower Humber, and Black Creek subwatersheds have generally poorer quality habitat due to smaller amounts of natural cover and negative urban influences.

⁴ The natural cover number referenced in **Table 2** (32.7%) includes streams and lakes (i.e., natural cover that is water), whereas the numbers in **Tables 4** and **5**, and the analyses in **Section 2.2** exclude water from the natural cover calculations.

Component	Key Findings
	<ul style="list-style-type: none"> • The watershed contains a large number of vegetation community types that support many sensitive and/or rare fauna and flora species (including several species at risk). • There are many areas in the watershed that are important for wildlife movements (e.g., ravines in the south and the northern parts of the watershed). Approximately 61% of the watershed is a priority for regional connectivity among habitat patches. Approximately 20% of the watershed is a priority for local connectivity among forest-to-wetland patches, and approximately 35% of the watershed is a priority for local connectivity among wetland-to-wetland patches (at the subwatershed scale). • Terrestrial ecosystem vulnerability to the impacts of climate change is greater in urban areas. Highly vulnerable areas are primarily found within the middle to lower reaches of the watershed where soil drainage is poor or absent and ground surface air temperatures are high. • Natural cover within the watershed currently stores more than 7 million megagrams of carbon making it important from a climate change perspective. • Urban forest canopy cover (i.e., trees and woody shrubs in urbanized spaces and forests) for the watershed is 29.1% and has remained stable from 2009 to 2021.
Water Quality (includes parameters of concern relative to Provincial Water Quality Objectives [PWQO] or Canadian Water Quality Guidelines [CWQG])	<ul style="list-style-type: none"> • Surface water quality is variable throughout the watershed with poorest conditions often in the lower watershed. Contaminants of particular concern include: <ul style="list-style-type: none"> ○ Chlorides (e.g., from road salts) ○ Phosphorus (e.g., from fertilizers and sewage cross-connections) ○ Metals such as iron, cadmium, copper, and zinc (e.g., from natural and industrial sources and/or roadways) ○ <i>E. coli</i> bacteria (e.g., from sewage/animal wastes)
Natural Hazards (includes flooding and erosion)	<ul style="list-style-type: none"> • There are seven FVCs located in the watershed, representing approximately 1.2% of the area of the watershed. • In general, comparing existing flood risk to the baseline period shows insignificant changes in 100-year flood peak flows to most of the FVCs, but FVCs that receive drainage from multiple subwatersheds appear to compound the effect of development on peak flows. • Most of the watershed can be categorized as moderate or high erosion sensitivity, and moderate stability.

Table 5 provides further details on watershed conditions and trends for each of these four categories (as well as for stormwater management and restoration planning). Trends are assessed as changes (%) from the baseline period (2002–2011) to current conditions period (2012–2021)⁵. Targets from the 2008 HRWP are included, where applicable, and progress in meeting the targets is discussed for each component, where applicable, throughout the relevant subsections in **Section 2.0 Existing Watershed Conditions**. Further information on the results of characterization analyses for each category can be found in the relevant subsections throughout **Section 2.0 Existing Watershed Conditions**. See **Section 6.0 Methodology** for details on the methods and approaches used for the characterization analysis, and a list of the technical reports that were prepared by TRCA in support of this Watershed Characterization Report.

⁵ The current conditions column in **Table 5** is based on the most recent available data. The trend assessment compares the two referenced time periods based on available data.

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Table 5 - Existing Watershed Conditions Summary

	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002-2011) and Current (2012-2021)	Target from 2008 HRWP ⁶ (if applicable)
Water Resource System			
Riparian cover	60.3% overall natural cover in riparian zone	<+1% increase ⁷	Greater than 75% of riparian areas with natural cover (60% forest or successional; 15% meadow or wetland) Increase wetland cover to 10% of total watershed area
In-stream aquatic barriers⁸	91 human-made in-stream barriers (affecting species passability)	-41% (decrease by 37 barriers)	Only strategic in-stream barriers remain; barriers removed/mitigated in priority sequence as identified in the 2008 HRWP
Riverine fish community health	71 fish species are present (59 native and 12 invasive/naturalized)	No change in # of species ⁹	Maintain or restore target fish communities in each catchment area

⁶ The 2008 HRWP established some targets for certain watershed components. If applicable, this report identifies that target for comparison with current conditions.

⁷ The overall small increase in riparian cover is driven by the wetland cover type. Losses in both meadow and forest cover have been observed between the time periods.

⁸ Instream barriers include only those barriers that are completely impassable to all species or are partially passable (passable only to jumping species). There are an additional 37 in-stream barriers that are completely passable to all species and were not considered in this assessment. **Map 7** shows the location of the in-stream barriers in the watershed (based on informal surveys of the watershed).

⁹ No native species were lost between the baseline and current period, but species range decreased for some target species.

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Current Conditions (2012-2021)		Trend Assessment (% change) Between Baseline (2002-2011) and Current (2012-2021)	Target from 2008 HRWP ⁶ (if applicable)
12 invasive species are present		+8% (increase of 1 species) ¹⁰	Prevent the introduction of any invasive or exotic species
Average IBI ¹¹ Score: 28.8 (‘good’)		No change	Developed, southern areas: Fish communities measured at Regional Watershed Monitoring Program (RWMP) sites in urban areas should maintain or improve over baseline conditions Undeveloped, northern rural areas (north of Highway 407): Fish communities measured at RWMP sites upstream of urban development should be rated as ‘good’ based on IBI scores
8 sites rated as ‘good’ north of urban area		Decline ¹²	
Sensitive species habitat	Redside Dace: Potentially occupied: 4,000 ha Potentially contributing: 279 ha Rapids Clubtail: Potentially occupied: 81 ha Potentially contributing: 686 ha	Lack of data/comparable methods between baseline and current time period prevented an assessment of trends	N/A

¹⁰ Two new invasive species appeared in the watershed during the baseline period (Round Goby and Rudd – and both have established), and two appeared during the current period (Tench and Weather Loach). However, Tench has since been eradicated so there was an increase in only one invasive species (Weather Loach) in the current period.

¹¹ IBI stands for Index of Biotic Integrity and measures a set of metrics (number of fish species, presence of sensitive species, abundance, and food chain classifications) to assign a rating of ‘very good’ (≥ 38), ‘good’ (28-37.9), ‘fair’ (20-27.9), or ‘poor’ (≤ 20). See **Section 2.1.4** for more information.

¹² Not provided as % change as not all sites sampled in the baseline period were sampled in the current period.

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002-2011) and Current (2012-2021)	Target from 2008 HRWP ⁶ (if applicable)
Estuary fish community health	42 fish species are present	No change	N/A
	5 invasive or introduced/naturalized species are present	No change	N/A
Benthic invertebrate community health	Average FBI ¹³ Score: 5.98 (‘fairly poor’)	Decrease ¹⁴	A minimum of 70% of RWMP sites rated as ‘fair’ or ‘good’ condition based on benthic invertebrate indices
	34.2% of sites rated ‘fair’ or better	No change ¹⁴	
Freshwater mussels	3 freshwater mussels species ¹⁵	No change	N/A
Groundwater recharge	Watershed: 235 mm/yr Main Humber: 390 mm/yr East Humber: 190 mm/yr West Humber: 125 mm/yr Lower Humber: 90 mm/yr Black Creek: 62.5 mm/yr	Estimation of recharge changed from 122,333,333 m ³ /yr to 212,105,125 m ³ /yr Oak Ridges Moraine and Niagara Escarpment: Estimated recharge of 300 mm/yr	Maintain baseline groundwater recharge rates and distribution

¹³ FBI refers to Family Biotic Index, which is often used to assess the quality of water in rivers and has a rating scale of excellent (0-3.75), very good (3.76-4.25), good (4.26-5.00), fair (5.01-5.75), fairly poor (5.76-6.50), poor (6.51-7.25), or very poor (7.26-10). See **Section 2.1.7 Benthic Invertebrate Community Health** for more information.

¹⁴ Not provided as % change as assessed only for the current period (2013-2021 in this case) when comparable data was available.

¹⁵ Assessed as presence of freshwater mussels species at a site searched qualitatively, once, in each of the baseline and current periods. A fourth species was found in 2022 at a site not surveyed during the baseline period.

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Groundwater discharge	Baseflow Index¹⁶ estimated at:	Baseflow Index (since baseline period):	Maintain baseline average annual baseflow rates (as determined by baseflow separation of long-term stream flow gauge data)
	Main Humber:	Main Humber:	
	HY053 - 0.34	HY053 - insufficient data	
	02HC025 - 0.68	02HC025 - no change	
	02HC023 - 0.69	02HC023 - 3% increase	
	02HC047 – 0.73	02HC047 - 3% increase	
	02HC057 - 0.71 (2011-13)	02HC057 - insufficient data	
	East Humber:	East Humber:	
	HY054 - 0.56	HY054 - insufficient data	
	02HC032 - 0.57	02HC032 - no change	
	02HC009 - 0.58	02HC009 - 3.5% increase	
	West Humber:	West Humber:	
	02HC031 - 0.36	02HC031 - 6% increase	
	Lower Humber:	Lower Humber:	
	02HC003 - 0.53	02HC003 - 10.5% increase	
	Black Creek:	Black Creek:	
	02HC027 - 0.36	02HC027 - 5.5% increase	

¹⁶ Baseflow Index, or BFI, is a measure of the ratio of long-term baseflow to total stream flow and it can be used as a proxy for the slow continuous contribution of groundwater to river flow.

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Groundwater use	Approximately 53,040,000 m ³	Increase from approximately 3.5% of the annual recharge to 25%	N/A
Streamflow¹⁷	Current 10-year (2012-2021): Average annual discharge of 291.4 mm/yr	10-year comparison (baseline 2002-2011 to current 2012-2021): Decrease by 3.4% from an average annual discharge of 301.6 mm/yr	Maintain or reduce baseline annual and seasonal flow volumes (based on long-term stream gauge measurements)
	Current 30-year (1991-2021): Average annual discharge of 280.4 mm/yr	30-year comparison (historic 1961-1990 to current 1991-2021): Increase by 20.3% from an average annual discharge of 233.0 mm/yr	Maintain or enhance baseline seasonal and annual baseflow rates
Natural Heritage System / Urban Forest			
Habitat quantity	Area in ha and % of watershed (2020)		Increase natural cover to at least 39% of total watershed area
	Total natural cover	28,326 ha or 31.4%	Increase wetland cover to 10% of total watershed area

¹⁷ Streamflow trends were assessed using both a 10-year time period (to align with analysis undertaken for other technical components) and a 30-year time period (which will give a more accurate streamflow representation since climatic conditions tend to be quite variable from year to year and even on the decadal scale). 10-year current conditions are defined as 2012-2021 and the 10-year baseline conditions are defined as 2002-2011. 30-year current conditions for the streamflow analysis are defined as 1991-2021 and historic conditions are defined as 1961-1990. The watershed scale streamflow/ baseflow values presented in **Table 5** are based on the most downstream gauge that receives flow from the majority of the watershed. For the Humber River watershed, this stream gauge is 02HC003, which is upstream of the Black Creek tributary. As the Black Creek tributary did not affect the flow values significantly, the values are taken from 02HC003 without additional flow volumes from the Black Creek tributary.

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Current Conditions (2012-2021)		Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Forest	14,962 ha or 16.6%	Decrease 8.7%	
Successional Forest	2,431 ha or 2.7%	Increase 47.7%	
Meadow	6,386 ha or 7.1%	Changes in methodology for how meadows are calculated prevented change comparison	
Wetland	4,545 ha or 5.0%	Changes in methodology for how wetlands are calculated prevented change comparison	
Beach/Bluff	3.6 ha or <0.1%	Changes in methodology for how beach/bluff are calculated prevented change comparison	
Habitat quality	Average LAM Score¹⁸: Watershed: 8.96 (High end of 'Poor') Main Humber: 9.56 (Fair) East Humber: 9.05 (Fair) West Humber: 8.21 (Poor) Lower Humber: 6.99 (Poor) Black Creek: 6.77 (Poor)	Lack of data/comparable methods between baseline and current time period prevented an assessment of trends	Average habitat patch total quality rating of 'good' for all patches in, or partially within, the watershed; and as follows for subwatersheds: Main Humber: Good East Humber: Good West Humber: Fair Lower Humber: Poor Black Creek: Poor

¹⁸ 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).

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)		
Terrestrial biodiversity	<p># vegetation communities of conservation concern (# of vegetation communities types (L1-L3); # ha)¹⁹:</p> <p>Main Humber: 124; 1,130</p> <p>East Humber: 106; 395</p> <p>West Humber: 50; 103</p> <p>Lower Humber: 43; 42</p> <p>Black Creek: 20; 17</p> <p># fauna (i.e., animal) species of conservation concern present (# species - L1-L3; L1-L4)²⁰:</p> <p>Main Humber: 87; 137</p> <p>East Humber: 76; 128</p> <p>West Humber: 53; 105</p> <p>Lower Humber: 16; 59</p> <p>Black Creek: 14; 56</p>	Lack of data/comparable methods between baseline and current time period prevented an assessment of trends	Maintain or improve baseline representation, and baseline abundance and distribution, of native vegetation community types and species (baseline to be determined through RWMP natural heritage inventories)		
Habitat connectivity	<p>Area in ha and % of watershed (2020)</p> <table><tr><td>Regional connectivity</td><td>54,764 ha; 60.7%</td></tr></table>	Regional connectivity	54,764 ha; 60.7%	Lack of data/comparable methods between baseline and current time period prevented	N/A
Regional connectivity	54,764 ha; 60.7%				

¹⁹ # of vegetation communities of conservation concern (L1-L3; # ha) in hectares based on data collected between 2000 and 2021.

²⁰ # of fauna species of concern (L1-L3; L1-L4) present based on data collected between 2012 and 2021.

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	Current Conditions (2012-2021)		Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
	Local connectivity (forest to wetland subwatershed scale)	18,408 ha; 20.4%	an assessment of trends for habitat connectivity	
	Local connectivity (wetland to wetland subwatershed scale)	31,962 ha; 35.4%		
Climate vulnerabilities	Highly vulnerable areas (ha and %)		No data to compare to for baseline period	N/A
	Habitat patches	2,173 ha; 7.7% of natural cover		
	Wetlands	343 ha; 1.2% of natural cover		
	Climate sensitive vegetation communities	31 ha; 0.1% of natural cover		
	Soil drainage	20,503 ha; 22.7% of watershed		

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002-2011) and Current (2012-2021)	Target from 2008 HRWP ⁶ (if applicable)
	Ground surface 31,210 ha; air temperature 34.6% of watershed		
Carbon storage	Amount of carbon stored in natural cover (MgC, 2020) Watershed: 7,497,079 Main Humber: 4,556,908 East Humber: 1,763,304 West Humber: 792,598 Lower Humber: 250,753 Black Creek: 133,516	No data to compare for baseline period	N/A
Urban forest (canopy cover for the entire watershed)	26,320 ha or 29.1% (SE $\pm 0.5\%$) ²¹ Canopy cover in each subwatershed with standard error²² Main Humber: 39.5 % ($\pm 0.9\%$) East Humber: 31.3% ($\pm 1.2\%$) West Humber: 15.2% ($\pm 0.9\%$)	0.2% change in the watershed since 2009 Relative canopy cover change in each subwatershed since 2009²³ Main Humber: -0.2% East Humber: -0.9% West Humber: +1.1%	N/A

²¹ Based on a sample size of 7,000 points, there is a 95% probability that the true canopy cover of Humber River watershed falls between 28.0% and 30.2%. Canopy cover percentages were based on the i-Tree Canopy random sample method which is sensitive to sample size. The smaller the sample, the greater the uncertainty associated with the estimate.

²² Canopy cover per subwatershed measures the canopy cover as a proportion of the subwatershed area.

²³ Relative canopy cover change per subwatershed is the percentage of canopy cover gain or loss since 2009.

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Current Conditions (2012-2021)		Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Lower Humber: 20.9% (±1.6%)		Lower Humber: +0.5%	
Black Creek: 18.3% (±1.7%)		Black Creek: +2.2%	
Water Quality²⁴			
% of samples meeting water quality objective		% more (+) or less (-) samples meeting water quality objective in 2016-2021 (current subset) compared to 2006- 2011 (baseline subset)	
Total suspended solids (CWQG objective = 30 mg/L)	Main, East and West Humber: 83% Lower Humber and Black Creek: 80%	Main, East and West Humber: +1% Lower Humber and Black Creek: -2%	Conventional pollutants: Levels of conventional pollutants in the Main, East and West Humber subwatersheds (Total Suspended Solids, Chloride, Total Phosphorus, Nitrate and Un-ionized Ammonia) meet more stringent PWQOs or Federal Water Quality Guidelines for at least 85% of the samples, and for the Lower Humber and Black Creek subwatersheds for at least 75% of the samples
Chloride (CWQG objective, chronic = 120)	Chronic Main, East and West Humber: 65%	Chronic Main, East and West Humber: -15%	

²⁴ The current conditions assessment for water quality parameters is based on 11 stations during the period from 2012-2021. Even though several parameters met targets when all stations/samples were pooled in the watershed (for the current time period), there were individual stations that did not meet targets suggesting location-specific sources of contaminants. Comparison between the baseline and current periods was based on a subset of 6 years from 9 water quality stations (from 2006-2011 for baseline and from 2016-2021 for current) due to data availability and this comparison should not be used to assess trends (exceedances were calculated on a subset of samples and the exceedance results differ if the entire current dataset is used). Samples with detection limits above water quality guidelines and objectives could not be included in the analysis. The comparison between baseline and current periods is shown as a percentage (“+/-” indicates “more/less” samples met the objective in 2016-2021).

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
mg/L, acute = 640 mg/L)	Lower Humber and Black Creek: 16%	Lower Humber and Black Creek: -3%	
	Acute	Acute	
	Main, East and West Humber: 99%	Main, East and West Humber: -1%	
	Lower Humber and Black Creek: 73%	Lower Humber and Black Creek: -7%	
Total phosphorus (PWQO objective = 30 µg/L)	Main, East and West Humber: 45%	Main, East and West Humber: +1%	
	Lower Humber and Black Creek: 30%	Lower Humber and Black Creek: -5%	
Nitrates (CWQG objective = 2.93 mg/L)	Main, East and West Humber: 99%	Main, East and West Humber: -2%	
	Lower Humber and Black Creek: 100%	Lower Humber and Black Creek: +2%	
Un-ionized Ammonia (PWQO objective = 0.02 mg/L)	Main, East and West Humber: 99%	Main, East and West Humber: No change	
	Lower Humber and Black Creek: 94%	Lower Humber and Black Creek: -2%	
Copper (PWQO objective = 5 µg/L)	Entire watershed: 90%	Entire watershed: +8%	Heavy metals and organic contaminants: Levels of heavy metals and organic contaminants meet more stringent of PWQOs or Federal Water Quality Guidelines at least 90% of the time
Iron (PWQO objective = 300 µg/L)	Entire watershed: 49%	Entire watershed: +4%	
Zinc	Entire watershed: 90%	Entire watershed: +9%	

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	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002-2011) and Current (2012-2021)	Target from 2008 HRWP ⁶ (if applicable)
(PWQO objective= 20 µg/L)			
Lead	Entire watershed: 97%	Entire watershed: +26%	
(PWQO objective= 5 µg/L)			
Chromium	Entire watershed: 99%	Entire watershed: +3%	
(PWQO objective= 8.9 µg/L)			
Cadmium	Entire watershed: 79%	Entire watershed: +6%	
(PWQO objective= 0.5 µg/L)			
Nickel	Entire watershed: 100%	Entire watershed: no change	
(PWQO objective= 25 µg/L)			
Escherichia coli	Main, East and West Humber: 56%	Main, East and West Humber: +13%	Bacteria: Bacteria levels in the Main, East and West Humber subwatersheds meet PWQO – 100 coliforms/100 mL more than 60% of the time
(PWQO objective= 100 CFU / 100 mL)	Lower Humber and Black Creek: 21%	Lower Humber and Black Creek: +9%	
			Bacterial levels in the Lower Humber and Black Creek subwatersheds meet PWQO – 100 coliforms/100 mL more than 50% of the time
Dissolved oxygen	99%	-2%	NA
(PWQO objective= 6 mg/L)			
Natural Hazards			

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	Current Conditions (2012–2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Flooding (peak flows) ²⁵	Based on 100-year²⁶ inflow at points for each of the seven FVCs:	Based on change from baseline period:	Maintain or reduce existing peak flows for 2-to-100-year return period events
	Albion Road FVC West Tributary: 223.1 m ³ /s	-4.7% to +0.1%	Reduce or maintain baseline number of flood vulnerable areas and roads (based on most recent update to TRCA database)
	Albion Road FVC East Tributary: 189.1 m ³ /s	+7.8% to +2.6%	
	Albion Road FVC Southwest Tributary: 77.8 m ³ /s	+1.2% to 0.0%	
	Bolton Core FVC West Tributary: 45.6 m ³ /s	-0.2% to +0.9%	
	Bolton Core FVC North Tributary: 48.0 m ³ /s	-0.3% to +0.5%	
	Edgeley/Vaughan Centre FVC Tributary: 20.6 m ³ /s	+1.8% to +3.3%	
	Jane/Wilson FVC Tributary: 118.9 m ³ /s	+7.4% to +1.7%	
	Lake Wilcox FVC at Lake Wilcox: 13.7 m ³ /s	+17.7% to +1.5%	
	Lake Wilcox FVC at Yonge St.: 5.0 m ³ /s	+7.9% to -1.0%	

²⁵ Peak flow results are based on the three land use datasets (2002, 2012, and 2020).

²⁶ 100-year refers to a rainfall event that statistically has a one percent chance of occurring in any given year, at any given place. A 100-year storm does not mean that it will only occur once every 100 years.

HUMBER RIVER WATERSHED CHARACTERIZATION REPORT

	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
	Lake Wilcox FVC at Regatte Ave.: 9.4 m ³ /s	+13.8% to -0.7%	
	Lake Wilcox FVC at Humberland Dr.: 13.1 m ³ /s	+5.6% to 0.0%	
	Lake Wilcox FVC at Bathurst St.: 21.4 m ³ /s	+16.9% to -0.5%	
	Rockcliffe FVC: 226.2 m ³ /s	+1.1% to +0.2%	
	Woodbridge FVC West Tributary: 101.4 m ³ /s	-0.1% to +0.8%	
	Woodbridge FVC East Tributary: 65.5 m ³ /s	+17.0% to -3.0%	
Developed / undeveloped land uses in regulatory flood plain	679 ha of developed land use and 8,254 ha of undeveloped land use in the regulatory flood plain	N/A	N/A
Erosion sensitive stream reaches	See Section 2.4.2 Erosion Risk for details		Channel morphology: Maintain or restore natural channel structure and rates of morphological change (baselines to be established for RWMP sites) Erosion indices and stream flow regime: Maintain or restore pre-development erosion indices and stream flow regime (based on long-term stream gauge measurements and additional gauges recommended for installation)

HUMBER RIVER WATERSHED CHARACTERIZATION REPORT

	Current Conditions (2012-2021)	Trend Assessment (% change) Between Baseline (2002–2011) and Current (2012–2021)	Target from 2008 HRWP ⁶ (if applicable)
Erosion hazard sites (actively monitored) ²⁷	2,931 inventoried erosion control structures (inventoried in 2012 and 2015 to 2017) 603 infrastructure hazard monitoring sites (within Region of Peel and Region of York) 281 TRCA-owned or managed erosion control structures	N/A ²⁸	Risk to public and private property from channel erosion/evolution: Reduce or eliminate infrastructure, buildings and other property at risk (database of existing infrastructure and properties at risk to be developed)
Stormwater Management			
Stormwater management facilities ²⁹	178 wet/dry stormwater ponds (as of 2020)	Increase from 162 facilities in 2012	Increase portion of urban area with stormwater quantity, quality and erosion controls.
Restoration Planning			
Completed restoration projects	1,281 restoration projects completed by TRCA and municipalities	Increase from 388	Priority subwatershed regeneration plans/areas were identified for restoration work (including priority regeneration actions), but no targets were set

²⁷ The erosion hazard site data was not collected as a full sweep inventory at different time intervals, but rather completed as funding drove monitoring priorities. Therefore, the erosion control structure inventory data collected for each of the most recent inspections is assumed to be indicative of current conditions within the watershed.

²⁸ Erosion hazards were not analyzed across the watershed for the baseline period. The number of inspections of erosion control structures and inventoried sites fluctuates year-to-year based on funding provided through municipal partnership programs.

²⁹ The stormwater management analysis did not hold the urban area constant, which increased over the years considered in this assessment.

2.1 Water Resource System

The Water Resource System (WRS) is a system of groundwater areas (i.e., recharge areas, discharge areas) and surface water features (e.g., watercourses, inland lakes, wetlands), and their hydrologic functions. Hydrologic functions are the natural processes that provide the water needed to sustain healthy aquatic (i.e., water-based) and terrestrial (i.e., land-based) ecosystems and drinking water for humans. Understanding the state of these areas and features, as well as the conditions of aquatic habitat and other components (including natural cover in the riparian zone, ecohydrology, groundwater conditions, and streamflow) is important for watershed management due to the many ecosystem benefits provided by the WRS, including maintaining a stable water balance (i.e., flow of water in and out of the system), supporting biodiversity, the timing and duration of flows, and managing water quality.

As part of watershed characterization, the WRS components (key hydrologic areas and features), natural cover in the riparian zone, in-stream aquatic barriers, riverine fish community health, sensitive species habitat, estuary fish community health, benthic invertebrate community health, freshwater mussels, aquatic habitat quality, ecohydrology, groundwater conditions, and streamflow were assessed. The following sections provide more detailed information about each of these components of the WRS.

2.1.1 Water Resource System Components

The components of the WRS are defined by provincial policy as Key Hydrologic Areas (KHAs) or Key Hydrologic Features (KHF). KHAs include significant groundwater recharge areas (SGRAs), ecologically significant groundwater recharge areas (ESGRAs), significant surface water contribution areas (SSWCAs), and highly vulnerable aquifers (HVAs). KHF include inland lakes, wetlands, seepage areas and springs, and permanent/intermittent watercourses. [Section 8.0 Glossary](#) provides the definitions of all of these KHAs and KHF. See [Map 3](#) for a map of the KHAs and [Map 4](#) for a map of the KHF. [Table 6](#) outlines the area (in hectares) of the KHAs and KHF (inland lakes, wetlands, and seepage areas/springs in the watershed) and the percentage of the total watershed area, as well as the length of the regulated watercourses and headwater drainage features (in kilometres) and the percentage of the total watercourse/feature length in the watershed.

[Table 7](#) outlines the area (in hectares) of the KHAs and KHF (inland lakes, wetlands, and seepage areas/springs in the watershed) and the percentage of the total area of each area/feature within each subwatershed, as well as the length of the regulated watercourses and headwater drainage features (in kilometres) and the percentage of the total watercourse/feature length in each subwatershed.

Table 6 - Summary of WRS Component Area/Size and Watershed Coverage

	Area (ha) or Length (km) ³⁰	Watershed Coverage (%)
Key Hydrologic Areas		
Ecologically Significant Groundwater Recharge Areas (ESGRAs)	14,476 ha	16%
Significant Groundwater Recharge Areas (SGRAs)	42,355 ha	47%
Highly Vulnerable Aquifers (HVAs)	37,131 ha	41%
Significant Surface Water Contribution Areas (SSWCAs)	11,451 ha	13%
Key Hydrologic Features		
Inland Lakes	467 ha	1%
Wetlands ³¹	4,969 ha	6%
Seepage Areas and Springs	11,111 ha	12%
Permanent Watercourses	767 km	40%
Intermittent Watercourses	508 km	27%
Unknown Watercourses	621 km	33%
Headwater Drainage Features	416 km	NA

³⁰ Permanent, intermittent, and unknown watercourses, and headwater drainage features are summarized only in length by kilometers.

³¹ The wetlands area and percentage for the WRS (4969 ha and 6% of watershed) is slightly different from the wetland natural cover values provided in **Section 2.2.1** (4545 ha and 5% of watershed) for habitat quantity. This is because the wetland layer for the WRS is a more comprehensive and refined layer (and includes the TRCA Ecological Land Classification wetland layer, MNRF wetlands evaluated using the Ontario Wetland Evaluation System, restored wetlands, and the natural cover layer from 2017 orthophoto interpretation). The wetland natural cover values in **Section 2.2.1** include only the natural cover layer.

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Table 7 - Summary of WRS Component Area/Size and Subwatershed Coverage

	Area (ha) or Length (km) and Subwatershed Coverage (%) ³²				
	Main Humber	East Humber	West Humber	Lower Humber	Black Creek
Key Hydrologic Areas					
Ecologically Significant Groundwater Recharge Areas (ESGRAs)	7,982 ha (55%)	2,643 ha (18%)	3,116 ha (22%)	336 ha (2%)	399 ha (3%)
Significant Groundwater Recharge Areas (SGRAs)	22,018 ha (52%)	14,710 ha (35%)	5,627 ha (13%)	0 ha (0%)	0 ha (0%)
Highly Vulnerable Aquifers (HVAs)	20,834 ha (56%)	5,029 ha (14%)	4,938 ha (13%)	3,708 ha (10%)	2,622 ha (7%)
Significant Surface Water Contribution Areas (SSWCAs)	6,269 ha (55%)	2,440 ha (21%)	2,513 ha (22%)	145 ha (1%)	85 ha (1%)
Key Hydrologic Features					
Inland Lakes	210 ha (45%)	178 ha (38%)	66 ha (14%)	9 ha (2%)	5 ha (1%)
Wetlands	2,925 ha (59%)	1,237 ha (25%)	696 ha (14%)	90 ha (2%)	23 (0%)
Seepage Areas and Springs	5,712 ha (51%)	2,973 ha (27%)	1,487 ha (13%)	569 ha (5%)	370 ha (3%)
Permanent Watercourses	366 km (41%)	167 km (40%)	154 km (33%)	48 m (73%)	33 km (66%)
Intermittent Watercourses	185 km (21%)	120 km (29%)	202 km (43%)	1 km (1%)	0 km (0%)
Unknown Watercourses	348 km (39%)	132 km (31%)	108 km (23%)	17 km (25%)	17 km (34%)
Headwater Drainage Features (Intermittent and Unknown)	185 km (44%)	117 km (28%)	88 km (21%)	19 km (5%)	8 km (2%)

Of the KHAs, SGRAs and HVAs cover the largest percentage of the watershed at 47% and 41%, respectively, whereas ESGRAs cover 16% and SSWCAs cover 13%. Of the KHF's (measured by area), seepage areas and springs

³² Permanent, intermittent, and unknown watercourses, and headwater drainage features are summarized only in length by kilometers.

cover the most area at 12%, while wetlands and inland lakes cover much less of the watershed at 6% and 1%, respectively. Spatially, more than half of the aerial (ha) coverage of the KHAs and KHF's fall within the Main Humber subwatershed, except for inland lakes (45%). Most of the remaining aerial coverage of KHAs and KHF's is split between the East and West Humber subwatersheds, with the more urbanized Lower Humber and Black Creek subwatershed containing the least amount of aerial coverage of KHAs and KHF's. Similarly, most of the coverage of each KHA and KHF is within the Greenbelt (79% wetlands, 70% inland lakes, 76% seepage areas and springs, 72% SGRAs, 63% ESRAs, 67% SSWCAs, and 60% HVAs). Overall, this demonstrates the importance of the Greenbelt in conserving these features and areas as well as the likely impact of previous development practices. Of note, if the whitebelt is fully developed in the future (resulting in a loss of 3-12% of the coverage of these features and areas from the whitebelt), this would increase the amount of KHF's and KHAs (measured by area) within urban land use to 21-40%.

There are a total of 1896 km of regulated watercourses within the watershed and of these, 40% are classified as permanent watercourses, 27% as intermittent watercourses, and 33% as unknown watercourses (see [Map 4](#) for permanency classifications for the regulated watercourses). Unknown watercourses have not been given permanency classification due to data deficiency. Additional monitoring will be required within the watershed to characterize the permanency of these unknown segments of regulated watercourses. Spatially, watercourses with unknown permanency are distributed fairly evenly among the subwatersheds (23-39%), while the Lower Humber and Black Creek subwatersheds have the fewest intermittent watercourses (0-1%), and the West Humber subwatershed has the most intermittent watercourses (43%). The results in these subwatersheds are expected, given the extensive urban land use. However, it is possible that some of the unknown streams are intermittent and insufficient data has been collected to support intermittent classification. From a land use perspective, most of the watercourses are located in the Greenbelt (62%) and urban areas (26%), while 12% are in the whitebelt. If the whitebelt were to be entirely developed in the future, this would increase the percentage of watercourses affected by urban land use to 38%.

Headwater drainage features (HDFs) are ill-defined, non-permanently flowing drainage features that may not have defined beds and banks. Of the 416 km of HDFs in the watershed, 52 km (12%) are intermittent and 364 km (88%) are of unknown permanency, meaning they may be permanent, intermittent, ephemeral, or not a feature. None of the potential HDFs were classified as permanent based on available data. Many HDFs are mapped on private land and do not cross the roads where HDF sampling took place. This made confidently characterizing these features difficult, which resulted in the large percentage of potential HDFs with unknown permanency. The majority of the HDFs are located in the Main Humber, East Humber, and West Humber subwatersheds (44%, 28%, and 21%, respectively). As with the whole watershed, 78-100% of the HDFs in each subwatershed and land use type have unknown permanency. The Lower Humber and East Humber subwatersheds have the largest percentage of intermittent HDFs (22% and 20%, respectively). As expected, the majority of the HDFs are in the Main Humber subwatershed (44%) and the Greenbelt (64%), as these are the largest and most natural parts of the watershed. Currently, 20% of HDFs are in areas of urban land use and 16% are in the whitebelt region of the watershed. As with the watercourses, converting the whitebelt to urban land use would increase the percentage of HDFs affected or lost due to urban development to 36%. See [Map 5](#) for the location and classification of potential HDFs in the watershed.

The regulated watercourses and HDFs were also classified as having Important, Valued/Contributing, or Limited/Recharge hydrology functions (see [Section 8.0 Glossary](#) for definitions) based on the HDF classification guidelines prepared by Credit Valley Conservation and TRCA (Credit Valley Conservation & TRCA 2014). In general, features that were classified as permanent were classified as having important hydrology functions. Features that were classified as intermittent were classified as having valued or contributing hydrology functions. Lastly, features that were classified as unknown permanency, were classified either as valued/contributing or limited/recharge, using wetlands and groundwater data to aid classification.

Of the total 1896 km of regulated watercourses, 767 km (40%) were found to have important hydrology functions, 942 km (50%) have valued/contributing functions, and 188 km (10%) have limited/recharge functions. In addition, 46% of the watercourses within the Greenbelt have important hydrology functions and 47% have valued/contributing functions. Similarly, in areas of urban land use, 41% and 46% of watercourses have important and valued/contributing functions, respectively. In the whitebelt region, only 10% of watercourses are classified as important and the majority (73%) are valued/contributing. This is due to the larger percentage of streams within the whitebelt that are intermittently flowing. See [Map 6](#) for a map of the watercourses and their hydrology function classifications.

Of the 416 km of HDFs, 253 km (61%) have valued or contributing functions and 163 km (39%) have limited or recharge functions. No HDFs were permanent features and were therefore not classified as having important hydrology functions. As with the watercourses, the majority of HDFs in the Greenbelt and urban areas have valued/contributing hydrology functions (66% and 60%, respectively). However, in the whitebelt region, 60% of HDFs have limited/recharge functions. See [Map 6](#) for a map of the HDFs and their hydrology function classifications.

Targets and Progress from 2008 HRWP

Targets for aquatic habitat were identified in the 2008 HRWP. Of these targets, one applies to the WRS: increase wetland cover to 10% of the total watershed area. As of 2022, this target has not been met as wetlands only cover approximately 6% of the total watershed area.

The following subsections characterize other related components of the WRS that support aquatic habitat and biodiversity, including riparian cover, in-stream aquatic barriers, riverine fish community health, sensitive species habitat, estuary fish community health, benthic invertebrate community health, freshwater mussels, aquatic habitat quality, ecohydrology (hydrology related to aquatic ecosystems), groundwater conditions, and streamflow.

2.1.2 Riparian Cover

The riparian zone is the transition area between terrestrial and aquatic ecosystems and is found along riverbanks, ponds, and lakes. The riparian zone is the corridor that follows the meander of a river and is comprised of vegetation that grows in the corridor. This vegetation plays an important role in the health of aquatic systems as it provides shade to streams which can reduce water temperature, filters out contaminants and sediment, and provides nutrients, detritus, and woody debris to support the habitat and organisms in the river (Gregory et al. 1991, Environment Canada 2013, and Riis et al. 2020). The riparian zone is defined based on the meander belt, bankfull width, and stream order (see [Section 6.1.2 Riparian Cover](#) for more details on

methodology). See [Table 8](#) for a breakdown of the amount (%) of the riparian zone that is natural cover, with a breakdown of four natural cover types, the amount of area in the riparian zone with no natural cover, and total area (in hectares) within the riparian zone. The results are presented at the watershed and subwatershed scale for the current time period (2020).

Table 8 - Percent Natural Cover within Riparian Zone at the Watershed and Subwatershed Scale (2020)

	% Natural Cover by Habitat Type				% Natural Cover	% No Natural Cover	Total Area (ha)
	Beach / Bluff	Forest	Meadow	Wetland			
Watershed	0.0%	29.7%	11.2%	19.4%	60.3%	39.7%	12,403
Main Humber	0.0%	33.7%	10.2%	24.0%	68.0%	32.0%	5,931
East Humber	0.0%	28.9%	13.2%	18.4%	60.6%	39.4%	2,767
West Humber	0.0%	20.9%	12.0%	14.3%	47.2%	52.8%	2,921
Lower Humber	0.0%	36.5%	6.2%	7.7%	50.5%	49.5%	478
Black Creek	0.0%	33.1%	12.7%	4.1%	49.9%	50.1%	306

Natural cover makes up 60.3% (12,403 ha) of the riparian zone at the watershed scale. As shown in [Table 8](#), of the riparian zone that supports natural cover (60.3%), 29.7% is forest cover, 11.2% is meadow cover, and 19.4% is wetland cover. The Main Humber (5,931 ha), West Humber (2,921 ha), and East Humber (2,767 ha) subwatersheds contain the largest area of riparian zone and the lowest amounts were observed in the Lower Humber (478 ha) and Black Creek (306 ha) subwatersheds. At the subwatershed scale, natural cover makes up a larger portion of the riparian zone in the upper reaches of the Main and East subwatersheds (68.0% and 60.6%, respectively), compared to the Lower Humber (50.5%), Black Creek (49.9%), and West Humber (47.2%) subwatersheds.

The amount of riparian cover was also evaluated at the catchment scale (a finer scale than subwatershed). There are 24 catchments in the Humber River watershed (delineated in the 2008 HRWP). The total riparian area at the catchment scale ranges from 1680 ha in the Main – Upper catchment to 19 ha in the Emery Creek catchment. The amount of natural cover is variable across the catchments with a maximum of 79.1% in the Centreville Creek catchment and 29.2% in Albion Creek catchment.

A temporal assessment of the amount of wetland cover among periods was not possible due to methodological differences between time periods. In the current period, the amount of wetland natural cover was evaluated based on orthophotography, field mapping, and mapping of restored and regulated wetlands, whereas in the baseline period, wetlands were mapped based solely on orthophotography. However, wetlands could not be excluded from the assessment of total natural cover in the riparian zone between time periods.

Comparing the amount of natural cover in the riparian zone over time reveals a loss in forest (-6.2%) and meadow cover (-5.9%) at the watershed scale between the baseline and current period. A gain in wetland cover (12.2%) was observed but cannot be confirmed due to methodological differences between time periods (as discussed above). Losses in forest cover at the subwatershed level range from 9.8% in the Main Humber subwatershed to 0.3% in the West Humber subwatershed. Losses in meadow cover range from 9.6% in the Black Creek subwatershed to 4.5% in the East Humber subwatershed.

Similar temporal trends are observed at the catchment scale, where most catchments demonstrated a loss of natural cover in the riparian zone from the baseline to current period (-8.8% to +2.7%). Forest loss in the riparian zone occurred in 66% of catchments and loss of meadow cover occurred in 100% of catchments between the two time periods.

Targets and Progress from 2008 HRWP

The 2008 HRWP identified two targets related to riparian cover in the watershed including: 1) Greater than 75% of riparian areas/zone should contain natural cover (60% forest or successional and 15% meadow or wetland); and, 2) increase wetland cover to 10% of total watershed area. The targets have largely not been met. The total coverage of natural cover in the riparian zone in the watershed is 60.3% (less than the 75% target), with just 29.7% forest cover (less than the 60% forest cover target). However, the amount of meadow cover (11.2%) and wetland cover (19.4%) in the riparian zone approaches and exceeds the meadow/wetland target of 15%. The total amount of wetland coverage in the watershed is 6.0% and falls short of the 2008 target of 10%, with the Black Creek (4.1%) and Lower Humber (7.7%) subwatersheds having particularly low levels of wetland cover in the riparian zone.

2.1.3 In-stream Aquatic Barriers

Aquatic barriers such as dams, weirs, and channelizing structures under road crossings (e.g., culverts) pose a significant challenge for fish to complete their life cycles (Jones et al. 2021). Fish barriers can impact movement among seasonal habitats (e.g., spawning and overwintering), as well as limit foraging and mating opportunities. For migratory species, barriers can eliminate access to spawning areas. Ultimately, barriers to fish movement reduce the total amount of accessible habitat to a species (Choy et al. 2018).

In the current period, 128 fish barriers have been identified based on informal surveys of the watershed. A total of 79 barriers are completely impassable to all species, 12 are passable to jumping species only (partially passable), and 37 are completely passable to all species (see [Map 7](#)). Of the impassable barriers, only three are considered natural (two beaver dams and one natural rock waterfall). The barrier assessment presented here relied on limited, haphazard field assessments undertaken over the past two decades along with a desktop analysis. To fully understand the extent and impact of barriers in the Humber River, a comprehensive, standardized, and watershed wide barrier assessment is recommended.

A total of 37 barriers have been mitigated in the watershed since 2008 (based on available information), which changes the passability of these structures from impassable to fully passable by all species. For example, two barriers located in Albion Hills Conservation Area (at Taylor Pond and Main Pond) were removed by 2017. Mitigated barriers were spread across the watershed with 26 in the Main Humber, eight in the West Humber, and three in the East Humber. [Map 7](#) shows the mitigated or removed barriers in the watershed.

In addition to barriers, the permanency of streamflow in the stream network affects fish passage and ecosystem connectivity (see [Map 7](#) for watercourse permanency). In stream segments where permanent barriers are found, 51 barriers are associated with permanent flow, 12 barriers are associated with intermittent flow, and stream flow is unknown at 16 barriers. All 12 barriers that have partial passability (jumping species only) are found in stream segments with permanent flow. Of the mitigated structures which have become fully passable, 36 structures are associated with permanent flow and flow is unknown at one structure.

Not all barriers in the watershed are undesirable. Two fishways located in the Lower Humber subwatershed were designed to facilitate the movement of migratory and resident fish species into the Main Humber subwatershed and create barriers for undesirable and invasive species such as Sea Lamprey (*Petromyzon marinus*) and Round Goby (*Neogobius melanostomus*). Despite the fishways in the Lower Humber, no migratory species have been observed in the West Humber or Black Creek subwatersheds due to other impassable barriers in those systems that have not been mitigated (e.g., Claireville Dam in the West Humber). Migratory species have been observed in the East Humber subwatershed; however, no formal assessment has occurred to characterize the amount, timing, or extent of species migration in the subwatershed.

Targets and Progress from 2008 HRWP

The 2008 HRWP identified one target for in-stream barriers: only strategic in-stream barriers remain (barriers removed/mitigated in priority sequence as identified in the 2008 HRWP). Despite restoration and mitigation efforts (including mitigation of 37 barriers since 2008), the 2008 target to reduce the number of barriers in the Humber River to only those identified for strategic species management (e.g., Sea Lamprey control) has not been met.

2.1.4 Riverine Fish Community Health

A diverse fish community is a good indicator of a healthy aquatic ecosystem. For example, fish species presence and community diversity can be used as indicators of ecosystem health because they are often associated with environmental parameters, such as water quality, water quantity, water temperature, and sediment/erosion. Specifically, changes in the number of species over time can be used as an indicator of the quantity and quality of habitat in an ecosystem.

Fish Species Presence

In the current time period, 71 fish species were captured in the Humber River of which 59 are native and 12 are invasive or naturalized. All non-invasive species captured during the baseline period were captured, or presumed present, in the current period (2012-2022), suggesting no loss of species diversity over the last two decades. Of note, Blacknose Shiner (*Notropis heterolepis*) were captured in the East Humber subwatershed in 2022, and this is the first time the species has been observed since 1972. Species presumed present, but not captured in the current period, include Longnose Gar (*Lepisosteus osseus*), Trout-perch (*Percopsis omiscomaycus*), and Yellow Bullhead (*Ameiurus natalis*). Blackside Darter (*Percina maculata*) is locally rare in the watershed and have only been captured at one regional monitoring site. Due to land access issues, this site has not been monitored since 2010. However, no obvious land-use changes have occurred near the site and Blackside Darter are presumed to be present (the species has been caught recently (2019 and 2021) in small numbers in the Lower Humber at Sea Lamprey traps). The remaining non-detected species are either transient, lake-based species (e.g., Longnose Gar) or utilize habitats that are not targeted in TRCA's monitoring program. Five species were captured in the current period that were not seen in the baseline period but are considered native to the watershed (Atlantic Salmon - stocked; *Salmo salar*), Channel Catfish (*Ictalurus punctatus*), Lake Chub (*Couesius plumbeus*), and Threespine Stickleback (*Gasterosteus aculeatus*). The return of Atlantic Salmon in the Humber River is a result of stocking efforts to restore the species. Black Bullhead (*Ameiurus melas*) were captured in the watershed for the first time in 2014 by the Royal Ontario Museum; however, it is presumed the

species was always present and mis-identified as Brown Bullhead (*Ameiurus nebulosus*) which may have limited past detections.

During the baseline period (2002-2011), a total of 64 fish species were detected in the Humber River, of which 10 were invasive or introduced. Coho salmon (*Oncorhynchus kisutch*) were not detected in the baseline period; however, this may be a sampling artifact related to program timing and methods (e.g., no fall migration surveys or spring smolt surveys) as opposed to being absent in the watershed. Other primarily lake-based species not detected in the baseline period are assumed to be present and their absence in the dataset is due to their transient use of the Humber River (e.g., Channel Catfish, Lake Chub, Threespine Stickleback, and Longnose Gar). Yellow Bullhead were not detected during the baseline period, but identification of this species from congeners is difficult and it is presumed they are still present in the watershed.

A total of 72 fish species were documented in the Humber River during the historical period (pre-2002; based on a revised species list). Sixty-four of these species were considered native to the Humber River and eight were considered non-native (i.e., invasive species such as Common Carp (*Cyprinus carpio*) or introduced such as Rainbow Trout (*Oncorhynchus mykiss*)). Fallfish (*Semotilus corporalis*), Finescale Dace (*Phoxinus neogaeus*), Northern Brook Lamprey (*Ichthyomyzon fossor*), and River Darter (*Percina shumardi*) were included in past accounts of the historical fish community of the Humber River watershed (TRCA 2005, TRCA 2008a); however, those occurrences are now considered erroneous and are not presented here. Two species were lost between the historical and baseline period as previously reported by TRCA (Blackchin Shiner (*Notropis heterodon*) and Blacknose Shiner, TRCA 2008b). Atlantic Salmon were extirpated from the watershed in 1896.

Silver Lamprey

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reported that one Silver Lamprey (*Ichthyomyzon unicuspis*) was detected in the Humber River Sea Lamprey control program in 2006 (COSEWIC 2020). Several TRCA monitoring programs continue to report infrequent captures of the *Ichthyomyzon* genus (which includes both Silver and Northern Brook lamprey). It is probable that the historic and current reports of Northern Brook Lamprey in the Humber River are in fact Silver Lamprey (E. Holm and D. Lawrie *p.comm.* 2022) or mis-identified American Brook (*Lampetra lamottei*) or Sea Lamprey, both of which are present in the watershed. No voucher specimens exist to verify the species and therefore all lamprey captures from the historic to current time period not definitively identified as American Brook or Sea Lamprey have been re-classified to the family level (Petromyzontidae). In the Great Lakes region, Silver Lamprey are designated as special concern.

Invasive Species

Four invasive species (not including naturalized species e.g., Coho) were consistently captured in both the baseline and current time periods (Common Carp, Goldfish (*Carassius auratus*), Round Goby, and Rudd (*Scardinius erythrophthalmus*)). Round Goby and Rudd were first detected during the baseline period (but were not present prior to 2008) and their continued presence demonstrates these invasive species have become established. Importantly, Round Goby have not been captured at RWMP sites above the Mill Dam as of 2022. Two additional exotic species were detected in the Humber River in the current period, although one, Tench (*Tinca tinca*), discovered in the watershed in 2014, has since been eradicated by the Ministry of Natural Resources and Forestry (MNR) (D. Lawrie *p.comm.*, 2022). One Weather Loach (*Misgurnus anguillicaudatus*) was captured in 2014 in Bond Lake.

Target Fish Species

An important target of the 2008 HRWP was to maintain or restore the historical distribution of “target” fish species in each catchment area. Target fish species included Brook Trout (*Salvelinus fontinalis*), Rainbow Darter (*Etheostoma caeruleum*), Rainbow Trout, and Redside Dace (*Clinostomus elongatus*). Several additional species were considered for target management in the Humber River Fisheries Management Plan (TRCA 2005) including Atlantic Salmon, Blackside Darter, and Smallmouth Bass (*Micropterus dolomieu*). The distribution of each of these target species is discussed below.

Brook Trout are a coldwater, sensitive species that require groundwater upwellings, clear water, and clean gravelly substrates to complete their lifecycle. Over the last three decades, the distribution of Brook Trout appears to have declined throughout the TRCA jurisdiction and across Ontario (Haxton et al. 2019). Despite the broader regional decline, the distribution of Brook Trout has been maintained across all three time periods at most RWMP sampling sites; however, the species is now restricted to the headwaters in the Main Humber subwatershed. Brook Trout were captured in Purpleville Creek (East Humber subwatershed) during the historical period using non-standard sampling methods, and during the baseline period as part of the RWMP. The absence of Brook Trout in Purpleville Creek at RWMP sites in the current time period may be due to a combination of low abundance and sampling methodology (i.e., the Ontario Stream Assessment Protocol without block nets). In 2020 and 2021, additional monitoring sites revealed that populations of Brook Trout persist in the western most reaches of the Main Humber subwatershed. The Ontario Ministry of Northern Development, Mines, and Natural Resources has stocked Brook Trout in several lakes and tributaries of the Main Humber subwatershed to restore and maintain natural populations as well as to support “put-grow-take” recreational fisheries.

The distributions of Blackside Darter and Rainbow Darter have been maintained between the baseline and current periods. The distribution of Smallmouth Bass has expanded in the current period and the species is now found at two sites above the Mill Dam in the West Humber subwatershed. Rainbow Trout are an important introduced and naturalized sportfish and they continue to be found throughout the Lower, Main, and East Humber subwatersheds.

Redside Dace (discussed further in [Section 2.1.5 Sensitive Species Habitat](#)) are a small, brightly coloured minnow that occupy small, cool water streams within riffle-pool areas that have a mix of surrounding forest and meadowlands with abundant overhanging vegetation. The presence of Redside Dace in a watercourse is strongly linked to stream flow and water quality, which can be impacted in urban and agricultural watersheds. Redside Dace have declined throughout TRCA’s jurisdiction over the past two decades (COSEWIC 2017) and are listed as endangered under provincial and federal legislation. The distribution of Redside Dace observed at RWMP sites has declined from the historical and baseline period to the current time period. The species was not captured in the Main Humber subwatershed in the current period and are primarily restricted to tributaries of the East and West Humber. Redside Dace continue to occupy at least one tributary in the East Humber subwatershed based on additional sampling efforts in 2020 and 2021. Sampling permit and land access restrictions have prevented surveys at occupied sites in the East Humber River from 2007 to 2019 so their continued presence at RWMP sites in these tributaries is unknown. See [Section 2.1.5 Sensitive Species Habitat](#) for a detailed discussion of Redside Dace habitat needs and regulated habitat. The change in distribution of Redside Dace should be considered relative to their historically occupied distribution as shown in [Map 8](#). That is, a finding of “absent” at

a site outside of the regulated habitat (historically or currently occupied) should not necessarily be considered a reduction in the species range.

As part of the Lake Ontario Atlantic Salmon Restoration Program, Atlantic Salmon have been stocked in the headwaters of the Main Humber subwatershed since 2008. From 2008 to 2021, there have been 523,418 fish and 396,775 eggs stocked by a number of agencies and partners (the Ontario Ministry of Northern Development, Mines, and Natural Resources, Ontario Streams, the Ontario Federation of Anglers and Hunters, Fleming College, Islington Sportsman Club, and the Belfountain Hatchery; B. Teskey. *p.comm* 2022). Relatively few stocked Atlantic Salmon have been observed through TRCA monitoring: three adults have been captured below the Old Mill Dam, and a total of 16 juveniles have been captured in the headwaters of the Main Humber subwatershed from 2013 to 2022. However, adult returns to the river are not monitored during the spawning migration and the exact number of returning individuals is unknown. Over a decade of stocking has not produced a self-sustaining population of Atlantic Salmon in the Humber River, suggesting factors such as overwintering conditions, trophic conditions in Lake Ontario such as competition with non-native salmonids, and barriers to fish movement have not improved enough to support the species in the watershed.

Fish Community Health – IBI Scores

The presence or absence of a diverse fish community at a site is an indicator of ecosystem health. A diverse fish community is related to good water quality and water quantity, thermal regimes within the natural tolerance of species, and natural levels of sediment/erosion. Fish community health is assessed using a health index known as the IBI (Index of Biotic Integrity), which measures the number of fish species, presence of sensitive species, species abundance, and food chain classifications to assign a rating from ‘poor’ to ‘very good’ to a site. Higher values indicate healthier fish communities (Steedman 1988). Only data collected through TRCA’s RWMP are included in the assessment of IBI and, thus, the analysis is limited to the baseline and current time periods. Additional sites surveyed using the RWMP protocol in 2020 and 2021 have only one year of sampling effort, and thus these sites were not included in the assessment of temporal trends in IBI.

Table 9 provides the results of mean site IBI ratings averaged across the watershed and subwatershed for the current and baseline time period. **Map 9** presents the mean IBI health ratings for fish communities at RWMP sites.

Table 9 - Mean Index of Biotic Integrity Ratings

	Average IBI Rating		Trend ³³
	Baseline (2002-2011)	Current (2012-2021)	
Watershed	29.3 (Good)	28.8 (Good)	No change
Main Humber	26.8 (Fair)	24.9 (Fair)	Decrease
East Humber	29.3 (Good)	28.8 (Good)	No change
West Humber	26.7 (Fair)	26.7 (Fair)	No change

³³ Assessed at the $p < 0.05$ level of statistical significance (to determine trends beyond a reasonable doubt).

	Average IBI Rating		Trend ³³
	Baseline (2002-2011)	Current (2012-2021)	
Lower Humber	17.5 (Poor)	19.1 (Poor)	No change
Black Creek	14.5 (Poor)	17.5 (Poor)	No change
Rating Scale: ≤20 (Poor), 20-27.9 (Fair), 28-37.9 (Good), ≥38 (Very Good)			

At the watershed scale, the mean IBI score in the current period is at the lower end of the ‘good’ rating (28.8) which is consistent with findings from the baseline period (29.3 rating - ‘good’; [Table 9](#)). This suggests that, at the watershed scale, the fish community is in good health. However, there are large differences in fish community health between the northern rural areas and the southern urbanized areas in the watershed. At the subwatershed scale, two subwatersheds are rated as ‘poor’ (Lower Humber and Black Creek), two are rated as ‘fair’ (Main and West Humber), and one (East Humber) is rated as ‘good’. Black Creek and the Lower Humber subwatersheds have the lowest benthic invertebrate community health scores (see [Table 12](#)) and the highest level of impervious cover (see [Table 13](#)) which aligns with a finding of ‘poor’ fish community health in the current period.

At the watershed and subwatershed scale, only the Main Humber subwatershed demonstrated a detectable change in IBI score between the baseline and current period. While the average IBI score declined between the two time periods in the Main Humber, the community rating is still considered to be ‘fair’ (26.8 to 24.9; [Table 9](#); [Map 9](#)).

In 2020 and 2021, seven and 12 additional sites were surveyed, respectively, to expand the spatial coverage of fish community surveys in the watershed. IBI scores in 2020 and 2021 show that fish communities in “poor” health occur in the northern range of the East, Main, and West Humber subwatersheds and that “good” condition sites were concentrated in the central areas of the subwatersheds (see [Map 9](#)). These sites represent only a single year of data collection and generalizations cannot be made; however, a finding of “poor” fish community health in the northern reaches of the watershed can be considered a cause for concern.

Overall, the average health of fish communities in the Humber River is relatively stable with a tendency towards a decline (although this cannot be statistically verified).

Targets and Progress from 2008 HRWP

A number of targets for fish community health and invasive/exotic species were identified in the 2008 HRWP. The targets and progress made to achieve these targets are outlined below.

An important target from the 2008 HRWP was to maintain or restore the historical distribution of “target” fish species in each catchment area. Target fish species included Brook Trout, Rainbow Darter, Rainbow Trout, and Redside Dace (discussed above). Several additional species were considered for target management in the Humber River Fisheries Management Plan (TRCA 2005) including Atlantic Salmon, Blackside Darter, and Smallmouth Bass. Overall, this 2008 HRWP target has largely been met, with important exceptions outlined above.

The target of preventing the introduction of any new invasive or exotic species was not met with the successful establishment of two invasive fish species (Round Goby and Rudd) during the baseline period (but after the 2008

HRWP). One additional invasive species (Weather Loach) was captured in 2014 in Bond Lake, but it is unclear whether this species has become established.

The 2008 HRWP identified two fish community health targets for the watershed based on the degree of urbanization: 1) Fish communities in the undeveloped, northern rural areas (upstream/north of Highway 407) should be rated as 'good' based on IBI scores; and, 2) Fish communities in the developed, urban areas in the southern portion of the watershed (downstream/south of Highway 407) should maintain or improve over baseline conditions (typically 'fair' or 'poor'). Measures of fish community health did not meet the target of all sites in 'good' condition in the undeveloped, rural areas in either the baseline (2001-2011) or current (2012-2021) period. Several sites in the urban area of the watershed have demonstrated a decrease in fish community health score from 'fair' to 'poor' (but not beyond a reasonable doubt). Fish communities overall in the southern, urban area largely maintained 'poor' or 'fair' condition between the baseline and current time period, meeting the 2008 target.

2.1.5 Sensitive Species Habitat

Redside Dace

Redside Dace are a small minnow species that are associated with small tributaries (5-10 m wide) that have cool, clear water and accessible pool habitat (11-100 cm in depth; COSEWIC 2017; Department of Fisheries and Oceans Canada (DFO) 2019). Threats to the persistence of the species include residential/commercial development, agriculture, pollution, natural system modifications, and invasive species (DFO 2019). Redside Dace are highlighted in this report as an indicator species because of their endangered status provincially and federally, restricted range, and sensitivity to urbanization (MNRF 2016). The presence of Redside Dace is negatively correlated with increasing amounts of impervious cover which is a measure of urbanization (Poos et al. 2012). As the amount of impervious cover increases in Redside Dace occupied areas, important habitat features are altered or lost including riparian cover, flow regimes, streambed form, nutrient and stormwater inputs, and the disruption of headwater features (COSEWIC 2017).

As a provincially listed endangered species, Redside Dace habitat is regulated by the Ontario Ministry of the Environment, Conservation, and Parks (MECP). Regulated habitat includes both occupied and recovery reaches, where occupied reaches are those in which Redside Dace has been sited/captured within the last 20 years and recovery reaches are historically occupied (but not currently occupied) reaches that have a good chance of recolonization. Additionally, regulated habitat includes contributing habitat which is defined as important habitat elements near the occupied/recovery stream reaches and areas that are important for augmenting or maintaining baseflows, coarse sediment supply, and surface water quality (COSEWIC 2017). A decline in the distribution of Redside Dace at RWMP sites in the Humber River between the historical and current time period is discussed in [Section 2.1.4 Riverine Fish Community Health](#).

In this section, occupied and contributing habitat is designated as "potential" area to convey to readers that the mapping presented is a screening layer and not an official designation on whether a specific reach is occupied or recovery habitat. Official designation at the site level remains the responsibility of the MECP/DFO. [Table 10](#) and [Map 8](#) show the potentially occupied and potentially contributing habitat of Redside Dace in the Humber River watershed and subwatersheds summarized by natural cover type.

Table 10 - Potentially Occupied and Potentially Contributing Habitat of Redside Dace in Humber River Watershed (and Subwatersheds) by Natural Cover Type

Occupancy	Scale	Stream Length (km)	Natural Cover (ha) ³⁴	% Forest	% Meadow	% Wetland	Other Cover Type (ha)
Potentially Occupied	Watershed	211	4,000	81.6%	5.1%	13.4%	210
Potentially Contributing	Watershed	21	279	71.9%	11.8%	16.3%	27
Potentially Occupied	East Humber	96	1,708	86.3%	5.1%	8.7%	77
	Main Humber	39	1,472	81.7%	0.8%	17.5%	49
	West Humber	76	805	72.8%	11.3%	15.8%	84
Potentially Contributing	East Humber	5	136	87.4%	6.7%	5.9%	8.6
	Main Humber	0	0	0.0%	0.0%	0.0%	0
	West Humber	16	140	57.9%	15.4%	26.4%	18

In the current period, there is an estimated 4,000 ha of potentially occupied and 279 ha of potentially contributing habitat for Redside Dace in the Humber River watershed (4,279 ha total). Within the delineated area of natural cover, forest cover makes up the largest portion of potentially occupied habitat (81.6%) and potentially contributing habitat (71.9%), followed by wetland cover (13.4% and 16.3%, respectively), and meadow cover (5.1% and 11.8%, respectively) at the watershed scale.

At the subwatershed scale, identified potential habitat of Redside Dace is restricted to the East, Main, and West Humber subwatersheds. The East Humber provides the largest amount of potentially occupied habitat (1,708 ha), followed by the Main and West Humber (1,472 and 805 ha, respectively). The most potentially contributing habitat is found in the West Humber (140 ha) followed by the East Humber (136 ha) subwatersheds. There is no potentially contributing habitat in the Main Humber subwatershed. Consistent with results at the watershed scale, across all subwatersheds, forest cover comprises the largest portion of natural cover in potentially occupied habitats (72.8 – 86.3%) followed by wetland and meadows (8.7-17.5% and 0.8-11.3%, respectively). These values represent the percentage of each natural cover type within the meander belt width plus 30 m

³⁴ This represents the amount of natural cover associated with Ecological Land Classification (ELC) codes that align with the definition of regulated habitat for Redside Dace.

riparian area, plus areas of forest or wetland that form continuous habitat patches connected to the 30 m buffer (a total area of 4,279 ha) of potentially occupied and contributing habitat. Other cover types not associated with regulated Redside Dace habitat, including impervious cover, represent 237 ha of the total area within the meander belt width plus 30 m of riparian area.

Rapids Clubtail

Rapids Clubtail (*Phanogomphus quadricolor*) is a medium-sized, brightly coloured dragonfly that is found in the Humber River watershed. Dragonflies utilize aquatic and terrestrial habitats to complete their life cycle and spawning occurs over water. The species is associated with clear, cool, medium to large (20-50 m) sized rivers with gravel substrate and sand/silt pools (Environment and Climate Change Canada (ECCC) 2019). Adults, especially females and young males, are also associated with mixed forest and treed swamp habitat within 200 m of occupied aquatic habitat, and larvae are associated with muddy pools (ECCC 2019). The species, like many dragonflies, is an indicator of relatively healthy aquatic environments. Major threats to the species are not well established but are thought to include urbanization, water quality degradation (e.g., sedimentation, urban stormwater, and agricultural runoff, etc.) and loss of adjacent riparian and forest habitat (COSEWIC 2018).

Rapids Clubtail is listed as endangered under both provincial and federal legislation. However, the Committee on the Status of Species at Risk in Ontario (COSSARO) has recommended the species be downlisted to threatened based on its globally secure status (COSSARO 2022). Regulated habitat for the Rapids Clubtail in Ontario includes any part of a river, stream, or waterbody up to the high-water mark that is used by the species or on which it depends, and deciduous, mixed forest, or mixed tree swamp habitat that is adjacent to occupied or recovery habitat within 200 m of the high-water mark (ESA regulation 242/08). The regulation applies to all occupied and recovery habitat until five years of consecutive data demonstrates non-use by the species. Additionally, the Key Biodiversity Area (KBA) Canada Coalition has proposed that an area of 10.8 km², following the Humber River from Major Mackenzie Drive northwards along the Humber River to King Road (and including all of the Nashville Conservation Area) be designated as a national KBA for Rapids Clubtail. KBAs are those areas that are important to the persistence of a specific species or ecosystem and are unique or vulnerable. KBA delineation does not presume or determine required management actions or responses but is a tool for use during land-use planning and protected area planning.

Table 11 and **Map 10** show the potentially occupied and potentially contributing habitat of Rapids Clubtail in the watershed summarized by natural cover type.

Table 11 - Potentially Occupied and Potentially Contributing Habitat of Rapids Clubtail in Humber River Watershed by Natural Cover Type

Occupancy	Stream Area (ha)	% Natural Cover ³⁵	Natural Cover (ha) ³⁵	% Beach / Bluff	% Forest	% Meadow	% Wetland
Potentially Occupied	34	28.8%	81	<1%	26.7%	<1%	<1%
Potentially Contributing	258	21.9%	686	<1%	18.2%	<1%	2.7%

Identified potential habitat of Rapids Clubtail is restricted primarily to the Main Humber subwatershed, with a small area also found in the East Humber subwatershed (see [Map 10](#)). The known distribution of Rapids Clubtail in the Humber River is limited to the aquatic and riparian area surrounding the Nashville Conservation Reserve. However, dragonfly and exuviae (exoskeleton of larvae cast off at the time of emergence) surveys are not completed as part of the TRCA's long-term monitoring program (LTMP) and occupancy data for Rapids Clubtail included in this report was limited to reports submitted to the citizen science platform iNaturalist. Therefore, the delineated areas of occupied and contributing habitat used by Rapids Clubtail in the Humber River is presented as potential habitat and the species may exist elsewhere in the watershed. For example, several un-verified, citizen-science reports have been submitted to the Natural Heritage and Information Centre (NHIC) that suggest Rapids Clubtail may exist in other areas of the West Humber, west of the Nashville Conservation Reserve (NHIC 2022).

In the current period, there is an estimated 1,058 ha of potentially occupied and potentially contributing instream (292 ha) and terrestrial (766 ha) habitat for Rapids Clubtail in the Humber River. Within the 200 m stream buffer, natural cover associated with Rapids Clubtail regulated habitat (e.g., deciduous, mixed forest, or mixed tree swamp) comprises 81 ha (28.8%) and 686 ha (21.9%) of potentially occupied and potentially contributing habitat, respectively (see [Table 11](#)). These findings do not imply that the remainder of landcover in the 200 m buffer is not natural cover, rather it is a cover type not associated with regulated Rapids Clubtail habitat and therefore does not contribute to potentially occupied or potentially contributing habitat. Forest cover makes up the largest portion of natural cover in the potentially occupied (26.7%) and potentially contributing (18.2%) habitat areas, with beach/bluff and meadow habitats making up less than 1%. Wetlands make up less than 1% of the natural cover in potentially occupied habitat and 2.7% of the natural cover in potentially contributing habitat.

³⁵ This represents the amount of natural cover associated with ELC codes that align with the definition of regulated habitat for Rapids Clubtail including deciduous, mixed forest, or mixed tree swamp, found within a 200 m buffer from the high-water mark.

2.1.6 Estuary Fish Community Health

Estuaries support communities of fish that can differ from rivers and streams and can offer a refuge and spawning habitat for many native fish. Estuaries can also support lake-based fish species during spawning and juvenile growth stages of their life cycle.

The fish community of the Humber River estuary was comprised of 42 fish species detected across two sampling transects in the current period. Of the 42 species, five were invasive or introduced/naturalized species, including Common Carp, Goldfish, Alewife (*Alosa pseudoharengus*), Rainbow Smelt (*Osmerus mordax*), and Round Goby (TRCA 2023). In the current period, the Humber River estuary fish community was predominantly comprised of pollution-tolerant species such as Fathead Minnow (*Pimephales promelas*) with decreasing abundances of invasive species. The average IBI score has remained stable across the three time periods (approximately 46.5). Measures of species diversity were highest during the baseline period. Mean trophic level has not significantly changed over time despite a shift in species assemblage.

Overall, measures of diversity and community health in the current period suggest that the fish communities of the Humber River estuary are gradually changing to one comprised largely of pollution tolerant species with fewer sensitive individuals. There are several inland lakes (e.g., Lake Wilcox) and large ponds in the Humber River watershed for which no standardized or systematic sampling program exists. To further understand the health of lake-based fish communities in the watershed (including important recreational species), a systematic monitoring program of inland lakes is recommended.

2.1.7 Benthic Invertebrate Community Health

Benthic macroinvertebrates (BMI) are bottom-dwelling aquatic organisms including aquatic insects, crustaceans, molluscs, and worms. BMIs provide an important ecological link between the microorganisms that they eat and predators, such as fish and other species, that eat them. The type and abundance of BMI species in a watercourse can be used to infer the overall health of the BMI community and the broader aquatic ecosystem. This relationship is based on the abundance of BMI, their relatively well-known pollution tolerances, their limited mobility, and the strong relationship between species presence and environmental conditions (Jones et al. 2007).

The Family Biotic Index (FBI) was used to assess the health of the BMI community at multiple sites in the watershed. FBI evaluates the presence and abundance of benthic invertebrate species collected in a sample to provide an estimate of the overall community health, where values range from 'excellent' quality to 'very poor' quality. Low values are assigned to groups which are sensitive to organic pollution while high values suggest groups which are tolerant to organic pollution.

Table 12 outlines the average FBI ratings for the watershed and subwatersheds for the historical, baseline, and current periods (in this case, due to data availability, 1999-2000, 2003-2012, and 2013-2021, respectively). **Map 11** presents the average FBI ratings of sites sampled in these three periods in the watershed.

Table 12 - Average Family Biotic Index Ratings

	Family Biotic Index Rating		
	Historical (1999-2000)	Baseline (2003-2012)	Current (2013-2021)
Watershed	5.59 (Fair)	5.93 (Fairly Poor)	5.98 (Fairly Poor)
Main Humber	5.24 (Fair)	5.83 (Fairly Poor)	5.85 (Fairly Poor)
East Humber	5.3 (Fair)	6.09 (Fairly Poor)	5.98 (Fairly Poor)
West Humber	5.72 (Fair)	5.77 (Fairly Poor)	5.88 (Fairly Poor)
Lower Humber	5.84 (Fairly Poor)	6.03 (Fairly Poor)	6.34 (Fairly Poor)
Black Creek	6.8 (Poor)	6.99 (Poor)	6.52 (Poor)
Rating Scale: 0-3.75 (Excellent), 3.76-4.25 (Very Good), 4.26-5.00 (Good), 5.01-5.75 (Fair), 5.76-6.5 (Fairly Poor), 6.51-7.25 (Poor), 7.26-10 (Very Poor)			

The average FBI value in the current period suggests that the BMI community is in ‘fairly poor’ condition in all subwatersheds except Black Creek, which is in ‘poor’ condition. The classification of ‘fairly poor’ suggests substantial to severe water quality impacts in the watershed. The average FBI value in the West Humber subwatershed increased significantly ($p < 0.05$) from 2013 to 2021, which suggests the health of the BMI community is deteriorating. However, only five RWMP sites are sampled annually in the West Humber subwatershed and the results presented here may not reflect conditions throughout the entire catchment. At the watershed scale, the average FBI value in the current period is ‘fairly poor’. The FBI declined significantly ($p < 0.05$) during the current period which suggests an improvement in BMI community health. However, this decline does not represent a biologically meaningful improvement in BMI community health because the average FBI remains ‘fairly poor’ at the watershed scale and at most sampling sites.

Compared to the historical period, average FBI has increased (i.e., a decline in BMI community health) in the baseline and current periods in nearly all subwatersheds and at individual sites. In the historical period, three of five subwatersheds were in ‘fair’ condition and two (Black Creek and the Lower Humber) were in ‘poor’ and ‘fairly poor’ condition, respectively. During the baseline and current periods all subwatersheds were found to be in ‘fairly poor’ condition except Black Creek which is in ‘poor’ condition.

Overall, the BMI community in the Humber River has declined from the historic to current period. Sites in the upper reaches of the Main and East Humber subwatersheds have, on average, declined from predominantly ‘good’ and ‘fair’ condition to ‘fair’ and ‘fairly poor’ condition. While individual sites may still achieve ‘good’ or ‘very good’ status in a year or multiple years within the dataset, on average the health of the BMI community has declined from the historic period. Individual sampling sites in the West Humber and Main Humber subwatersheds continue to demonstrate ‘good’ or ‘fair’ condition in some years, but these sites are restricted to reaches of the subwatersheds where development is limited. In urban areas of Black Creek and the Lower Humber subwatersheds, the average BMI condition has declined from ‘fairly poor’ to ‘poor’ at many sites.

Targets and Progress from 2008 HRWP

In the 2008 HRWP, one target was established related to benthic invertebrate community health: a minimum of 70% of RWMP sites rated as 'fair' or 'good' condition based on benthic invertebrate indices. This target was not met in any year during the current period at the watershed scale. At the subwatershed scale, the Main Humber and West Humber subwatersheds consistently had more benthic invertebrate sites rated as 'fair' or better; however, large interannual variability is observed and, in most years and across subwatersheds, this target is largely unmet during the current period. In 2020, the West Humber subwatershed exceeded the target for benthic invertebrates (80% of sites were in 'fair' or better condition).

2.1.8 Freshwater Mussels

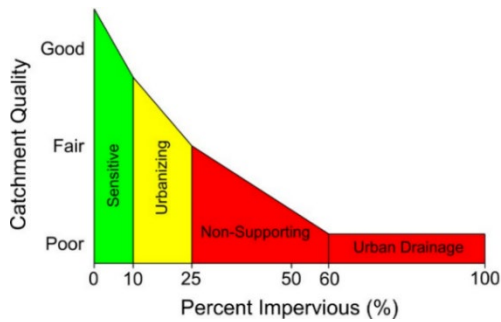
Native freshwater mussels (Unionidea) occur in the Humber River watershed but their distribution is largely unknown due to limited sampling. Unionids are filter-feeding macroinvertebrates that live on and in the sediment of the river and are not typically captured in traditional aquatic monitoring programs (e.g., Ontario Stream Assessment Protocol and Ontario Benthos Biomonitoring Network). Unionids are considered indicators of water quality and have a unique life history strategy that relies on the presence of fish, and in some cases specific fish species. Unionids are one of the most imperiled group of organisms in Canada. Forty-one species of Unionids are known in Ontario, and almost one-third are listed as a species at risk under the federal *Species at Risk Act* (Reid and Morris 2017).

In 2022, two timed-search visual, qualitative surveys were completed in the West Humber subwatershed to assess the presence of Unionids at sites that were informally surveyed in 2007 (TRCA 2008b). Four common species of freshwater mussel (Unionidae) were collected at these two sites in the current period and species diversity is consistent with limited sampling conducted during the baseline period. No species at risk were detected.

2.1.9 Aquatic Habitat Quality

Rain and snow fall to the ground as precipitation that can either infiltrate the soil, enter surface waters, or flow overland to nearby streams, rivers, and lakes. The pathway that precipitation follows depends on the receiving land surface and the amount and rate of precipitation. As natural surfaces are converted to impervious surfaces, water can no longer infiltrate soils and instead flows over these surfaces and directly into storm sewers, stormwater ponds, and watercourses. The amount of impervious surfaces in a watershed impacts the natural flow regime of watercourses, water temperature, and water quality (Booth 1991, Schueler 1994, and Gergel et al. 2002). This subsequently impacts aquatic species and ecosystems through changes in aquatic habitat quality.

As shown in [Figure 4](#), Environment Canada has defined the quality of aquatic habitat based on the amount of impervious cover in a catchment area (Environment Canada 2013) where 'sensitive' quality habitat occurs when there is 0-10% impervious cover, and declines in aquatic habitat quality are demonstrated when impervious cover is between 11-25% ('impacted'/'urbanizing'), greater than 25% ('non-supporting'), and greater than 60% ('urban drainage').



Urban Stream Classification	Sensitive (0-10% Impervious)	Impacted (11-25% Impervious)	Non-supporting (26-100% impervious)
Channel Stability	Stable	Unstable	Highly Unstable
Water Quality	Good	Fair	Fair-Poor
Stream Biodiversity	Good-Excellent	Fair-Good	Poor

Figure 4 - Overall Stream Quality as it Relates to Impervious Cover (adapted from Schueler 1994 and Environment Canada 2013)

For this analysis, the amount of impervious cover was assessed at four spatial scales, including the watershed, subwatershed, catchment, and reach contributing area (RCA; i.e., smaller areas within the subwatershed tied to particular stream segments) scales. **Table 13** presents the amount (%) of impervious cover observed at three points in time (2002, 2012, and 2020) at the watershed and subwatershed scale. Currently, at the watershed scale, conditions are ‘urbanizing’ or ‘impacted’ (23.1% impervious cover). However, there are vast differences in aquatic habitat quality across the subwatersheds. In the current time period, Black Creek and the Lower Humber subwatersheds are classified as ‘urban drainage’ (64.6% and 61.2% impervious cover, respectively), while Main Humber, East Humber, and West Humber subwatersheds are classified as ‘urbanizing’ or ‘impacted’ (12.1%, 14.4%, and 22.6% impervious cover, respectively). In the current time period, the Main Humber and East Humber subwatersheds have considerably less impervious cover; however, the West Humber subwatershed is very close to being classified as non-supporting for aquatic communities.

Trends at the watershed and subwatershed scale indicate that there have been increases in the amount of impervious cover between 2002 and 2020. The West Humber subwatershed has experienced the largest increase in impervious cover from the baseline to current period (13.5% impervious cover in 2002 to 22.6% impervious cover in 2020), while the remaining subwatersheds have experienced modest increases. In terms of habitat quality, the East and Main Humber subwatersheds declined from ‘sensitive’ to ‘urbanizing/impacted’ within the baseline period (2002 to 2012), with no improvement in classification in the current time period (2012 to 2020). Lower Humber subwatershed declined from ‘non-supporting’ to ‘urban drainage’ in the baseline period with only a very small change/increase (0.02% impervious cover) in the current period. Black Creek subwatershed’s classification as ‘urban drainage’ (over 60% impervious cover) has not changed throughout the baseline and current period, and this subwatershed has experienced small increases in impervious cover over time suggesting a further decrease in habitat quality.

Table 13 - Percent Impervious Cover by Watershed and Subwatershed in 2002, 2012, and 2020

	Percent Impervious Cover ³⁶		
	2002	2012	2020
Watershed	17.8%	21.7%	23.1%
Main Humber	8.0%	10.8%	12.1%
East Humber	9.2%	13.4%	14.4%
West Humber	13.5%	19.7%	22.6%
Lower Humber	58.4%	61.2%	61.2%
Black Creek	60.4%	64.1%	64.6%

Map 12 and **Map 13** present the changes in impervious cover at three points in time (2002, 2012, and 2020) at the subwatershed catchment and RCA scale, respectively. Impervious cover at these two scales demonstrates that the Humber River watershed headwaters continues to provide ‘sensitive’ quality habitat and has experienced the smallest increases in impervious cover from the historical to current time periods (<5%). The largest increases in impervious cover from the historical to current period (15-20%) have occurred in catchments of the lower portions of the Main and West Humber subwatersheds. Across the watershed, there has been a decline in the number of ‘sensitive’ RCAs and an increase in the number of ‘urbanizing’, ‘non-supporting’, and ‘urban drainage’ RCAs from the historical to the current time period. For example, in 2020, 212 RCAs were classified as ‘sensitive’, compared to 250 RCAs were in ‘sensitive’ condition. The margin of error associated with classifying land cover types using the methods provided here is roughly 3% and therefore meaningful change is considered changes in land cover greater than 10%. This is especially important to consider when analyses reveal decreases in impervious cover of <3%, which is more likely associated with methodological limitations and not a reduction in impervious cover.

2.1.10 Ecohydrology

Information about the assessment of streamflow (average annual discharge/streamflow), average annual precipitation, average annual baseflow, and streamflow variability is provided in **Section 2.1.12 Streamflow**. This

³⁶ **Section 1.3** describes how the land use change was determined over the three time periods (2002, 2012, and 2020) including the land use classification alignment and refinement of the layers to ensure as much consistency as possible between the datasets from the different time periods (although measurement error is possible and there is a level of uncertainty in the land use alignment/refinement exercise). Each land use classification was assigned an impervious cover value that is used as part of the hydrology modelling/flood risk assessment and for other technical disciplines (see **Appendix A – Land Use Classifications** for details). As shown in **Appendix A**, the calculations of impervious cover for the hydrology modelling/flood risk assessment assumes that water is 100% impervious in terms of flood risk. However, for this aquatic habitat quality assessment, the calculation of impervious cover assumes that water is 0% impervious (from an ecological perspective).

section provides a brief summary of how hydrology has changed over time as it relates to the aquatic ecosystem assessment.

Flow is considered the master variable in riverine systems and consists of five major components: magnitude, duration, timing, frequency, and rate of change. These hydrological components influence sediment transport, bedform, water temperature, the wetted area of a river, and ultimately the health of the river ecosystem. An assessment of the Indicators of Hydrological Alteration (IHA) was undertaken for the Humber River watershed. The IHA were developed to help understand the hydrological impacts of human activities on the aquatic ecosystem (Richter et al. 1996). The IHA were calculated based on stream discharge data obtained from nine Water Survey of Canada (WSC) gauges located throughout the watershed (this includes one additional gauge - located in the Main Humber subwatershed - that was not included in the streamflow assessment in [Section 2.1.12 Streamflow](#)).

The results of the IHA assessment demonstrate that important hydrological changes have occurred between the historical time period (late 1940s to mid-1980s for this assessment) and current time period (2012-2020 for this assessment) including increased mean annual flow, an increase in median monthly winter flow, and a shift in peak median monthly flow from March to April at 62.5% of the gauge stations. The mean date of maximum flow (i.e., the date with the largest single flow reading in a hydrological year) has also shifted, on average, 18.3 days from the historic to current time period. These hydrological changes can contribute to phenological mismatches between organisms and their environment or among predators and prey (Woods et al. 2022). For example, a shift in the spring freshet may impact the success of fish spawning and recruitment, and higher than normal flows (i.e., loss of low flows) in the summer may impact the benthic invertebrates that rely on low flow cues to initiate emergence to their terrestrial life stage (Woods et al. 2021).

2.1.11 Groundwater Conditions

Groundwater recharge rates in the Humber River watershed are correlated with the physiography (i.e., Oak Ridges Moraine and Niagara Escarpment) and land use patterns (i.e., urbanization). Evaluation of groundwater recharge and discharge, and their associated targets, are heavily reliant on groundwater modeling. Groundwater modelling advancements have been made since the 2008 HRWP. The preliminary TRCA Tier 1 numerical groundwater/surface water model (TRCA 2010) developed under the *Clean Water Act* was used for the 2008 HRWP. Since then, the York Region Tier 3 source model (that assesses sustainability, risk, and ecological stress) and expanded TRCA model (based on the York Tier 3 model but expanded to include the Humber River watershed), have been developed. Groundwater recharge for the entire watershed for the current period is estimated to be 235 mm/yr with the groundwater recharge rates varying in the subwatersheds from highest in the Main Humber subwatershed (390 mm/yr) to lowest in the Black Creek and Lower Humber subwatersheds (62.5 mm/yr and 90 mm/yr, respectively) (see [Table 5](#) for a summary of the results). These new modelling efforts also suggest that groundwater recharge is focused within the hummocky terrain (i.e., closed depressions) and surficial sand and gravel deposits of the Oak Ridges Moraine within the Main Humber subwatershed, and this plays an important role in the recharge distribution across the watershed.

Caution should be used when comparing 10-year intervals for baseflow. With respect to the baseline period, insufficient data was available at some of the stations to analyze trends, and current trends seen over the last twenty years are consistent with natural fluctuation. Baseflow Index (BFI) is a measure of the ratio of long-term

baseflow to total streamflow, and is used as a proxy for groundwater discharge, which is discussed further in [Section 2.1.12 Streamflow](#). As shown in [Table 5](#) and [Map 14](#), based on the BFI, the five subwatersheds of the Humber River all appear to have received neutral to increased groundwater discharge in the current period (2012-2021) from the baseline period (2002 to 2011). Stations 02HC047 and 02HC057 show the highest baseflow indices (0.73 and 0.71, respectively) and roughly occur within the Oak Ridges Moraine Physiography in the Main Humber subwatershed. Stations 02HC023 and 02HC025 in the Main Humber subwatershed, and Stations 02HC009 and 02HC032 in the East Humber subwatershed show the next highest baseflow indices (0.69, 0.68, 0.58, and 0.57, respectively) and roughly occur along the South Slope Physiography. Station 02HC003 in the Lower Humber subwatershed has a baseflow index (0.53) elevated comparatively to stations along the Peel Plain Physiography and roughly occurs along the Lake Iroquois Shoreline Physiography.

Groundwater allocations appear to have increased since the publication of the 2008 HRWP, but aquifer water levels appear to be stable. In 2022, groundwater use is estimated to be approximately 53,040,000 m³ (approximately 25% of the total annual groundwater recharge – annual recharge estimation having increased from 122,333,333 m³/a to 212,105,125 m³/a) (United States Geological Survey 2023). About 31% of all active groundwater withdrawals are from 14 municipal wells in the watershed, with the remainder for private wells, agricultural irrigation, industrial processing, commercial, and recreational purposes (e.g., golf course irrigation).

The Provincial Groundwater Monitoring Network (PGMN) was established in April 2000 to report on ambient (baseline) conditions and to provide an early warning system for changes in groundwater levels and quality. Within the Humber River watershed, there are a total of nine PGMN wells as well as two monitoring wells associated with Permits to Take Water (PTTW) held by TRCA. Of the nine PGMN wells, two show a slight decline, and two show a slight rise. The other wells either have too short a record to establish a trend or indicate rising conditions. There are eight active groundwater sourced PTTWs in the East Humber subwatershed, seven in the Main and Lower Humber subwatersheds, and six in the Black Creek and West Humber subwatersheds. [Map 14](#) shows the active groundwater source PTTWs in the watershed.

Groundwater Quality

Water quality conditions were assessed at 47 groundwater quality stations using data collected through the Oak Ridges Moraine Groundwater Program (ORMGP) database between 2001 and 2021 and annual groundwater sampling through the PGMN program. Concentrations of nitrate, primarily from agricultural practices, and chloride, mainly from the urban use of road de-icing salt, were used to assess regional groundwater quality at a regional scale. Based on the current conditions results (2011 to 2021 in this case), groundwater quality in the Humber River watershed is generally similar compared to other watersheds within TRCA's jurisdiction. With respect to chlorides, 90% of measurements meet the Canadian Guidelines for the Protection of Aquatic Life³⁷. With respect to nitrates, 95% of measurements meet the Canadian Guidelines for the Protection of Aquatic Life and 100% of measurements meet the Ontario Drinking Water Standard. When comparing to baseline conditions (2001 to 2010 in this case), with respect to chloride, only 75% of measurements met the Canadian Guidelines for

³⁷ The Canadian Council of the Ministers of the Environment set the Water Quality Guidelines for the Protection of Aquatic Life (also called the Canadian Guidelines for the Protection of Aquatic Life).

the Protection of Aquatic Life. However, the data shows no trend positive or negative in the last twenty years (between baseline and current periods). Trends for nitrates could not be provided due to lack of data.

Based on water quality data collected from RWMP stations administered by TRCA and Provincial Water Quality Monitoring Network (PWQMN) stations administered by MECP, it was determined that chlorides tend to be a concern at all stations in the watershed (using data from 2016-2020 for the current time period assessment due to data availability). Particular attention should be given to the sources of chlorides affecting the Black Creek subwatershed (baseflow water quality indicated that chloride concentrations in the Black Creek subwatershed on average were >500 mg/L whereas chloride concentrations in other subbasins on average were <500 mg/L). The main sources of chlorides include Highways 7, 400, 401, and 407. Scientific literature continues to demonstrate the strong relationship between chloride concentrations and the amount of urban development. If development using traditional methods continues in this region and upstream, chloride concentrations are expected to continue to rise. [Section 2.3 Surface Water Quality](#) provides additional information about surface water quality and parameters of concern.

Contaminants of Emerging Concern - PFASs

Perfluoroalkyl substances (PFASs) are a broad class of more than 6000 synthetic fluorinated organic chemicals used extensively in personal, commercial, and industrial applications, often to provide protective coating for surfaces or as additives in certain products. PFASs can be grouped into two categories including perfluorosulfonic acids (PFSAs) and perfluorocarboxylic acids (PFCAs) (Lake Simcoe Region Conservation Authority 2021).

One of the more well-known compounds listed above, perfluorooctane sulfonate (PFOS), was used primarily as a repellent to water, oil, soil, and grease for various products and was also used in fire-fighting foams against fuel-based fires. Though PFOS are now prohibited in Canada, they were widely used and are believed to be ubiquitous in our environment. Monitoring of background levels of PFOS in the Humber River watershed showed a decline since 2000 possibly from the phasing out of these substances in consumer products. Trends of the levels of PFOS in Lake Ontario are not as clear but, over time, concentrations are expected to decline. The MECP continues to monitor PFOS in some parts of Ontario (Lake Simcoe Region Conservation Authority 2021).

TRCA does not typically test for PFSAs at monitoring wells. As a pilot-project for the new HRWP, a demonstration PFSA sampling event was undertaken at Claireville station MW-1s/d and the lab analysis did not detect any PFSAs that were above the threshold/detectable limit. In future, it is recommended that any additional lab testing/analysis for PFSAs take place at a laboratory that offers a lower-level detection limit.

The limited sampling has identified trace concentrations of PFSAs, including PFOS, below the detection limits at the nested monitoring well located at Claireville Conservation Area. PFCAs have been identified within TRCA's jurisdiction, including in the Main Humber subwatershed. Given the limited data, additional monitoring would likely document other occurrences.

[Section 2.3 Surface Water Quality](#) provides additional information on chemicals of emerging concern in relation to surface water.

Targets and Progress from 2008 HRWP

The 2008 HRWP set three targets related to groundwater including: 1) Maintain baseline groundwater recharge rates and distribution; 2) Maintain baseline average annual baseflow rates (as determined by baseflow separation of long-term stream flow gauge data); and, 3) Prevent groundwater contamination (maintain/reduce chloride levels).

The targets of maintaining groundwater recharge and discharge appear to have been achieved at least within the context of the substantial error margin in estimating these parameters. With respect to maintaining existing annual average recharge rates, post to pre water balance analysis and targets were established following the publication of the 2008 HRWP. In addition, since the 2008 HRWP, ESGRAs have been identified within TRCA's jurisdiction (and are included in the definitions of significant groundwater recharge areas in the Growth Plan for the Greater Golden Horseshoe (Ontario 2020) and Greenbelt Plan (Ontario 2017)). Even where the volume of groundwater discharge may be relatively low, groundwater discharge plays an important role in the ecological health throughout the watershed.

Groundwater discharge within a riverine system (i.e., baseflow) has been relatively stable across all five subwatersheds over the period analyzed. When considering low flow spot measurements over the same period, most reaches of the Humber River are gaining during most years with some losses within the Oak Ridges Moraine and Peel Plain physiography.

There are nine PGMN wells and two monitoring wells associated with PTTWs within the Humber River watershed. The monitoring wells represent a decent distribution across the Oak Ridges, Thorncliffe, and Scarborough Aquifer Complex. No significant declining trends were observed at any of the monitoring wells. The monitoring wells are concentrated in the northern reaches of the watershed, so a monitoring well installed in the mid-portions of the watershed might provide additional insight.

2.1.12 Streamflow

The terms 'streamflow' and 'discharge' are used interchangeably in hydrology and refer to the volume of water flowing past a gauge in a watercourse. Streamflow is expressed as an annual volume (mm/yr). As land use in a watershed changes, the proportions of overland runoff and baseflow (i.e., portion of water flowing into the stream not associated with runoff) could also be expected to change. Increasing impervious cover, such as asphalt, concrete, and roofs within a watershed, is expected to increase total streamflow and decrease groundwater recharge and evapotranspiration, as less water soaks into the ground and more is diverted into watercourses as runoff. In urbanizing watersheds, the net result of these changes is often increased total runoff and peak discharge. This results in increased erosion leading to enlarged stream channels, reduced stream habitat quality (through removal of coarse bed sediments and woody debris), and water quality impairments. The effects of urbanization on baseflow are more complex, and baseflow has been found to increase or decrease with increasing urban cover in different settings. One explanation could be the drawdown of stormwater ponds being interpreted as baseflow in our analysis. However, to separate the signal from stormwater pond outflow from baseflow requires significant data collection and extensive research which was beyond the scope of this analysis. Changes to precipitation type and volume will also have an impact on the total streamflow and the volumes of its two components.

Summary of Streamflow Characteristics at Watershed Flow Gauges

Streamflow trends for the Humber River watershed were assessed using both a 10-year time period (to align with analysis undertaken for other technical components) and a 30-year time period (to provide a more accurate streamflow representation since climatic conditions tend to be quite variable from year to year and even on decadal scale). The time period for the 10-year current conditions assessment was 2012-2021 and for the 10-year baseline conditions was 2002-2011. The time period for the 30-year current conditions assessment was 1991-2021 and for the 30-year historic conditions was 1961-1990.

Appendix B – Streamflow Characteristics Analysis Results presents a summary of the results of the streamflow characteristics analysis at all eight Humber River watershed flow gauges. Comparing streamflow characteristics at the eight flow gauges, the highest current average annual discharge (30-year time period) is at the Black Creek station near Weston Road (Station 02HC027 - 473.1 mm/yr) and the lowest is at the East Humber station at King Creek (Station 02HC032 - 222.9 mm/yr). The highest current average annual baseflow (30-year time period) is at Black Creek station near Weston Road (Station 02HC027 – 301.7 mm/yr) and the lowest is at the West Humber station at Highway 7 (Station 02HC031 – 88.5 mm/yr). The highest current streamflow variability (10th to 90th percentile ratio which is explained further below) (30-year time period) is at the West Humber station at Highway 7 (Station 02HC031 – 44.8) and the lowest is at the Cold Creek station near Bolton (Station 02HC023 – 3.7).

The following discussion about streamflow characteristics is generally based on the 30-year time period since this longer time period provides a more accurate representation of streamflow (since, as noted above, climatic conditions including precipitation tend to be quite variable from year to year and on the decadal scale).

Average Annual Discharge/Streamflow and Average Annual Precipitation

The average annual discharge/streamflow for each of the eight flow gauges located in the watershed (during the 30-year current and historical period) as well as the associated gauge catchment area (in hectares) is shown in **Map 15**. In general, streamflow has increased in magnitude across the entire distribution of flow values in the watershed, with the largest relative increases being in the middle range for the watershed as a whole.

Station 02HC003 (Humber River at Weston Road) was used to represent flows of the entire watershed as it is one of the most downstream gauges passing flows originating from the majority of the watershed. Based on the 30-year time period, the current average annual discharge/streamflow in the watershed is 280.4 mm/yr (which represents 33% of average annual precipitation – 851 mm). Streamflow in the watershed has increased by 20.3% from historical conditions of 233.0 mm/yr (representing 29% of the average annual precipitation – 812 mm). The increase in discharge can be a result of both an increase in impervious cover (from 17.8% in 2002 to 23.1% in 2020) and average annual precipitation (increase of 5% in 30-year time period³⁸). Precipitation amounts vary moderately across the watershed. For the current 30-year time period, there is a clear trend of increasing

³⁸ Note that based on historical climate trends for the watershed (discussed in **Section 3.0 Historical Climate Trends**), average total annual precipitation increased by 3% overall based on Environment and Climate Change Canada climate station data.

average annual precipitation from downstream to upstream subwatersheds. The most downstream subwatershed has an average annual precipitation of 819 mm/yr, which increases to 883 mm/yr at the most upstream subwatershed. Comparing the average annual precipitation of the current 30-year time period to the historical, the average annual precipitation has decreased for the two of the most downstream subwatersheds and increased for subwatersheds upstream.

Average Annual Baseflow

Of the average annual streamflow (280.4 mm/yr) based on the current 30-year time period, approximately 139.5 mm/yr is currently estimated to be baseflow (again taken from Station 02HC003 near the mouth of the watershed). Baseflows show a slight decreasing trend (11%) when comparing the 30-year historical (1961-1990) and current (1991-2021) periods. This is likely attributable to increased imperviousness between these periods. The baseflow contributed 68% and 50% of the flow to the total discharge during the historical and current 30-year time periods. Conversely, baseflow volumes have increased based on the 10-year time period (153.9 mm/yr in current period and 146.4 mm/yr in baseline period) and are higher than the historical 30-year period, which is likely due to an increase in average annual precipitation in the current and baseline 10-year periods relative to the historical period. Furthermore, the relatively unurbanized upstream recharge areas may be supporting groundwater recharge and there may be additional inflow from leaking underground stormwater management infrastructure. In fact, upstream gauges from unurbanized subwatersheds show an increase in both the average annual baseflow and the proportion of baseflow to total discharge from the historical to current periods. While increased baseflow may be perceived as benefitting aquatic ecosystems and overall watershed health (due to lower warm season temperatures in groundwater relative to streams and surface waters, which contribute to maintenance of suitable thermal habitat for coolwater and coldwater aquatic species), the quality of this additional urban baseflow water is uncertain, and may contribute in some regards to water quality degradation.

Generally, the effects of urbanization on baseflow are difficult to predict and, in different settings, watershed urbanization has been found to increase or decrease total baseflow (Bhaskar et al., 2016). In the case of the Humber River watershed, urbanization between the historical and current period has likely decreased the proportion of precipitation amount of groundwater recharge. The increase in baseflow during the 10-year baseline and current periods needs further investigation. Possible explanations include accumulated baseflow from previous years discharging in the latter current period.

Streamflow Variability (10th and 90th Percentile Ratio)

Understanding the variability of streamflow conditions is achieved through ratios such as 10th to 90th percentile (or '10/90 ratio'), with larger ratios indicating larger variability in streamflow conditions. Percentiles are used to refer to exceedances, where the 10th percentile is taken to represent flows that are exceeded 90% of the time (low flows), while the 90th percentile represents a flow rate that is only exceeded 10% of the time (high flows). The 10/90 ratio for the Humber River watershed is currently 9.0 (based on the 30-year time period), decreased from 9.3 from the historical (30-year) conditions, indicating a slight decrease in flow variability. In comparison, Etobicoke Creek watershed has the largest 10/90 ratio (16.4) of the larger TRCA watersheds (>200 km²), likely due to higher impervious cover. The Rouge River watershed has a 10/90 ratio of 8.84, which is comparable to Humber's ratio. This indicates that the Humber River watershed does not have as "flashy" a hydroperiod as the Etobicoke Creek watershed.

It is important to note that even if average annual precipitation doesn't vary significantly from year to year, the temporal and spatial distribution of precipitation will impact the 10/90 ratio. The current 10-year time period has a lower ratio (6.7) than the baseline 10-year time period (9.5). While the average annual precipitation between these periods was similar, the baseline years had more spatial variability with some subwatersheds receiving as much as 906 mm and others as low as 810 mm of average annual precipitation. Urbanization of the watershed and increasing impervious cover will also increase the ratio by causing higher flows during rainfall events and creating a greater separation from low flows occurring during the inter-event period.

Targets and Progress from 2008 HRWP

The 2008 HRWP established the targets of preserving or reducing baseline streamflow and preserving the baseflow including: 1) Maintain or reduce baseline annual and seasonal flow volumes (based on long-term stream gauge measurements); and, 2) Maintain or enhance baseline seasonal and annual baseflow rates. The annual target for annual streamflow has been achieved, with an average of 301.6 mm/yr during the baseline period (2002-2011) and 291.4 mm/yr during the current period (2012-2021). The target of preserving annual baseflow has also been met, with average values of 146.4 mm/yr during the baseline period and 153.9 mm/yr during the current period. However, when comparing the baseflow between the 30-year historical and 30-year current periods, the average annual baseflow has decreased from 157.6 to 139.5 mm/yr. The modest increase of only 5.35% in impervious cover is likely the reason for achieving these targets when comparing the 10-year baseline and 10-year current periods. It is crucial to note that relying solely on average annual values alone does not provide a complete understanding of how the flow regimes have been impacted. It is necessary to evaluate the dynamics of flow, particularly seasonal variations, to assess potential impacts on aquatic biota and channel characteristics. Although this analysis was not possible in this report, it will be undertaken in the future. As urbanization continues in the watershed, ongoing monitoring of these metrics remains crucial.

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 difference between the urban forest and natural cover is described below.

Difference Between Urban Forest and Natural Cover

The term **urban forest** is used to describe the trees and woody shrubs located on all private and public property within a watershed, including urbanized spaces (i.e., along roads) and in forests. The percentage of urban forest cover is determined by the area covered by the canopies of all trees and shrubs in both built and natural areas.

Natural cover is the area of the watershed covered by natural habitats, including forests, meadows, and wetlands.

Natural cover includes habitats with varying amounts of trees and shrubs. Meadows, for example, are open habitats that do not contain trees. Although meadows are natural cover, they are not part of the urban forest. Conversely, the urban forest includes trees in built portions of the watershed that are not part of natural cover. For these reasons, **the amount of natural cover and the amount of urban forest in a watershed will not be equal.**

Understanding the state of the NHS (including natural cover, habitat quality etc.) and the urban forest is important for watershed management due to the many ecosystem benefits and services that terrestrial features like forests, meadows, and street trees provide. Some of these benefits include supporting biodiversity and providing habitat, water retention and filtration, biogeochemical cycling, and cleaner air. See [Section 4.1 Natural Heritage System Comparison](#) for an evaluation of single-tier and upper tier-municipal NHSs as identified in Official Plans and TRCA's regional target NHS (2022).

As part of watershed characterization, the total amount of natural cover (i.e., habitat quantity), habitat quality, terrestrial biodiversity, habitat connectivity, climate vulnerabilities, carbon storage, and urban forest quantity were assessed. Due to limitations in the availability of data on urban forest composition and health for the entire watershed, general trends were reported and the available municipal data was compiled in [Appendix C – Urban Forest Quantity and Quality](#).

The terrestrial ecosystem in the Humber River watershed varies greatly by subwatershed with some general patterns outlined in [Table 4](#) and in [Map 16](#). The continued loss of natural cover is the greatest concern due to cumulative impacts (i.e., death by a thousand cuts). While each small loss might seem negligible, over longer time periods these small losses accumulate and can be difficult to track through research studies or watershed plans (Theobald et al. 1997).

2.2.1 Habitat Quantity

The total amount of natural cover in the watershed is 28,326 ha (31.4% of the watershed area), including 16.6% forest, 2.7% successional forest, 7.1% meadow, 5% wetland, and <0.1% beach/bluff. Between 2002 and 2020, 1,289 ha of terrestrial natural cover was lost in the watershed (decrease in total amount of natural cover by 4.4%). Notable habitat losses occurred in the watershed due to urban development and associated land use changes (including construction of industrial buildings and residential communities). See [Map 17](#) for a map of the distribution of natural cover by habitat type in the watershed.

The highest amount of natural cover is in the Main Humber subwatershed, and specifically in the northwest area of the watershed (north of Caledon and Bolton to Mono Hills and Palgrave). These areas largely consist of forest and swamp, and are interspersed with successional forest and meadow. Several TRCA properties are located in this area including Caledon Tract, Albion Hills, Bolton Resource Management Tract, and Glen Haffy. Large patches of natural cover are found in the lower parts of the Main Humber subwatershed as well and into the East Humber subwatershed including several TRCA properties (Boyd, Kortright, and Nashville Resource Management Tract). These areas include primarily forest and successional habitats but also a smaller amount of wetlands and meadows. Large amounts of natural cover are also found in the East Humber subwatershed particularly on the Oak Ridges Moraine and just east of Nobleton. In the West Humber, Lower Humber, and Black Creek subwatersheds, due to the high amount of urbanization or agriculture, natural cover is generally limited to watercourses and ravines. In the West Humber subwatershed, there are also larger patches of natural cover including swamps in the west and Claireville in the south.

Terrestrial conditions in the watershed have changed over time reflecting both broadscale patterns and localized changes. Habitat losses since the baseline period occurred mainly to forests and meadows, with an increase in wetlands and successional habitats, as shown in [Table 14](#) (and explained below).

Table 14 - Change in Natural Cover by Habitat Type

Habitat Type	2002		2020	
	ha	% of watershed	ha	% of watershed
Forest	16,396	18.2%	14,962	16.6%
Successional forest	1,646	1.8%	2,431	2.7%
Meadow	9,995	11.1%	6,386	7.1%
Wetland	1,577	1.7%	4,545	5.0%
Beach/bluff	0.5	<0.1%	4	<0.1%
Total natural cover³⁹	29,615	32.8%	28,326	31.4%

Decreases in forest cover over the past 20 years were due to the removal of many small woodlots for industrial or residential development and road construction. Some timber harvest was also evident. Methodology differences also contributed as many swamps were considered forest in 2002 but were considered wetland in 2020. Forests have also been affected by regional disturbances including both the December 2013 ice storm and widespread distribution of Emerald Ash Borer (*Agrilus planipennis*). These disturbances have led to changes in tree community composition, increased tree mortality, snag production, decreased crown vigour, increased regeneration of woody species, and an increased production of ash seedlings.

Increases to successional forest are the result of a shift in natural cover type from meadow to successional forest, restoration practices (including tree planting contributing to changes from meadow to early successional natural cover types), and impacts of the December 2013 ice storm, Dutch Elm disease, and Emerald Ash Borer (leading to opening of once closed canopies and subsequent plant growth due to increased light exposure).

Changes/decreases in meadows are partially due to losses through development (e.g., densification within the urban boundary to residential or industrial, including areas south of King Vaughan Road and Mayfield Road, and conversion of large meadow blocks to subdivisions in rural areas), succession (i.e., change to forest), and differences in data collection standards and methodologies between 2002 and 2020.

Increases to wetlands are partially due to changes in classification from forest to wetland (i.e., swamp), completed restoration projects, and differences in data collection standards and methodologies between 2002 and 2020.

Targets and Progress from 2008 HRWP

The 2008 HRWP established two targets related to habitat quantity including: 1) Increase natural cover to at least 39% of total watershed area; and, 2) Increase wetland cover to 10% of total watershed area. Neither of

³⁹ The natural cover number referenced in **Table 2** (32.7%) includes streams and lakes (i.e., natural cover that is water), whereas the numbers in **Tables 4, 5, and 14** (31.4%) exclude water from the natural cover calculations and are, therefore, slightly lower.

these habitat quantity targets have been met. The total amount of natural cover in the watershed is only 31.4% of the watershed area, and wetland cover is only 5% of the watershed area.

2.2.2 Habitat Quality

Natural areas (forests, wetlands, meadows) become fragmented when a portion is removed for agriculture, urban development, roads, or other land uses. The remaining natural cover “patches” are of variable quality for wildlife based on their size, shape, and influences from adjacent land uses (matrix influences/edge effects). Larger, more circular patches adjacent to other natural areas are considered to be higher quality as they are more likely to provide suitable conditions for sensitive plant and animal species.

On average, the Humber River watershed has ‘poor’ habitat quality (total LAM score = 8.96), although the designation of ‘poor’ ranges from a total score of 6 to 8 and ‘fair’ ranges from 9 to 10. This suggests that, while on average patch quality is considered ‘poor’, based on these broad categories, it is generally in between ‘poor’ and ‘fair’. Based on area, most of the habitat patches in the watershed are of ‘fair’ quality followed by ‘good’ quality, then ‘poor’ quality. Habitat patches in the middle to lower areas of the watershed tend to be small and linear and influenced negatively by the surrounding urban landscape. Habitat patches in these areas are of ‘fair’, ‘poor’, or ‘very poor’ quality due to smaller patch sizes, more linear shapes, and negative matrix influences. Habitat patches in the upper areas tend to be larger and less linear and the dominant surrounding land use remains agriculture, which has a less negative influence on habitat quality. Good quality patches are better able to support species of regional conservation concern compared to poorer quality patches.

Landscape-scale influences are reflected in average patch scores across the subwatersheds. Black Creek, Lower Humber, and West Humber subwatersheds had an average patch score of ‘poor’ (L4) while East Humber and Main Humber subwatersheds had an average patch score of ‘fair’ (L3) (see summary results in [Table 5](#)). While protecting natural cover from further habitat loss and fragmentation is important in areas undergoing development, it is also essential to ensure that the areas surrounding habitat patches are maintained at a landscape-scale (e.g., rural land use supporting biodiversity), and that these areas are effectively buffered from human impacts and planted with native species.

See [Map 18](#) for a map of habitat patch quality rankings in the watershed.

Targets and Progress from 2008 HRWP

The 2008 HRWP established the following target related to habitat patch quality: average habitat patch total quality rating of ‘good’ for all patches in, or partially within, the watershed; and, as follows for subwatersheds – Main Humber (‘good’), East Humber (‘good’), West Humber (‘fair’), Lower Humber (‘poor’), Black Creek (‘poor’). These two targets have generally not been met. On average, the Humber River watershed has only ‘poor’ habitat quality and, based on area, most of the habitat patches in the watershed are of ‘fair’ quality followed by ‘good’ quality, then ‘poor’ quality. In addition, only the Lower Humber and Black Creek subwatersheds are meeting the targeted quality rating (of ‘poor’).

2.2.3 Terrestrial Biodiversity

Vegetation Communities

The Humber River watershed contains a large number of vegetation community types (343 types) representing 19% of the watershed and 16,696 ha. These vegetation community types primarily consisted of a mix of natural forests (32% of area surveyed, 5,287 ha), plantations (19% of area surveyed, 3,142 ha), meadows (18% of area surveyed, 2,940 ha), swamps (8% of area surveyed, 1,326 ha), and marshes (5% of area surveyed, 853 ha).

Cultural savannahs, cultural woodlands, cultural thickets, open/shallow water, hedgerows, sand barrens, beaches, bars, bluffs, tallgrass prairie, clay barrens, bogs, fens, floating and submerged vegetation, and cliffs were also present but comprised a smaller area. Deciduous forest (FOD) was the dominant vegetation community type (by coverage), and cultural plantations (CUP) and cultural meadow (CUM) were the second and third most dominant vegetation community, respectively. The watershed also contains many rare and sensitive vegetation community types including fens such as Beaked Sedge Open Fen (FEO1-5) and Bog Buckbean – Sedge Open Fen (FEO1-4), thicket swamps such as Spiraea Organic Thicket Swamp (SWT3-A) and Buttonbush Organic Thicket Swamp (SWT3-4), and marshes such as Bur-reed Organic Shallow Marsh (MAS3-B) and Water Arum Organic Shallow Marsh (MAS3-11).

There are 160 different types of vegetation communities of regional conservation concern (L1-L3 ranked) within the watershed covering approximately 1,687 ha or approximately 10% of the total area of natural cover surveyed using ELC. As shown in the summary results in [Table 5](#), vegetation communities of concern are located throughout the watershed with the highest area in the Main Humber (1,130 ha) and East Humber (395 ha) subwatersheds, and lower amounts in the West Humber (103 ha), Lower Humber (42 ha), and Black Creek (17 ha) subwatersheds.

Fauna

Based on fauna inventory surveys conducted between 2012 and 2021, 198 fauna species (including Species at Risk in Ontario) were found in the watershed including:

- 6 L1 species
- 31 L2 species
- 63 L3 species
- 55 L4 species
- 34 L5 species
- one LV species
- 8 L+ species

This is likely an underestimate of the actual number of species. These species include a mix of birds, reptiles, amphibians, and mammals that are either the focus of inventory surveys or are incidentally encountered. Of these 198 fauna species, 100 are considered to be species of regional conservation concern. Similar to

vegetation communities, these species occurred throughout the watershed although the highest number were found in the Main Humber, East Humber, and West Humber subwatersheds (87, 76, and 53 L1-L3 ranked species respectively) (see summary results in [Table 5](#)). [Section 6.2.3 Terrestrial Biodiversity](#) provides details on TRCA's Scoring and Ranking System for species.

Inventory Surveys

Inventory data have been updated and summarized in formal inventory reports at six main locations in the watershed over recent years including Albion Hills Conservation Area, Boyd Conservation Area, Cold Creek Conservation Area, Glen Haffy Conservation Area, the Humber Arboretum, and the Mid Humber Gap. These reports can be referred to for additional details on fauna, flora, and vegetation communities across the watershed. [Figure 5](#) and [Figure 6](#) show species of regional conservation concern located at Albion Hills Conservation Area and Boyd Conservation Area, respectively. [Figure 7](#) shows the notable Old-growth Hemlock – Sugar Maple Mixed Forest vegetation community at Cold Creek Conservation Area.



*Figure 5 - Regionally Rare Species at Albion Hills Conservation Area including Watershield (*Brasenia schreberi*) (left) and Magnolia Warbler (*Setophaga magnolia*) (right)*



Figure 6 - Scarlet Tanager (Piranga olivacea): A Species of Regional Conservation Concern at Boyd Conservation Area

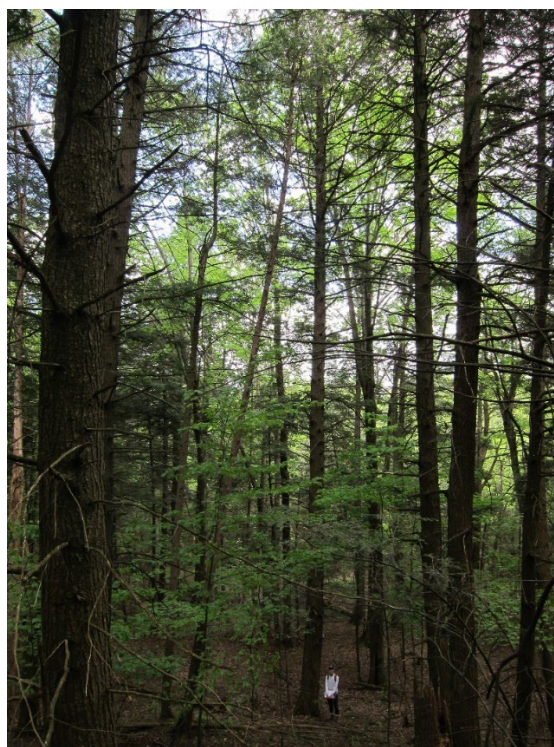


Figure 7 - Old-growth Hemlock – Sugar Maple Mixed Forest (FOM6-1) at Cold Creek Conservation Area

Based on the information obtained from TRCA's 2021 summary report of the Terrestrial LTMP plots, species communities in all habitat types (forest, wetland, and meadow) continue to reflect the strong, negative effects of urbanization on these ecosystems. Monitoring stations in urban areas consisted of fewer species, lower abundances, and communities consisting of more generalists or tolerant species. Several factors related to urbanization likely continue to affect biodiversity producing these spatial patterns including habitat loss, fragmentation, isolation, invasive species, and urban noise.

Invasive Species

Invasive species are non-native terrestrial and aquatic flora and fauna species whose introduction and spread can pose significant harm to the environment, economy, and society (Government of Canada 2004). Within the Humber River watershed, and across TRCA's jurisdiction, invasive species are negatively affecting native species communities through competition and displacement. Not all exotic species are invasive, although exotic species are those which are not native to southern Ontario. Disturbance of vegetation communities by exotic plant species ranged from none to severe across the watershed with more severe levels of disturbance in urbanized areas. Many of the fragmented habitat patches in the West Humber, Lower Humber, and Black Creek subwatersheds were severely affected by exotics, but the larger, more contiguous habitat patches in the Main Humber and East Humber subwatersheds were not severely affected.

Species at Risk

The Humber River watershed is currently home to at least 19 terrestrial species listed as threatened, endangered, or special concern under Provincial or Federal legislation. 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. The presence of these species means that additional efforts must be made to protect their existing habitat under the *Endangered Species Act* if changes are suggested (i.e., development or restoration).

Species at risk within the watershed range from reptiles (e.g., Blanding's Turtle - *Emydoidea blandingii*) and amphibians (e.g., Jefferson Salamander - *Ambystoma jeffersonianum*), to birds (e.g., Eastern Wood-pewee - *Contopus virens*), bats (e.g., Little Brown Myotis - *Myotis lucifugus*), and flora (e.g., butternut - *Juglans cinerea*, spike blazing-star - *Liatris spicata*). The number of records of each species varied with the most abundant being Eastern Wood-pewee (310 records), Bobolink (*Dolichonyx oryzivorus*; 295 records), Wood Thrush (*Hylocichla mustelina*; 293 records), and Eastern Meadowlark (*Sturnella magna*; 167 records). Less common species with only one or two records included Louisiana Waterthrush (*Parkesia motacilla*), Least Bittern (*Ixobrychus exilis*), Common Nighthawk (*Chordeiles minor*), Blanding's Turtle, and Jefferson Salamander. [Figure 8](#) shows Eastern Wood-pewee and spike blazing-star, two species at risk in the watershed.



Figure 8 - Eastern Wood-pewee and Spike Blazing-star: Two Species at Risk in the Humber River Watershed

Targets and Progress from 2008 HRWP

The 2008 HRWP established the following target related to terrestrial biodiversity: maintain or improve baseline representation, and baseline abundance and distribution, of native vegetation community types and species (baseline to be determined through RWMP natural heritage inventories). This target has generally been met as the watershed contains a significant richness of terrestrial biodiversity and vegetation community types. However, monitoring stations in urban areas of the watershed consisted of fewer species, lower abundances, and communities consisting of more generalists or tolerant species. As noted above, several factors related to urbanization likely continue to affect biodiversity producing these spatial patterns including habitat loss, fragmentation, isolation, invasive species, and urban noise.

2.2.4 Habitat Connectivity

Several areas in the watershed are important for habitat connectivity (e.g., for wildlife movements). Connectivity priorities include regional connectivity (i.e., areas important for large-scale movements such as dispersal) and local connectivity (i.e., areas important for seasonal or daily movements).

Regional connectivity priorities (54,764 ha) were located primarily in the upper areas of the watershed. Most regional connectivity priorities were found in the Main Humber (25,715 ha) and East Humber (18,742 ha) subwatersheds followed by the West Humber (9,611 ha), Lower Humber (364 ha), and Black Creek (332 ha) subwatersheds. [Map 19](#) shows the areas identified as important for regional habitat connectivity.

Local connectivity priorities were assessed relative to the subwatershed where the natural cover exists allowing for the identification of the most important areas of each subwatershed. Areas important for connecting forests to wetlands included 18,408 ha and areas important for connecting wetlands to other nearby wetlands included 31,962 ha. Similar to regional connectivity, the majority of local connectivity priority areas were found in the upper areas of the watershed. A large area in the West Humber subwatershed has been identified as important for wetland-wetland movements. This area is primarily agricultural with small pocket wetlands interspersed across the landscape. Due to the low resistance of agricultural landscapes and the importance of these landscapes for movements, the area is of importance. [Map 20](#) and [Map 21](#) show the areas identified as

important for local habitat connectivity (forest-wetland and wetland-wetland, respectively) at the subwatershed scale.

Connectivity priorities are primarily found in the upper reaches of the watershed (e.g., Main Humber and East Humber subwatersheds), where habitat patches are concentrated. These areas are important for both north-south and east-west movements across the Oak Ridges Moraine. The West Humber subwatershed has several areas important for movement primarily in ravines or more linear north-south headwater streams. The ravines in the Lower Humber and Black Creek subwatersheds are also identified as highly important for both local and regional movements. These linear ravine systems are important corridors for north-south movements (e.g., from Lake Ontario to upper areas). Unfortunately, these corridors cross many east-west roads that often act as barriers. Corridors for east-west movement are limited in the lower watershed with the remaining opportunities existing as open areas/meadows next to major roads or highways which may even be avoided by wildlife. Opportunities may also exist along abandoned railways (e.g., the Belt Line rail trail) or between Sheppard Avenue West and Wilson Avenue near Jane Street and Keele Street. These local and regional connectivity priority areas highlight areas for mitigation if any known barriers are present or construction is being planned (e.g., high traffic roads).

2.2.5 Climate Vulnerabilities

TRCA, in partnership with the Ontario Climate Consortium⁴⁰ and the Region of Peel, developed a framework to assess the vulnerabilities of existing natural features to climate change and to identify priority areas for adaptation for the Region of Peel (Tu et al. 2017). An adapted version of this vulnerability assessment was applied to the terrestrial system for the entire TRCA jurisdiction (TRCA 2018). This adapted framework uses five vulnerability indicators: habitat patch quality, climate sensitive ELC vegetation community types, wetland hydrologic vulnerability, mid-afternoon ground surface air temperature, and soil drainage. [Table 15](#) and [Map 22](#) identify the area and percentage of natural cover, or percentage of the watershed, that is highly vulnerable to the impacts of climate change for each of these five indicators.

Table 15 - Climate Vulnerability Indicators and Areas

Vulnerability Indicator	Highly Vulnerable Areas (ha)	Highly Vulnerable Areas (%)
Habitat patch quality	2,173	7.7% of natural cover
Wetlands	343	1.2% of natural cover
Climate sensitive communities	31	0.1% of natural cover
Soil drainage	20,503	22.7% of watershed

⁴⁰ As of August 2021, the Ontario Climate Consortium has formally transitioned into a TRCA climate change program.

Vulnerability Indicator	Highly Vulnerable Areas (ha)	Highly Vulnerable Areas (%)
Ground surface air temperature	31,210	34.6% of watershed

Terrestrial system vulnerability to climate change varied across the watershed based on each of the five vulnerability indicators. Highly vulnerable areas were primarily found within the middle to lower reaches of the watershed where soil drainage is poor (or absent), and ground surface air temperatures are high. These areas occupied between 23% and 35% of the watershed within Peel Region (43% of the total watershed lies within Peel Region). Natural features within these areas are more susceptible to climate change impacts as these conditions exacerbate the impacts of extreme climate events (e.g., drought, flooding).

Of the existing habitat patches, about 2,173 ha (7.7% of the natural cover) in the watershed are considered highly vulnerable due to their structural attributes. These patches are often small, fragmented, narrow ribbons of green located within a highly urbanized surrounding landscape. All of these factors create stressful conditions for habitat patches and their ecosystem functions. Climate change impacts and associated extreme events will exacerbate these stresses and make these patches more vulnerable unless mitigated.

Highly vulnerable wetlands (i.e., those with limited hydrological inputs) covered about 343 ha (1.2% of the natural cover) (see [Section 6.2.5 Climate Vulnerabilities](#) for climate vulnerability indicator scoring methods). These wetlands were distributed throughout the watershed but were concentrated in the more northern areas of the watershed. The hydrology of these highly vulnerable wetlands is not moderated by supplemental sources of water beyond precipitation that might stabilize the hydroperiod during drought conditions.

Highly climate sensitive vegetation communities were limited (30.5 ha or 0.1% of the natural cover) but included several types of treed or open sand barrens, riparian bars, fens, treed bluffs, and tallgrass prairies, woodlands, and savannahs. These vegetation communities represent those most at risk from climate change impacts based on expected changes in hydrology, soil fertility, and natural dynamics that are required for community persistence.

2.2.6 Carbon Storage

Table 16 shows the amount of carbon stored in various natural cover types under current conditions (2020). The Humber River watershed has carbon pools estimated to be storing 7,497,079 MgC (megagrams of carbon; one megagram = one metric tonne). The subwatersheds vary in how much carbon they store ranging from 133,516 MgC in the Black Creek subwatershed to 4,556,908 MgC in the Main Humber subwatershed. This largely reflects the amount of natural cover across subwatersheds, and particularly forest and successional cover which has the highest carbon storage.

Table 16 - The Amount of Carbon Stored in Each Pool Based on Natural Cover Type under Current Conditions (2020)

Natural Land Cover Class	Carbon Storage by Subwatershed (MgC)					
	Black Creek	East Humber	Lower Humber	Main Humber	West Humber	Total Watershed
Forest	100,794	1,339,667	189,285	3,502,252	507,172	5,639,170
Successional Forest	10,117	179,890	21,891	521,349	130,158	863,405
Meadow	21,064	163,885	34,227	343,639	107,658	670,474
Wetland	1,541	79,862	5,350	189,668	47,609	324,030
Beach/Bluff	0	0	0	0	0	0
Total Natural Cover	133,516	1,763,304	250,753	4,556,908	792,598	7,497,079

2.2.7 Urban Forest

The term urban forest **quantifies** the trees and woody shrubs located on all private and public property within a watershed, including urbanized spaces (i.e., along roads) and in forests. One measure of the urban forest is canopy cover, which is the surface area of land covered by the layers of leaves, branches, trunks, and stems of trees and tall shrubs when viewed directly from above. In general, ecosystem services and benefits increase as canopy cover increases. The current canopy cover for the Humber River watershed is approximately 29.1% (26,320 ha), an increase of 0.2% since 2009. The watershed covers a large area and extends over large tracts of rural and urban lands. Portions of Toronto, Brampton, and Vaughan are highly industrialized and commercialized, with high levels of impervious surfaces and managed grass. Further north, Caledon composes approximately 35% of the watershed area and much of that is set aside for agricultural use in which the dominant land cover types are grass/herbaceous and soil/bare ground.

Table 17 identifies the amount of canopy cover (as a percentage) in the watershed and in each subwatershed, as well as percent change in canopy cover since 2009. The Black Creek subwatershed had the biggest net gain of canopy cover at 2.2% (relative to the area of the subwatershed) while the East Humber subwatershed had the largest net loss at -0.9% (relative to area of the subwatershed). The West Humber subwatershed had the lowest canopy cover of any subwatershed in both the baseline and current period, but shows a positive trend, gaining 1.1% since 2009. However, only the East Humber (-0.9%) and Main Humber (-0.2%) subwatershed's declines were statistically significant. See **Map 23** for a map of the distribution of canopy cover across the watershed and **Map 24** for a map of the distribution of canopy cover and canopy cover change by subwatershed. Due to data limitations, there is no spatially explicit canopy cover data for the Township of Adjala-Tosorontio and Town of Mono.

Table 17 - Total Canopy Cover and Trends by Watershed and Subwatershed

	Total Canopy Cover (As a proportion of total area in %)	Trend Assessment (% change since 2009)
Watershed	29.1	+0.2
Main Humber	39.5	-0.2
East Humber	31.3	-0.9
West Humber	15.2	+1.1
Lower Humber	20.9	+0.5
Black Creek	18.3	+2.2

Canopy cover was assessed by land use type across the watershed (see [Figure 9](#) and [Appendix C – Urban Forest Quantity and Quality](#)). The bar labels on [Figure 9](#) indicate the contribution of each land use type to the total canopy cover area as a percent. The ‘Open Space & Other’ classification is made up of a wide variety of land uses including recreational/open space, institutions, golf courses, and cemeteries. While the first and third largest land use types across the watershed are ‘Agriculture & Aggregate Extraction’ and ‘Residential’, the second largest land use type is ‘Forest & Successional Forest’. ‘Forest & Successional Forest’ areas have the highest canopy cover percentage and contribute the most to total canopy cover at 62%, followed by ‘Meadow, Wetland, Lacustrine, Riverine & Beach/Bluff’ and ‘Residential’ areas, which both contribute 14% to total canopy cover.

The City of Toronto, City of Mississauga, City of Vaughan, City of Richmond Hill, and Township of King have set municipal-wide targets for canopy cover of 40% (City of Toronto 2013a), 15-25% (City of Mississauga 2014), 20-25% (City of Vaughan 2020), 30% (City of Richmond Hill, 2020), and 36-41% (Township of King 2022), by 2050 respectively. Municipalities in York Region (Vaughan, Richmond Hill, King, and Aurora) are guided by the recommended total canopy cover targets in the York Region Forest Management Plan (2016). Brampton’s municipal target focuses on the planting of 1 million new trees by 2040. Caledon, Aurora, Adjala-Tosorontio, and Mono have not yet set municipal canopy cover targets. Aurora and Mississauga have less than 2 km² within the boundaries of watershed and have been excluded from detailed discussion.

Within the Humber River watershed, most municipalities are meeting or close to meeting their canopy cover targets (with the exception of Toronto); with a canopy cover estimate for Toronto of 22.2%, Vaughan of 22.2%, Richmond Hill of 26.7%, and King of 33.7%. Of the other municipalities in the watershed, current canopy cover was measured as follows: Brampton has a canopy cover of 22.3%, Caledon of 34.6%, Adjala-Tosorontio of 48.1%, and Mono of 47.9%. Caledon (-0.4%) and Richmond Hill (-3.4%) had statistically significant declines in canopy cover, however the standard error for Richmond Hill’s canopy estimates is high enough that this could be due to low sample size. Other, non-significant declines were seen in Adjala-Tosorontio (-2.0%) and Mono (-2.7%), and increases were seen in Brampton (1.4%), Toronto (0.9%), and Vaughan (0.5%).

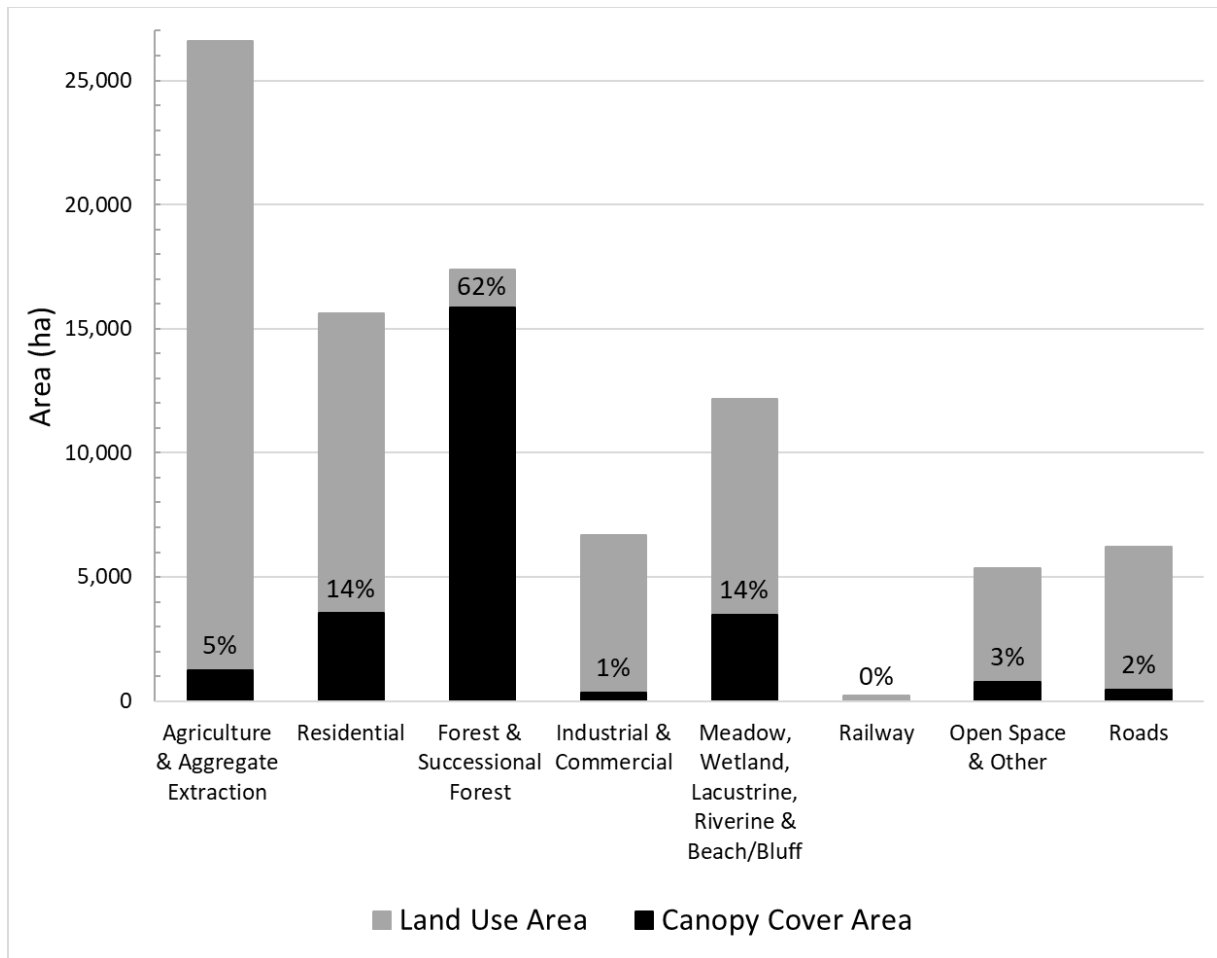


Figure 9 - Land Use Area, Canopy Cover Area, and Proportion of Total Canopy Cover Area Found in Each Land Use Type in 2021

While established canopy cover targets are municipal-scale, it is important to consider watershed-scale targets, especially in such an urbanized watershed. Natural areas play a vital role in contributing to the urban forest throughout the watershed and need to be protected, enhanced, and restored. However, the high levels of urbanization in the watershed necessitates enhancements to canopy cover in residential and other built-up land use types. Additionally, despite making up the largest land use area in the watershed, ‘Agricultural & Aggregate Extraction’ areas only constitute 5% of the total canopy cover area. Although planting opportunities are more restricted in this land use type, increasing planting between farm fields and on pastures can significantly increase canopy cover. This will require partnerships and stewardship initiatives with private landowners. Through this watershed planning process, the establishment of watershed-based canopy cover targets will be established.

In an urban forest, it is important to have trees of various ages and sizes to ensure that there are mature trees to replace older trees as they die and make up for tree losses that occur at all ages. Further, as trees grow, they provide significantly more ecosystem services, such as air pollution removal and reduced rainwater runoff. Protecting medium and large trees is important because of the benefits they provide, as well as caring for small trees to increase the likelihood they reach maturity.

A greater diversity of tree species supports more ecosystem services and increases urban forest resilience. Disturbed and fragmented sites, which are common in the highly urbanized areas of the watershed, are favourable to invasive species introduction and spread. While non-native species can contribute significantly to ecosystems services, some may become invasive and displace native plants making them a potential threat to natural areas. For example, Norway maple (*Acer platanoides*) is aesthetically pleasing and has been commonly planted as a street tree across many municipalities; however, it is considered a top thirty invasive species by TRCA. European buckthorn (*Rhamnus cathartica*) is also a threat that spreads rapidly along disturbed areas such as fence lines, roadsides, and abandoned fields and can reduce biodiversity and habitat quality (Anderson, 2012). To ensure a healthy urban forest into the future, it will be important to increase the diversity and proportion of native species, thus further work should focus on enhancing the healthy composition of tree species by planting diverse native and appropriate non-native species and managing invasive species.

Healthier trees live longer and provide more ecosystem services. Many ecosystem services such as rainfall interception and air pollution removal are directly related to the amount of healthy, functioning leaves. Healthy trees are also more resilient to stressors such as storms and diseases and are less likely to become safety hazards to the public. It is important to monitor changes to the health of the urban forest over time. A decline in forest health or a forest in poor condition may require management intervention. As climate change increases and more invasive species are potentially introduced, it will be critical to monitor the status of trees in the urban forest particularly in natural areas and take actions to help protect their health. This can include planting species which are more heat and drought resistant as well as a greater diversity of trees which can resist introduced species.

A complete analysis of the size distribution, species composition, and health of the urban forest across the watershed was not possible because of the gaps in available data for both the baseline and current period. Baseline and current data were only available for Toronto, Vaughan, Richmond Hill, and King in municipal urban forest study reports and the results pertain to the entire urban forest across each municipality, beyond the boundaries of the watershed. Results are summarized in [Appendix C – Urban Forest Quantity and Quality](#), however meaningful comparisons could not be made to understand trends in urban forest quality due to the data limitations. Future field data collection would support a more comprehensive understanding of the quality of the urban forest in the watershed.

Based on the state of the urban forest in the watershed, management intervention is necessary to increase canopy cover, particularly in land use types and subwatersheds with low canopy cover. Assessing species diversity and evenness, and monitoring and protecting trees and tree health across all age classes contributes to a healthy urban forest. A healthier, diverse, and better distributed urban forest will provide more ecosystem services and will be more resilient to extreme weather events, pests, and diseases.

To sustain terrestrial ecosystems (the NHS and urban forest) in the Humber River watershed, a complete natural system needs to be protected, restored, and enhanced. Specific elements integral to this system include:

- most importantly, maintaining existing natural cover
- protecting natural cover through a robust NHS and urban forest
- creating a fully connected system for wildlife movements

- an absence of physical disturbances (e.g., chemical pollution, noise pollution, habitat loss)
- planting trees that have adequate soil health, soil volumes, and quantities to grow to maturity in residential and other built-up land use types
- quality habitat (e.g., larger areas of natural cover, minimized recreational pressures)
- prioritized management of invasive species

2.3 Surface Water Quality

Characterizing surface water quality is important to understand the overall health of the watershed and is linked to the health of fish, vegetation, and other aquatic life. Tracking changes in water quality over time (i.e., trends) helps to identify threats to the watershed and understand how land use changes are influencing water quality.

Surface water quality is variable throughout the watershed with poorest conditions often in the lower watershed. In general, watersheds with degraded water quality either have more agricultural, or more urbanized land (e.g., industrial, residential, roadways). With increases in impervious surfaces, there is more runoff of contaminants from the land to the watercourses. Agriculture is also a major source of nutrients, such as phosphorus, which, in high concentrations, negatively affects water quality.

Table 5 shows the percentage of water quality samples meeting water quality objectives for 14 water quality parameters (with chloride divided into chronic and acute concentrations) during the current time period (2012-2021) based on data from 11 water quality stations within the watershed. Out of total suspended solids, chloride (chronic and acute), total phosphorus, nitrate, un-ionized ammonia and *E.coli*, only three of these water quality parameters (acute chloride (chronic chloride does not meet targets), nitrate, and un-ionized ammonia) are currently meeting targets in the upper watershed with sites along the Main, East, and West Humber subwatersheds, and only three of these water quality parameters (total suspended solids, nitrate, and un-ionized ammonia) are currently meeting targets in the Lower Humber and Black Creek subwatersheds. In contrast, five of the seven metal water quality parameters (copper, zinc, lead, chromium, and nickel) are currently meeting the watershed level targets. There was no target in the 2008 HRWP for dissolved oxygen. See **Map 25** for a map of the water quality stations in the watershed and the water quality concerns at each station. Water quality parameters identified on **Map 25** do not meet targets in the current time period (2012-2021) at site level/individual long term and temporary water quality stations (temporary stations (n=10) were from 2019 and 2020).

To assess water quality trends over time, both exceedance changes between subsets of the current and baseline time periods and concentration trend analyses were considered. **Table 5** shows the changes (percentage more or less) of samples meeting water quality objectives for each water quality parameter based on a subset of the current period (2016-2021) compared to a subset of the baseline period (2006-2011 baseline). This comparison was based on a subset of six years from nine water quality stations (due to baseline data availability). Since data (e.g., % samples meeting targets) from the current period and the baseline period subset did not always align (and exceedance results differ if the entire current dataset is used), this comparison between current and baseline periods should not be used to assess trends. As a result, a concentration trend analysis was also completed and **Table 18** presents the results of this trend assessment including the percentage of sites for each

water quality parameter where there is an increase (↑), decrease (↓) or no change (↔) in water quality concentrations over time.

Between 2002 and 2021, concentrations of:

- Dissolved oxygen and total suspended solids remain similar.
- Phosphorus is increasing in the headwaters of the Main Humber subwatershed and in the Black Creek subwatershed (these concentration increases did not always result in fewer water quality samples meeting PWQO set to protect aquatic life (e.g., fish, insects), but illustrate, in some cases, that concentrations are still going up).
- Nitrate is increasing in the upper watershed and decreasing in the West, East, Black Creek, and Lower subwatershed outlets.
- Nitrate and total phosphorus, despite site specific increases and decreases, are generally unchanging at approximately half of the monitoring locations.
- Chloride and unionized ammonia are increasing.
- Chloride, cadmium, *E. coli*, un-ionized ammonia, and zinc in streams are increasing both at the mouth of the Humber River and in the headwaters of the Main Humber subwatershed.
- *E. coli*, nickel, and lead are decreasing throughout most of the watershed (however, *E. coli* targets are not being met).
- Zinc, chromium, and cadmium are decreasing in the lower watershed.

There are high amounts of chlorides present throughout the watershed, with increasing trendlines that are above the chronic objective (120 mg/L) in the West Humber, East Humber, Black Creek, and Lower Humber subwatersheds. Notably, the highest chloride concentrations are in the Black Creek subwatershed where the increasing trendline exceeds the acute objective (640 mg/L) in the upper portion of the subwatershed.

Phosphorus continues to be a concern throughout the watershed with trendlines above the water quality objective (30 µg/L) in the headwaters, West Humber and Black Creek subwatersheds, and watershed outlet. In contrast, copper, chromium, lead, and nickel metal concentrations are decreasing, yet there are high amounts of metals present in the Main Humber subwatershed and at the mouth of Humber River in the Lower Humber subwatershed. *E. coli* bacteria also continues to be a concern throughout the watershed but particularly in the West Humber, Lower Humber, and Black Creek subwatersheds.

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Table 18 - Trend Assessment for Water Quality Parameters

Water Quality Parameter and Objective	Subwatershed Location	Trend direction			Trendline Location Relative to Objective in Subwatersheds	Watershed to Lake trend
		↑	↓	↔ ⁴¹		
		(% of sites)				
Total suspended solids (CWQG objective = 30 mg/L)	Main, East and West Humber	14%	29%	57%	Below	↔
	Lower Humber and Black Creek	-	25%	75%	Below	
Chloride (CWQG objective, chronic = 120 mg/L, acute = 640 mg/L)	Main, East and West Humber	100%	-	-	Above in West Humber and East Humber	↑, trendline above chronic objective
	Lower Humber and Black Creek	100%	-	-	Above chronic; above and <i>approaching acute</i> in Upper Humber and Lower Black Creek, respectively	
Total phosphorus (PWQO objective = 30 ug/L)	Main, East and West Humber	29%	43%	29%	Above at 5/7 sites	↔, trendline above objective
	Lower Humber and Black Creek	25%	25%	50%	Above at 3/4 sites	
Nitrates (CWQG objective = 2.93 mg/L)	Main, East and West Humber	29%	29%	43%	Below	↓
	Lower Humber and Black Creek	-	50%	50%	Below	
Un-ionized Ammonia (PWQO objective = 0.02 mg/L)	Main, East and West Humber	86%	-	14%	Below	↑
	Lower Humber and Black Creek	75%	-	25%	Below	
Copper	Entire watershed	27%	36%	36%	Below	↔

⁴¹ No changes in concentrations/no trend

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Water Quality Parameter and Objective	Subwatershed Location	Trend direction			Trendline Location Relative to Objective in Subwatersheds	Watershed to Lake trend
		↑	↓	↔ ⁴¹		
		(% of sites)				
(PWQO objective = 5 ug/L)						
Iron (PWQO objective = 300 ug/L)	Entire watershed	18%	55%	27%	Above the objective at Black Creek and Lower Humber outlet	↔, trendline above objective
Zinc (PWQO objective = 20 ug/L)	Entire watershed	45%	55%	-	Below	↑, trendline <i>approaching</i> objective
Lead (PWQO objective = 5 ug/L)	Entire watershed	-	100%	-	Below	↓
Chromium (PWQO objective = 8.9 ug/L)	Entire watershed	-	64%	36%	Below	↔
Cadmium (PWQO objective = 0.5 ug/L)	Entire watershed	45%	55%	-	Below at 10 sites	↑, trendline above objective
Nickel (PWQO objective = 25 ug/L)	Entire watershed	-	100%	-	Below	↓
<i>Escherichia coli</i> (PWQO objective = 100 CFU / 100 mL)	Main, East and West Humber	-	43%	57%	Above at West Humber outlet	↓, trendline above objective
	Lower Humber and Black Creek	-	75%	25%	Above at Lower and Black Creek outlets	
Dissolved oxygen (PWQO objective = 6 mg/L)	No target outlined	-	-	100%	Above (i.e., sufficient oxygen)	↔

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The four parameters (chlorides, total phosphorus, iron, and *E. coli*) that had the lowest number of samples currently meeting water quality objectives are discussed below. Following the discussion of these four parameters, is additional information on chemicals of emerging concern, microplastics, and spills.

Chlorides

Probable sources of chlorides include road salt application, leaching from salt storage facilities or areas where cleared snow has been relocated, fertilizers, industrial discharge, and natural sources. High chloride concentrations in the lower areas of the watershed are likely a result of urban and industrial areas but may also be influenced by naturally elevated chloride levels in the local bedrock (marine shale). When snow melts, excess salt runs off roads and parking lots overland and into the watercourses. The relationship between chloride concentration and the amount of urban development is strong (Kaushal et al. 2005, Todd and Kaltenecker 2012, Mazumder et al. 2021), and legacy chloride in groundwater may be contributing to increasing summer concentrations (Mazumder et al. 2021).

Chloride concentrations are particularly elevated in the West Humber, East Humber, Black Creek, and Lower Humber subwatersheds aligning with highly urbanized portions of the watershed. While the headwaters of the Main Humber subwatershed are below chronic guidelines (120 mg/L), concentrations significantly increase in the lower Main Humber subwatershed near Highway 7. Most, if not all, samples exceeded the chronic guidelines in all other subwatersheds and temporary sampling stations below Highway 7, also located within urban/industrial areas. Chloride concentrations in the Main Humber subwatershed near Highway 7 and in the Black Creek subwatershed were the most elevated with concentrations exceeding acute guidelines (640 mg/L) nearly 50% of the time. The highest concentrations were observed in the headwaters of Black Creek (more than 12 times the acute guideline) with the majority of samples exceeding the acute guideline.

Phosphorus

Probable sources of phosphorus include fertilizers, animal wastes, and sanitary sewage. Fine textured clay soils, such as those found in the West Humber subwatershed, have been shown in other agricultural systems to contain more adsorbed phosphorus than coarse-sized sands and silts due to the larger surface-to-volume ratio (Sharpley et al., 1992). In general, phosphorus concentrations have declined in streams entering Lake Ontario between 1979 and 2011 predominantly due to reducing phosphorus concentrations in detergents (Stammler et al. 2017, DeBues et al. 2019). Even though phosphorus concentrations have decreased in streams and nearshore areas of Lake Ontario in general, there has been localized nuisance growth of *Cladophora* (i.e., algae), which continues to be a concern (ECCC and United States Environmental Protection Agency 2018). Regardless of these general declines, phosphorus concentrations in the Humber River watershed continue to be high and concentrations are above water quality objectives.

Phosphorus concentrations (similar to nitrate concentrations) are elevated in the West Humber, Black Creek, and Lower Humber subwatersheds. In contrast, there are also sites within the Main Humber subwatershed with median concentrations exceeding the PWQO (30 µg/L), although these sites appear to dilute by the time they reach the upper Lower Humber subwatershed. With well oxygenated waters,

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legacy nutrients within the streambed and respiration/excessive plant growth/decay are likely not the cause of elevated nutrients within the subwatersheds. Elevated phosphorus concentrations at the outlet to the lake are therefore likely attributed to the West Humber and Black Creek subwatersheds, which is suggestive of agriculture and sewage cross-connection issues.

Iron

While iron (and other trace metals such as copper, zinc, and cadmium) are present naturally within the environment, they can be toxic to aquatic life at concentrations above water quality objectives and guidelines. Iron was found throughout the watershed, even in predominantly rural catchments, suggesting the local environment (e.g., weathering, soil characteristics, etc.) may be a significant source.

Iron concentrations exceed guidelines (300 µg/L) in all subwatersheds by up to 22 times the water quality objective (excluding 1 statistical outlier) suggestive of non-point (e.g., environmental) sources. Concentrations appear to be greater in Caledon, Palgrave, Vaughan, Woodbridge, Black Creek, and at the Humber River watershed outlet. The high range of iron concentrations at the watershed outlet, in comparison to outlets of subwatersheds discharging into the Lower Humber subwatershed, suggests there is either a significant iron source within or discharging to the Lower Humber subwatershed.

E. Coli

E. coli are a group of bacteria commonly found in the intestines of warm-blooded animals and indicate the presence of fecal waste in water. Probable sources of *E. coli* include stormwater outfalls, inputs from wildlife, livestock, and domestic animals, and organic fertilizers. Staley et al. (2016) tracked sources of fecal contamination at several sites along the Humber River and Black Creek, in addition to several stormwater outfalls (in the Main Humber, Black Creek, and Lower Humber subwatersheds). The authors found that all river sites usually exceeded PWQOs for recreational water with both human and gull fecal sources at all locations; greater concentrations of human markers indicated pervasive sewage contamination at stormwater outfalls and in the river. Black Creek was highlighted as having prominent sewage cross-connection issues in need of remediation. In the upper watershed, two small wastewater treatment plants, sewage cross-connections with stormwater systems in rural communities, and leaking septic systems were identified as potential *E. coli* sources contributing to samples not meeting water quality objectives. Ruminant contamination was also evident. However, greater concentrations were observed in the mid and lower Humber River suggestive of a greater importance from combined sewer overflows and sewage cross-connections with stormwater systems.

E. coli concentrations were greatest in West Humber, Black Creek, and Lower Humber subwatersheds. While agriculture and livestock likely impact the headwaters, recent data and higher elevations within these subwatersheds suggest that stormwater outfalls, inputs from wildlife, and human fecal sources from sewage cross-connection/contamination issues are more likely sources.

Chemicals of Emerging Concern

Over 200 chemicals of emerging concern have been identified in the Great Lakes. Chemicals of emerging concern include industrial chemicals, household chemicals, fragrances, pharmaceuticals, personal care products, disinfectants, pesticides, and nanomaterials (International Joint Commission (IJC) 2009).

Several chemicals of emerging concern have been studied within the Humber River watershed and their sources have been identified.

PolyCyclic Musks (PCMs) are used as fragrances in many personal care products, including soaps, shampoo, detergents, and deodorants. PCMs are a concern because their chemical structure is similar to persistent organic pollutants (e.g., PolyChlorinated Biphenyls - PCBs), which are widely suspected to have carcinogenic and negative developmental and reproductive effects (Safe 1992). In a 2019 study, the East Humber subwatershed and mid-reaches of the Main Humber subwatershed had greater PCM concentrations than the headwaters of the Main Humber subwatershed, and similar PCM concentrations to rural locations within Rouge River and Little Rouge River. The Lower Humber subwatershed had a similar PCM concentration as Mimico and Etobicoke Creeks but had lower concentrations compared to Highland Creek and the Don River (Wong et al. 2019). Urban sites had higher PCM concentrations compared to rural sites and sources included stormwater, illegal sewer cross connections, and wastewater treatment plant discharges (Wong et al. 2019).

Chemicals of emerging concern have many effects on the natural environment, including a range of negative effects on aquatic life. The Great Lakes basin is home to more than 30 million people and numerous species of plants and wildlife that rely on the lakes for freshwater and habitat. It is important to recognize the land-lake connection and the need to manage these chemicals at their source before they enter waterways.

Microplastics

Microplastics are plastic particles less than 5 mm long. They have been found throughout the world and in the Great Lakes (Driedger et al. 2015). Microplastics degrade slowly releasing toxic chemicals and causing many effects on wildlife (Rochman et al. 2013, Tanaka et al. 2013). Microplastics accumulate along beaches, throughout the water column, and in sediments. Rivers and urban creeks are major pathways for microplastics (Lechner et al. 2014) and research has shown that microplastics in coastal sediments originate in the watersheds and are transported to the coast via tributaries (i.e., streams and rivers) (Ballent et al. 2016).

In and around the watershed, Grbic et al. (2020) found that microplastic concentrations in wastewater and stormwater were greater than agricultural samples, with correlations between concentrations and total road length and end-of-life vehicle facilities. While stormwater contained an abundance of black rubbery particles (possibly tire and road wear particles), fibers were prevalent in wastewater effluent. In the watershed, microfibers were also prevalent in stormwater with potential sources including shedding of clothing/textiles, litter/debris, and building materials. The authors have suggested that microfibers could also be transported to agricultural areas (such as the upper Humber watershed) through sewer sludge where non-agriculture source material was applied.

Other microplastic studies in and around the watershed have shown that microplastic abundance increased by an order of magnitude moving through the lower watershed and the high concentrations were also reflected in high microplastic concentrations observed in Humber Bay. Of the 66 watersheds studied along the north shore of Lake Ontario, the Humber River has one of the highest number of plastic manufacturers, distributors, and service businesses (Ballent et al, 2016).

Microbeads were listed as toxic substances by the federal government in 2016 and a ban on microbeads in health products became law in 2017. A nation-wide manufacture, import, sale, and eventually export ban on six categories of single-use plastic products began in 2022. Depending on what type of plastic manufacturing is occurring in the Humber River watershed, this may alleviate some of the microplastic pollution issues. Further research and monitoring are needed to determine the impacts of restrictions and bans, and the watershed sources (e.g., variation within the watershed, concentrations at stormwater, or combined sewer outfalls) to inform how to modify current practices to treat microplastic pollution before it enters waterways.

Spills

Accidental spills or intentional discharges of contaminants to streams negatively impact water quality and aquatic life (and groundwater quality). The Humber River watershed contains a large amount of industrial and urban land uses, which increases the likelihood of spills. TRCA and municipalities work in collaboration with the MECP to communicate information on recent spills and coordinate monitoring/clean up efforts to achieve the best outcome possible when a spill occurs.

As part of this watershed characterization, TRCA attempted to obtain more recent spills data for the watershed from MECP, but due to delays associated with recent policy changes, the request was not completed in time for inclusion in this report.

In the absence of current data, past reports that examined spill occurrence within the TRCA jurisdiction were reviewed. Between 1988 and 2000, the Humber and Don River watersheds experienced the greatest number of spills throughout all watersheds in Toronto (Li 2002), with approximately 900 oil spills and 750 chemical spills recorded in the Humber River watershed (TRCA 2008); approximately 50% drained to the Humber River or one of its tributaries (TRCA 2008). On a volume basis, the chemical, transportation, and general manufacturing sectors contributed the most to chemical spills, often because of container or fuel tank leaks. Most oil spills were in the lower watershed within highly urbanized lands (Li 2002). Between 2003 and 2005, most spills occurred in the Don River (361) and the Etobicoke Creek (247) watersheds, followed by the Humber River watershed (225; TRCA 2006). Within the Humber River watershed, most spills were to land followed by air, a combination of mediums, and water, and were primarily caused by equipment failure (TRCA 2006). In a study with greater temporal resolution, Cao et al. (2012) identified the Humber River as one of the two major rivers in Southern Ontario with the most spills between 1998 and 2007 and this was attributed to industrial land use within the vicinity.

Recommendations for additional work include creating a geo-coded spills database; identifying spill-prone watersheds/sewersheds; developing sewer use by-laws with emphasis on public education and industrial pollution prevention plans; developing spill control plans (e.g., retrofit stormwater ponds, outfall oil/water separators); and, developing or redeveloping spill response systems. It is very likely that the Humber River watershed continues to be heavily impacted by spills and would benefit from implementing of some of these recommendations.

Targets and Progress from 2008 HRWP

The following water quality targets were established in the 2008 HRWP for water quality parameters: 1) At least 85% of samples of total suspended solids, chloride, total phosphorus, nitrate, and un-ionized ammonia in the Main, East, and West Humber subwatersheds and 75% of samples in the Lower Humber and Black Creek subwatersheds should meet the appropriate CWQC or PWQO objective; 2) At least 90% of samples of metals (copper, iron, zinc, lead, chromium, cadmium, and nickel) should meet the water quality objective; and, 3) At least 60% of samples of *E. coli* bacteria in the Main, East, and West Humber subwatersheds and 50% of samples in the Lower Humber and Black Creek subwatersheds should meet the water quality objective. No target was set for dissolved oxygen.

The following provides a summary of whether each water quality parameter is currently meeting the targets from the 2008 HRWP (also see [Table 5](#)):

- **Total suspended solids** – approximately 83% and 80% of samples met the 30 mg/L objective in the upper and lower watershed, respectively, so the target for the upper watershed (Main, East and West Humber subwatersheds) was not met but the target for the lower watershed (Lower Humber and Black Creek subwatersheds) was met. Although the objective was met in the lower watershed with the data pooled, mid-watershed sites (east, west, and lower main locations) in the “upper” watershed and in the lower watershed by the tributary mouth did not meet targets.
- **Chloride** – only 65% of samples met the 120 mg/L objective for chronic effects, while 99% of the samples met the 640 mg/L objective for acute effects of chloride in the upper watershed. In the lower watershed, only 16% of samples met the 120 mg/L objective for chronic effects, while 73% of the samples met the 640 mg/L objective for acute effects of chloride. So, the only target met was in the upper watershed for acute chloride.
- **Total phosphorus** - approximately 45% and 30% of samples met the 30 µg/L objective in the upper and lower watershed, respectively, so the targets were not met.
- **Nitrates** - approximately 99% and 100% of samples met the 2.93 mg/L objective in the upper and lower watershed, respectively, so the targets were met.
- **Un-ionized ammonia** - approximately 99% and 94% of samples met the 0.02 mg/L objective in the upper and lower watershed, respectively, so the targets were met.
- **Copper** - approximately 90% of samples met the 5 µg/L objective, so the watershed-scale target was met.
- **Iron** - approximately 49% of samples met the 300 µg/L objective, so the watershed-scale target was not met.
- **Zinc** - approximately 90% of samples met the 20 µg/L objective, so the watershed-scale target was met.
- **Lead** - approximately 97% of samples met the 5 µg/L objective, so the watershed-scale target was met.

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- **Chromium** - approximately 99% of samples met the 8.9 µg/L objective, so the watershed-scale target was met.
- **Cadmium** - approximately 79% of samples met the 0.5 µg/L objective, so the watershed-scale target was not met.
- **Nickel** - 100% of samples met the 25 µg/L objective, so the watershed target was met.
- ***E. coli*** - approximately 56% and 21% of samples met the 100 CFU/100 mL objective in the upper and lower watershed, respectively, so the targets for the upper and lower watershed were not met.
- **Dissolved oxygen** – although no target was set in the 2008 HRWP, on a site-by-site basis, 97-100% of samples were greater than the 6 mg/L objective, with 99% of the samples meeting the objective at the watershed scale.

2.4 Natural Hazards

One of the main responsibilities of TRCA is to protect life and property from natural hazards (i.e., riverine flooding and erosion risks). As part of watershed characterization, TRCA assessed the current flood and erosion risks in the watershed.

2.4.1 Flooding

Riverine flood risk is well understood within the Humber River watershed; floodplain mapping and the underlying hydrology model have been updated within the last decade, and further refinements to the floodplain mapping are currently underway. Riverine flooding occurs when water levels rise, and the streams overtop their banks. Urban flooding, on the other hand, is caused by limited capacity of stormwater infrastructure or drainage systems. Historically, urbanization has generally increased flood risk by altering the volume, intensity, and timing of runoff to streams. This is especially true for areas that were built without stormwater management features in place (i.e., developments pre-1980s).

The Regulatory Floodplain is the approved standard used in a particular watershed to define the limit of the floodplain for regulatory purposes. Within TRCA's jurisdiction, the Regulatory Floodplain is based on the flood resulting from the regional storm (i.e., the greater of Hurricane Hazel or the 100-year return period) applied to the watershed developed to an approved future planning horizon (e.g., 2031) without controls.



Figure 10 - Flooding after Storm Event, Jane Street North of Steeles Avenue. Photo taken August 9, 2011.



Figure 11 - Flooding after Storm Event, Toronto Works Yard, off Black Creek Drive. Photo taken July 8, 2020.

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Table 19 provides the estimated amounts of developed (e.g., buildings and infrastructure) and undeveloped (e.g., open space and natural) land within the Regulatory Floodplain by subwatershed (based on 2020 land use data). The Black Creek subwatershed has the highest amount of developed land (229 ha) and Lower Humber and West Humber subwatersheds have the lowest (85 ha and 95 ha, respectively). The Main Humber subwatershed has the highest amount of undeveloped land (3,363 ha) and the Black Creek subwatershed has the lowest (302 ha). The estimates in **Table 19** exclude spills, the extents of which are currently not known. Developed land is susceptible to flooding under the most severe storm events.

Table 19 - Developed / Undeveloped Land Use in the Regulatory Floodplain

	Developed Land (ha)	Undeveloped Land (ha)
Main Humber Total ⁴²	138	3,363
Main Humber	34	1,054
Upper Main Humber	68	1,861
Rainbow Creek	36	448
East Humber	132	1,793
West Humber	95	2,044
Lower Humber	85	752
Black Creek	229	302

Hypothetically, flood risk as defined by the Regulatory Floodplain should not significantly change between the baseline and current periods because it is based on future development conditions; however, data-driven techniques such as model recalibration, validation, and general refinement (e.g., higher resolution topographic information), as well as policy-driven processes such as Official Plan Amendments, may result in a current Regulatory Floodplain that is somewhat different than the previous versions used to regulate land use in years past. Looking at TRCA’s identified FVCs can provide a nuanced understanding of how urbanization impacts flood risk during the baseline and current conditions, as these areas have historically experienced, or are likely to experience, flooding during less intense events than the Regulatory storm.

Seven of the 41 FVCs within TRCA’s jurisdiction are located in the Humber River watershed, representing approximately 1.2% of the area of the watershed (excluding spills such as those present in the Woodbridge and Edgeley/Vaughan Centre FVCs). **Table 20** identifies the storm events at which flooding becomes an issue for each FVC. **Map 26** presents the location of the seven FVCs in the watershed.

⁴² For the Humber River watershed characterization, the Rainbow Creek subwatershed is combined with the Main and Upper Main Humber subwatersheds, which is collectively referred to as the “Main Humber” subwatershed. Rainbow Creek flows roughly parallel to Highway 50 from around Healey Road down to Highway 407, and Upper Main Humber is the upper portion of the Main Humber subwatershed.

Table 20 - Flood Risk by Storm Event

Flood Vulnerable Cluster	Risk by Storm Event
Albion Road	Risk at 50-year event and above
Bolton Core	Risk at 5-year event and above
Edgeley/Vaughan Centre	Risk at 25-year event and above
Jane/Wilson	Risk at 5-year event and above
Lake Wilcox	Risk at 2-year event and above
Rockcliffe	Risk at 5-year event and above
Woodbridge	Risk at 10-year event and above

Comparing the change in total impervious area, the watershed experienced relatively significant development during the baseline period (2002 to 2011), which tapered off considerably during the current period (for land use changes/calculations of total impervious area the current period is 2012 to 2020 and is based on 2002, 2012, and 2020 using land use mapping)⁴³. In both periods, the West Humber, East Humber, and Rainbow Creek subwatersheds (which as noted above is part of the larger Main Humber subwatershed) experienced the most development. The West Humber subwatershed had the greatest increase in impervious area of 4,933 ha from 2002 to 2020, while the East Humber and Rainbow Creek subwatersheds had respective increases of 899 ha and 701 ha in the same period. The Rainbow Creek subwatershed had the greatest increase in imperviousness (i.e., impervious area relative to the size of the subwatershed) of 17.7% to 37.0% from 2002 to 2020. In the same period, the imperviousness of the West Humber subwatershed increased from 14.2% to 23.1% and that of the East Humber subwatershed increased from 11.0% to 16.4%. The Black Creek and Lower Humber subwatersheds are generally considered to be fully built out and did not observe significant development in both periods. TRCA's stormwater management criteria for quantity control aims to prevent the off-site impacts of development (e.g., increasing flood risk elsewhere in the system), typically through some version of controlling post-development flows to pre-development levels or, in some cases, overcontrol of post-development flows. However, changes in the hydrologic characteristics of individual subwatersheds can be compounded where these major watercourses confluence and where some of the FVCs are located; for example, the Woodbridge and Albion Road FVCs.

Table 5 and **Table 21** present a summary of the results of the flood risk assessment. The peak flows are based on the 100-year inflows at various points for the seven FVCs within the Humber River watershed. The 100-year return period is a typical level of service for quantity control ponds. The west tributary to the Woodbridge FVC observed no significant changes in peak flow from the baseline to current period, which seems to correlate with the contributing subwatersheds (Upper Main and Main Humber) having

⁴³ Impervious cover for flood risk calculations is slightly different from the numbers presented in **Section 2.1.9** (for aquatic habitat quality), as water is assigned to be 100% impervious in terms of flood risk but 0% impervious from an ecological/aquatic habitat perspective.

the lowest changes in impervious area during those periods and is in line with the objectives of TRCA's stormwater management criteria. However, the east tributary to the Woodbridge FVC (East Humber) observed a 17.0% increase in peak flow during the baseline period and a 3.0% decrease in the current period, though the East Humber observed a relatively low change in imperviousness. Going downstream of the Woodbridge FVC, the east tributary to the Albion Road FVC observed a 7.8% increase in the baseline period and a 2.6% increase in the current period, which reflects the changes in peak flow from the East Humber subwatershed routed through the Woodbridge FVC compounded with the peak flow changes from Rainbow Creek. In contrast, the west tributary (West Humber) to the Albion Road FVC observed a 4.7% *decrease* in peak flow during the baseline period and no significant changes in the current period, despite the relatively large increase in imperviousness of the contributing drainage area. The hydrologic characteristics of the East Humber and Rainbow Creek, as well as the history of stormwater management in those subwatersheds, warrant further discussion.

The West Humber and East Humber both have approximately 200 km² of drainage area, with respective drainage densities of about 2.4 km/km² and 2.1 km/km². Hydrologically, the East Humber is characterized by permeable soils, kettle lakes, and good forest cover, while the West Humber is characterized by comparatively tighter soils and low forest cover. These hydrologic differences are further highlighted by historically low peak flows observed from stream gauge data of the East Humber compared to those observed in the West Humber. The Rainbow Creek subwatershed is about 52 km², with a drainage density of about 2.3 km/km²; it is hydrologically similar to the West Humber, characterized by impermeable soils and low forest cover, so high peak flows were historically expected in Rainbow Creek. However, it was not until 2004 that Rainbow Creek was gauged, and therefore calibrated, separately from the Main Humber. By then, unitary flows for quantity control developed by Aquifor Beech in the 1997 Humber River watershed hydrology update were being implemented, with the West Humber criteria being applied to Rainbow Creek.

The unitary flow approach, in short, is a stormwater management strategy that estimates target 2 to 100-year release rates for proposed development by relating the subject area to the design flows of its parent subwatershed in the 1997 hydrology. The East Humber subwatershed pre-development flows from the 1997 hydrology, while relatively low in that study, are still significantly higher than what the baseline models for the current work are predicting for a similar period. This may partly explain why the East Humber peak flows increase in the baseline and current period models even though the relevant and most up to date stormwater management facility information was incorporated into each period; it is possible that stormwater management infrastructure implemented in those periods had higher target release rates. For the historic reasons discussed previously, stormwater management facilities in Rainbow Creek are typically sized using the West Humber unitary flows, which could be considered conservative because these targets factor in the flood routing provided by the Claireville Dam; however, the increasing peak flows from the baseline to current conditions of Rainbow Creek suggests that flood control criteria specific to the hydrologic characteristics of the subwatershed should be evaluated. Indeed, similar observations about the East Humber and Rainbow Creek were also highlighted in the report for the 2015 hydrology update by Civica Infrastructure.

Targets and Progress from 2008 HRWP

The 2008 HRWP established two targets related to flood risk including: 1) To maintain or reduce existing peak flows for 2-to-100-year return period events; and, 2) To reduce or maintain baseline number of flood vulnerable areas and roads (based on most recent update to TRCA database).

Regarding the first target, the 1997 hydrologic model was updated in 2002 by Aquifor Beech, which was then used for setting flood risk targets in the 2008 HRWP. The watershed model was updated again in 2015 (with a 2018 addendum) by Civica Infrastructure, which discretized the watershed into a greater number of subcatchments than the 2002 update and used different parametric approaches to incorporate such details as internally draining areas (i.e., Hummocky terrain in the headwaters), as well as the differences in hydrologic response between minor and major rainfall events. Though the respective existing conditions scenarios of the 2002 and 2015/2018 models would roughly cover the baseline period for the current work, a direct comparison is not recommended due to the structural and parametric differences between the two models. Therefore, the 2015/2018 model was modified to reflect baseline and current land cover and use, while preserving its overall structure and calibration factors; this reasonably ensures that baseline, current, and future peak flow analyses use the same base model, with same attendant errors and assumptions. As noted above and with few exceptions, the changes in peak flow over the baseline and current periods, which incidentally encompasses the period of the 2008 HRWP, are generally not significant. The peak flows and changes (%) between the current and baseline periods for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storms is presented in [Table 21](#).

Regarding the second target, the number of flood vulnerable areas and roads have remained consistent with the 2008 HRWP. More recent studies have grouped the areas and roads into broader areas/communities or clusters (i.e., FVCs) to assess which areas need a greater level of study for a given risk. Since the 2008 HRWP, TRCA has undertaken numerous studies to evaluate the feasibility of infrastructure solutions (e.g., Environmental Assessments) to flooding in the FVCs, specifically the Bolton Berm in the Bolton FVC, and the complex riverine and drainage infrastructure affecting the Rockcliffe FVC. The maintenance of flood control infrastructure, such as dams and channels, and keeping the associated operating procedures up to date, contributes to managing the flood risk of the FVCs. For example, the Claireville dam regulates flood flows from the West Humber, which is the west tributary to the Albion Road FVC, and the Black Creek dam attenuates some flows entering the Jane/Wilson FVC, which also has downstream effects on the Rockcliffe FVC. To date, only the Environmental Assessment work to address flooding in the Rockcliffe FVC has proceeded beyond assessing feasibility to a level of pre-design. The recommended flood protection measures target the 350-year level of protection or greater.

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Table 21 - Peak Flows and Changes (%) between Current and Baseline Periods for Various Design Storms at Each Flood Vulnerable Cluster

Flood Vulnerable Clusters	Peak flows (m ³ /s) and Changes (%) between Periods									
	2-year			Changes		5-year			Changes	
	2002	2012	2020	Baseline	Current	2002	2012	2020	Baseline	Current
Albion Road FVC, West Tributary	36.8	38.7	38.8	+ 5.0%	+ 0.3%	55.7	58.3	58.7	+ 4.4%	+ 0.7%
Albion Road FVC, East Tributary	36.2	43.0	46.3	+ 15.8%	+ 7.0%	59.1	66.4	70.6	+ 11.0%	+ 5.9%
Albion Road FVC, Southwest Tributary	21.5	21.9	22.0	+ 2.1%	+ 0.2%	30.6	31.2	31.2	+ 1.8%	+ 0.1%
Bolton Core FVC, West Tributary	4.7	5.1	5.2	+ 8.0%	+ 0.3%	8.6	8.6	8.7	+ 0.4%	+ 1.4%
Bolton Core FVC, North Tributary	3.0	3.3	3.3	+ 8.9%	-	4.6	5.0	5.0	+ 7.2%	-
Edgeley/Vaughan Centre FVC	4.9	5.2	5.5	+ 4.7%	+ 5.4%	7.2	7.5	7.9	+ 3.9%	+ 4.9%
Jane/Wilson FVC	24.5	24.9	24.8	+ 1.6%	- 0.2%	36.1	36.6	36.5	+ 1.1%	- 0.3%
Lake Wilcox FVC at Lake Wilcox	4.2	5.1	5.3	+ 17.6%	+ 2.4%	5.9	7.1	7.3	+ 16.8%	+ 2.1%
Lake Wilcox FVC at Yonge St.	1.3	1.5	1.4	+ 9.9%	- 1.9%	1.9	2.1	2.1	+ 9.2%	- 2.0%
Lake Wilcox FVC at Regatte Ave.	2.8	3.5	3.4	+ 19.5%	- 1.6%	4.1	4.9	4.9	+ 17.0%	- 1.3%
Lake Wilcox FVC at Humberland Dr.	4.3	4.7	4.7	+ 8.3%	-	6.2	6.7	6.7	+ 7.3%	-
Lake Wilcox FVC at Bathurst St.	4.9	6.1	6.1	+ 20.8%	- 0.6%	7.6	9.5	9.4	+ 19.9%	- 0.5%
Rockcliffe FVC	54.4	57.1	57.1	+ 4.6%	-	83.3	87.4	87.3	+ 4.6%	- 0.1%
Woodbridge FVC, West Tributary	10.2	11.8	12.2	+ 13.3%	+ 3.6%	14.3	18.5	19.0	+ 22.7%	+ 2.8%
Woodbridge FVC, East Tributary	10.5	13.8	13.2	+ 23.5%	- 3.9%	19.1	24.0	23.1	+ 20.3%	- 3.6%

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Flood Vulnerable Clusters	Peak flows (m ³ /s) and changes (%) between periods									
	10-year			Changes		25-year			Changes	
	2002	2012	2020	Baseline	Current	2002	2012	2020	Baseline	Current
Albion Road FVC, West Tributary	123.0	119.7	121.2	- 2.8%	+ 1.3%	165.2	159.1	160.4	- 3.9%	+ 0.8%
Albion Road FVC, East Tributary	92.7	103.0	109.3	+ 10.0%	+ 5.8%	120.1	129.2	138.7	+ 7.1%	+ 6.9%
Albion Road FVC, Southwest Tributary	46.1	47.8	47.8	+ 3.6%	-	58.5	59.3	59.3	+ 1.5%	-
Bolton Core FVC, West Tributary	22.1	22.3	22.4	+ 0.8%	+ 0.7%	30.1	30.2	30.4	+ 0.5%	+ 0.7%
Bolton Core FVC, North Tributary	22.8	22.8	22.9	- 0.1%	+ 0.5%	32.0	31.7	32.0	- 0.8%	+ 1.0%
Edgeley/Vaughan Centre FVC	11.6	11.9	12.7	+ 2.6%	+ 6.3%	14.9	15.3	15.8	+ 2.1%	+ 3.6%
Jane/Wilson FVC	58.3	59.1	60.1	+ 1.3%	+ 1.7%	73.2	81.9	83.1	+ 10.7%	+ 1.4%
Lake Wilcox FVC at Lake Wilcox	7.2	8.6	8.7	+ 16.1%	+ 1.9%	8.8	10.4	10.6	+ 15.7%	+ 1.6%
Lake Wilcox FVC at Yonge St.	2.6	2.8	2.8	+ 9.5%	- 1.7%	3.4	3.7	3.6	+ 8.2%	- 1.3%
Lake Wilcox FVC at Regatte Ave.	5.0	5.9	5.9	+ 15.8%	- 1.1%	6.3	7.4	7.3	+ 13.9%	- 0.9%
Lake Wilcox FVC at Humberland Dr.	7.5	8.1	8.1	+ 6.7%	-	9.5	10.1	10.1	+ 6.0%	-
Lake Wilcox FVC at Bathurst St.	9.9	12.2	12.1	+ 18.5%	- 0.7%	13.1	15.8	15.7	+ 16.7%	- 0.6%
Rockcliffe FVC	142.0	144.8	145.1	+ 2.0%	+ 0.2%	169.6	176.2	176.4	+ 3.7%	+ 0.1%
Woodbridge FVC, West Tributary	53.3	55.0	55.4	+ 3.2%	+ 0.7%	71.7	71.5	72.1	- 0.2%	+ 0.7%
Woodbridge FVC, East Tributary	26.5	32.5	31.4	+ 18.4%	- 3.6%	37.7	43.6	43.3	+ 13.5%	- 0.5%

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Flood Vulnerable Clusters	Peak flows (m ³ /s) and Changes (%) between Periods									
	50-year			Changes		100-year			Changes	
	2002	2012	2020	Baseline	Current	2002	2012	2020	Baseline	Current
Albion Road FVC, West Tributary	200.6	191.4	192.3	- 4.8%	+ 0.4%	233.9	223.0	223.1	- 4.7%	+ 0.1%
Albion Road FVC, East Tributary	144.8	156.9	161.7	+ 7.7%	+ 2.9%	170.9	184.3	189.1	+ 7.8%	+ 2.6%
Albion Road FVC, Southwest Tributary	67.7	68.6	68.6	+ 1.4%	- 0.1%	76.9	77.8	77.8	+ 1.2%	-
Bolton Core FVC, West Tributary	37.4	37.3	37.7	- 0.4%	+ 1.2%	45.2	45.2	45.6	- 0.2%	+ 0.9%
Bolton Core FVC, North Tributary	39.6	39.5	39.7	- 0.2%	+ 0.5%	47.9	47.8	48.0	- 0.3%	+ 0.5%
Edgeley/Vaughan Centre FVC	17.3	17.6	18.2	+ 1.9%	+ 3.3%	19.6	20.0	20.6	+ 1.8%	+ 3.3%
Jane/Wilson FVC	90.5	99.9	101.4	+ 9.4%	+ 1.5%	108.9	116.9	118.9	+ 7.4%	+ 1.7%
Lake Wilcox FVC at Lake Wilcox	10.1	11.9	12.1	+ 15.2%	+ 1.6%	11.4	13.5	13.7	+ 17.7%	+ 1.5%
Lake Wilcox FVC at Yonge St.	4.0	4.4	4.3	+ 7.9%	- 1.1%	4.7	5.1	5.0	+ 7.9%	- 1.0%
Lake Wilcox FVC at Regatte Ave.	7.3	8.4	8.3	+ 13.0%	- 0.8%	8.3	9.5	9.4	+ 13.8%	- 0.7%
Lake Wilcox FVC at Humberland Dr.	10.9	11.6	11.6	+ 5.6%	-	12.4	13.1	13.1	+ 5.6%	-
Lake Wilcox FVC at Bathurst St.	15.8	18.6	18.5	+ 15.3%	- 0.5%	18.4	21.5	21.4	+ 16.9%	- 0.5%
Rockcliffe FVC	193.5	198.7	198.9	+ 2.6%	+ 0.1%	223.3	225.8	226.2	+ 1.1%	+ 0.2%
Woodbridge FVC, West Tributary	85.5	85.5	86.1	- 0.1%	+ 0.8%	100.7	100.7	101.4	- 0.1%	+ 0.8%
Woodbridge FVC, East Tributary	47.2	55.8	54.1	+ 15.4%	- 3.1%	57.7	67.5	65.5	+ 17.0%	- 3.0%

2.4.2 Erosion Risk

Over time, it is normal for watercourses to naturally change, with erosion playing an important part in watercourse evolution. Erosion hazards become a risk when a changing watercourse negatively impacts infrastructure or property. For example, a river can become deeper over time and expose a sanitary sewer crossing underneath it, or a shifting river can encroach onto a public trail or private property. Erosion rates can be significantly increased due to human changes to a watershed. For example, paving the watershed to facilitate urbanization can increase flow volumes and velocity in watercourses. This, in turn, increases the potential for erosion in the receiving watercourses. Rerouting natural drainage patterns and concentrating runoff to stormwater outfalls can increase the risk for erosion as well. The introduction of infrastructure (e.g., watermain, sanitary sewers, trails etc.) within river valleys increases the number of locations where erosion hazards may become a risk. This erosion characterization for the Humber River watershed attempts to quantify the types and magnitude of these potential erosion risk areas based on the fluvial geomorphological stability and the sensitivity of the watercourses to erosion, as well as the location of infrastructure.

A watershed wide fluvial characterization exercise was previously conducted in 2001 where 35 fluvial geomorphic monitoring sites were established and analyzed. The study conducted in 2001 (and reported in the 2008 Humber River State of the Watershed Report – Fluvial Geomorphology) provides the majority of baseline data for this erosion assessment. Baseline conditions were also determined using geomorphic survey data from the years 2004/2005, 2007/2008, and 2010. Some sites were also surveyed in 2008. In 2021, TRCA undertook another round of geomorphic monitoring to collect fluvial data for analysis to inform the current conditions of the watershed. Detailed fluvial analysis was undertaken to help characterize the change in the watershed between baseline and current conditions. [Map 27](#) shows the location of the various fluvial geomorphic monitoring sites established as part of the RWMP and the reaches associated with these sites.

Erosion Stability and Sensitivity

To determine reach channel stability for each subwatershed, a number of stability parameters were assessed including entrenchment ratio, bank angle, inter-pool slope ratio, width to depth ratio, and substrate sorting. To determine the erosion sensitivity of stream reaches for each subwatershed, a number of sensitivity parameters were assessed including Specific Stream Power Ratio, erosion control structure density, cross sectional changes, Rapid Geomorphic Assessment, and shear stress ratio. Parameter rating thresholds for each of these values were determined and weight averaged to obtain an overall stability and sensitivity value (see [Section 6.4.2 Erosion Risk](#) and below for details on the thresholds and parameter weights). The definitions for each of these parameters is also provided below.

[Table 22](#) provides a list of qualitative reach stability ratings based on geomorphic data collected in 2001 and in 2021, as well as reach sensitivity ratings for the 2021 data set for each subwatershed. Not all subwatersheds contain the same number of geomorphic monitoring sites. Based on the 22 sites surveyed in 2021, two sites have high channel stability (decrease from 4 sites in 2001), 18 sites have moderate channel stability (increase from 14 sites in 2001), and two sites have low channel stability (decrease from 4 sites in 2001). Based on the 22 sites surveyed in 2021, 12 sites have high channel sensitivity, nine sites have moderate channel sensitivity, and one site has low channel sensitivity.

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Table 22 - Reach Stability (2001 and 2021) and Reach Sensitivity (2021 Ratings)

Sub-watershed	Site	Stability		Sensitivity
		2001	2021	2021 ⁴⁴
West Humber	GHU-3 ⁴⁵	Low	-	High
	GHU-8	Moderate	-	Moderate
	GHU-9	Moderate	-	High
	GHU-10	Moderate	-	High
	GHU-14	High	High	High
	GHU-15	Low	-	Moderate
	GHU-16	Moderate	Moderate	Moderate
	GHU-17	Low	Moderate	Moderate
	GHU-18	Moderate	Moderate	High
	GHU-19	Low	-	Low
East Humber	GHU-11	Moderate	Moderate	Moderate
	GHU-20	High	Moderate	High
	GHU-22	Moderate	-	High
	GHU-23	Moderate	-	High
	GHU-24	Moderate	Moderate	Moderate
	GHU-25	Moderate	-	High
	GHU-30	Low	-	Moderate
Black Creek	GHU-4	Moderate	Moderate	Moderate
Main Humber	GHU-6	Moderate	Moderate	High
	GHU-7	High	Moderate	High
	GHU-12	Moderate	High	High
	GHU-13	Moderate	-	Moderate
	GHU-21	Moderate	Moderate	High
	GHU-26	High	Moderate	Moderate
	GHU-27	Moderate	Moderate	High
	GHU-28	Moderate	Moderate	Moderate

⁴⁴ Erosion sensitivity was not analyzed for the baseline period.

⁴⁵ **GHU-3** format/shading indicates a site monitored in 2001 only, and **GHU-14** format/shading indicates a site monitored in 2001 and 2021.

Sub-watershed	Site	Stability		Sensitivity
		2001	2021	2021 ⁴⁴
	GHU-29	Low	Moderate	High
	GHU-31	Moderate	-	Low
	GHU-32	Low	-	Low
	GHU-33	Low	Low	Low
	GHU-34	Moderate	Moderate	Moderate
	GHU-35	Moderate	Moderate	Moderate
Lower Humber	GHU-1	Moderate	Moderate	High
	GHU-2	Low	Moderate	High
	GHU-5	Moderate	Low	High

Table 23 lists the number of geomorphic monitoring sites in each subwatershed that were initially set up in 2001 (35 sites), the number of sites that were surveyed in 2021 (22 sites), the overall/averaged reach stability score (and change in stability score between 2001 and 2021) for each subwatershed, and the overall/average reach sensitivity ratings in 2021 for each subwatershed. In terms of reach stability, all subwatersheds are categorized as having moderate channel stability in 2021 (with the Black Creek, Main Humber, and Lower Humber subwatersheds showing an increase in channel stability from 2001). In terms of reach sensitivity, all subwatersheds, in 2021, are categorized as highly sensitive with the exception of Black Creek which is categorized as moderately sensitive. However, the sensitivity rating for Black Creek is only based on one site.

Table 23 - Subwatershed Averaged Reach Stability and Reach Sensitivity Scores

Subwatershed	Total # of sites (set up in 2021)	# of sites surveyed in 2021	Overall Stability Score ⁴⁶			Overall Sensitivity Rating 2021 ⁴⁷
			2001	2021	% Diff ⁴⁸	
West Humber	10	4	6.3 (moderate)	6.0 (moderate)	4%	2.4 (high)

⁴⁶ Categorization: **Stability scores** – 0 to 4 *low stability*, 5 to 7 *moderate stability*, and 8 to 10 *high stability*.

⁴⁷ Categorization: **Sensitivity scores** – 1 *low sensitivity*, 2 *moderate sensitivity*, 3 *high sensitivity* (≥ 2.0 *highly sensitive*).

⁴⁸ The negative percent difference numbers in this table indicate an increase in stability.

Subwatershed	Total # of sites (set up in 2021)	# of sites surveyed in 2021	Overall Stability Score ⁴⁶			Overall Sensitivity Rating 2021 ⁴⁷
			2001	2021	% Diff ⁴⁸	
East Humber	7	3	6.7 (moderate)	6.0 (moderate)	10%	2.6 (high)
Black Creek	1	1	5.0 (moderate)	6.0 (moderate)	-20%	2.0 (moderate)
Main Humber	14	11	5.7 (moderate)	6.2 (moderate)	-8%	2.2 (high)
Lower Humber	3	3	4.3 (low)	5.7 (moderate)	-31%	3.0 (high)

Table 24 shows the subwatershed level results for the following **stability parameters**.

- Entrenchment Ratio (ER) is a ratio of the floodprone width and the bankfull width. The floodprone width is the width of the channel measured at an elevation equivalent to two times the mean bankfull depth. Higher Entrenchment Ratio values indicate that these channels have floodplains that are easily accessible in flood conditions.
- Bank Angle (BA) refers to bank angle measured from the low flow channel elevation on the bank to the bankfull elevation on the steeper of the right or left bank of the channel.
- Inter-Pool Slope Ratio (IPR) refers to the ratio of the inter-pool slope (slope between pools in a given reach) to the bankfull slope.
- Width to Depth Ratio (W:D) is the ratio of channel width and channel mean depth.
- Substrate sorting is a parameter that demonstrates the range of channel bed substrate sizes. Poorly sorted substrates contain a variety of grain sizes whereas well sorted substrates have a limited variety of sediment sizes. A “stable” channel has a variety of sediment sizes on its channel bed.

Table 24 provides mostly a qualitative assessment of the existing state in terms of stability as well as an assessment of trends exhibited between 2001 and 2021 for those sites studied within each subwatershed for both years. **Map 28** and **Figure 12** show the reach stability results/maps for the reaches surveyed in 2021, and **Figure 12** also shows the results/maps for the parameters that make up reach stability (including ER, BA, IPR, W:D, and Substrate Sorting). **Section 6.4.2 Erosion Risk** provides details about the stability ratings.

Table 24 - Summary of Stability Parameter Results by Subwatershed

Sub-watershed	Parameter	Summary Results ⁴⁹ shows the subwatershed level results for the following stability parameters	
West Humber	ER	↓	80% reduction, indicating reduction in the channel's access to the floodplain
	BA	↓	Bank angles showed some steepening and hence reduction in bank stability
	IPR	↓	Reduction in stability due to increase in the divergence of the Inter-Pool Slope from Bankfull Slope
	W:D	↓	Slight reduction in stability due to reduction in width to depth ratio over time
	Sorting	↑	Sorting scores show well graded sediments. No evident substrate related indicators showing channel aggradation and degradation.
East Humber	ER	↓	100% reduction, indicating reduction in the channel's access to the floodplain
	BA	↑	Bank angles were noted to be less steep in 2021 than in 2001
	IPR	→, ●	No change in trend, moderate divergence between Inter-Pool and Bankfull Slopes
	W:D	→, ●	No change in trend, average width to depth values noted
	Sorting	↑	Sorting scores show well graded sediments. No evident substrate related indicators showing channel aggradation and degradation.
Black Creek	ER	↓	100% reduction, indicating reduction in the channel's access to the floodplain
	BA	↑	Bank angles were noted to be less steep in 2021 than in 2001
	IPR	●	Average values noted in 2021; no data available for 2001.
	W:D	→, ●	No change in trend, high width to depth score denoting channel stability
	Sorting	↑	Sorting scores show well graded sediments. No evident substrate related indicators showing channel aggradation and degradation.
Main Humber	ER	↓	75% reduction, indicating reduction in the channel's access to the floodplain
	BA	↑	Bank angles were noted to be less steep in 2021 than in 2001
	IPR	↓	Reduction in stability due to slight increase in the divergence of the Inter-Pool Slope from Bankfull Slope
	W:D	→, ●	No change in trend, average width to depth values noted
	Sorting	↑	Sorting scores show well graded sediments. No evident substrate related indicators showing channel aggradation and degradation.
	ER	↓	50% reduction, indicating reduction in the channel's access to the floodplain

⁴⁹ The symbols in **Table 24** (●, ●, ●) denote high, average and low values for the parameter assessed, respectively. Similarly, ↑, ↓, and → indicate increasing, decreasing, and stable trends, respectively, for the parameter assessed. These symbols were used where data were both available and clearly converged on a result.

Sub-watershed	Parameter	Summary Results ⁴⁹ shows the subwatershed level results for the following stability parameters
Lower Humber	BA	→ No notable change in bank angles over time
	IPR	↓ Reduction in stability due to increase in the divergence of the Inter-Pool Slope from Bankfull Slope
	W:D	↓, • Reduction in channel stability noted; low width to depth ratio scores
	Sorting	↑ Sorting scores show well graded sediments. No evident substrate related indicators showing channel aggradation and degradation.

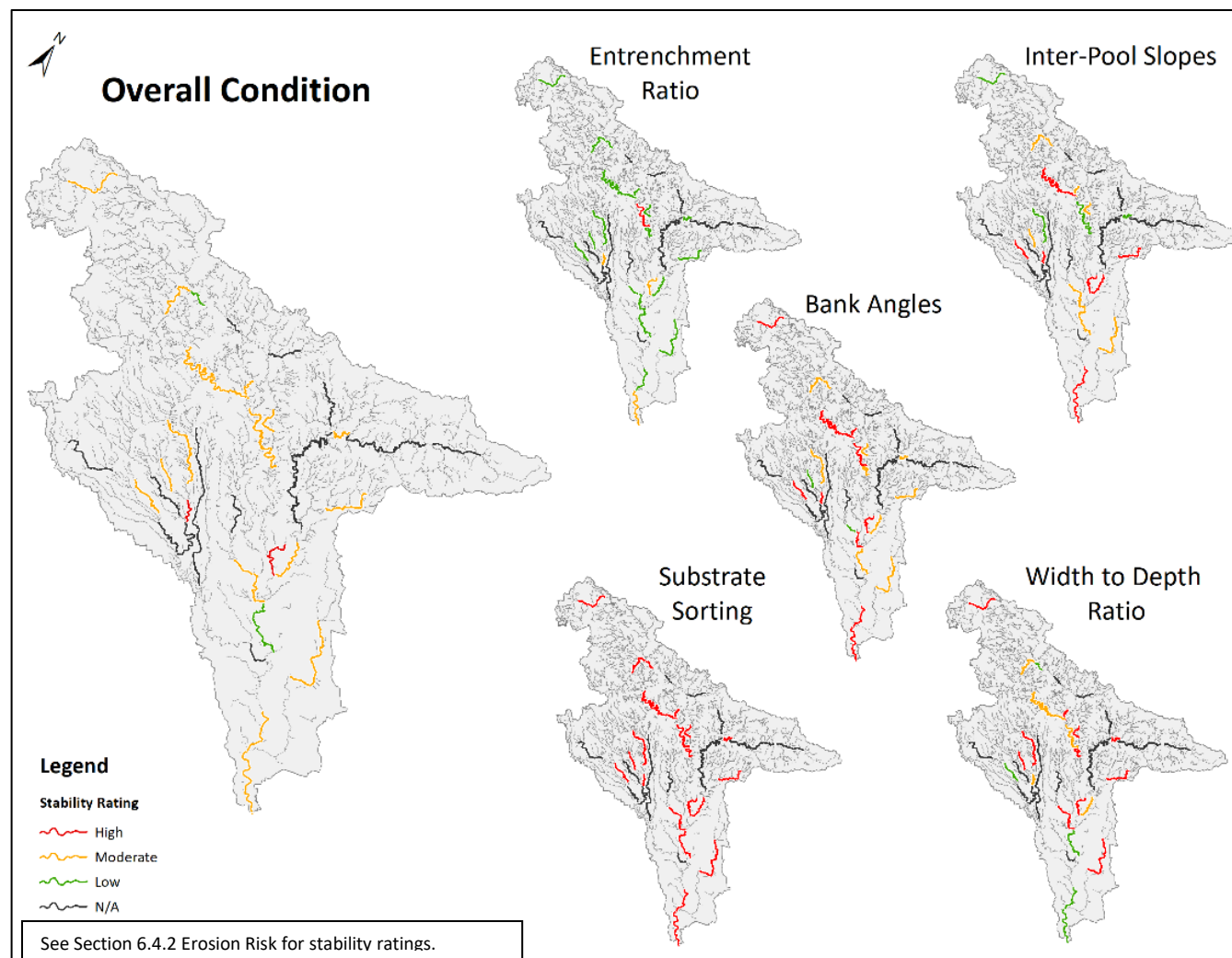


Figure 12 - Overall Reach Stability Parameter Results (2021 data)

The following is a summary of the notable observations from the **stability assessment**:

- The monitored channels in all subwatersheds have become increasingly entrenched (i.e., do not have ready access to the floodplain) over the last 20 years. In general, the increase in entrenchment is higher in the East Humber, West Humber, and Black Creek subwatersheds. The channels in the Main Humber and Lower Humber subwatersheds exhibit increased entrenchment to a lesser degree.
- In general, bank angles appear to be steepening in all subwatersheds except in the Main and Lower Humber subwatersheds.
- All sites show better sorting scores in 2021 than in 2001. Better scores indicate a range of sediment sizes in the channel.
- More sites show changes in width than changes in depth. Three sites (all located in West and Main Humber subwatersheds) show a reduction in width and one site in the Main Humber subwatershed shows a reduction in depth.
- Only two sites showed largely unstable bank angles.
- The recent observations show that most channels were composed of well graded sediments (also called poorly sorted sediments – sediment in channel are a variety of sizes which is an indirect denoter of channel stability) as compared to the previous pebble count scores.

Table 25 shows the subwatershed level results (qualitative assessment) for the following **sensitivity parameters**:

- Specific Stream Power Ration (SSPR) refers to the increase in specific stream power (i.e., energy expended by water against channel bed and banks per unit channel width) from a rural (pre-urbanization) state, which is assumed to be in equilibrium, to current conditions. The SSPR is assumed to be a measure of erosion sensitivity.
- Erosion Control Structure Density (EC) is based on the density of these structures in a specified area.
- Cross-sectional changes (XS) refer to the changes to channel area, average depth, and width at the top of bank elevation.
- Rapid Geomorphic Assessment (RGA) is a classification technique based on the presence and/or absence of key indicators of channel instability such as exposed tree roots, bank failure, excessive deposition, etc.
- Shear stress ratio ($\tau_o:\tau_{crit}$) represents the force of flowing water against the channel cross section.

Map 29 and **Figure 13** show the overall reach sensitivity results/maps for the reaches surveyed in 2021, and **Figure 13** also shows the results/maps for the individual parameters that make up reach sensitivity (including SSPR, EC, XS, RGA, and Shear Stress). **Section 6.4.2 Erosion Risk** provides details about the sensitivity ratings.

Table 25 - Summary of Sensitivity Parameter Results by Subwatershed

Sub-watershed	Parameter	Summary Results ⁵⁰
West Humber	SSPR	Moderate values for Specific Stream Power Ratio noted
	EC	Moderate number of erosion control structures noted in the reaches
	XS	Large changes noted in the cross sections over time during the current period
	RGA	RGA scores show stressed/transitional channels
	$\tau_o:\tau_{crit}$	Values show that boundary shear stresses are moderately higher than the critical shear stress
East Humber	SSPR	Moderate values for Specific Stream Power Ratio noted
	EC	Moderate number of erosion control structures noted in the reaches
	XS	Moderate changes noted in the cross sections over time during the current period
	RGA	RGA scores show channel in adjustment
	$\tau_o:\tau_{crit}$	Values show that boundary shear stresses are moderately higher than the critical shear stress
Black Creek	SSPR	Moderate values for Specific Stream Power Ratio noted
	EC	No erosion control structures were found in the reach representing this subwatershed. Note that elsewhere in the subwatershed, EC density is high.
	XS	Minimal changes noted in the cross sections over time during the current period
	RGA	RGA scores show stressed/transitional channels
	$\tau_o:\tau_{crit}$	Values show that boundary shear stresses are moderately higher than the critical shear stress
Main Humber	SSPR	Moderate values for Specific Stream Power Ratio noted
	EC	Majority of the reaches in this subwatershed show no erosion control structures
	XS	Moderate changes noted in the cross sections over time during the current period
	RGA	RGA scores show stressed/transitional channels

⁵⁰ Unlike the symbols used in **Table 24** for stability, the symbols in **Table 25** used for sensitivity rating denote low ●, average ●, and high ● values for the parameter assessed, respectively, where high parameter values indicate that the channel is more sensitive/susceptible to erosion.

Sub-watershed	Parameter	Summary Results ⁵⁰
Lower Humber	$\tau_o:\tau_{crit}$ ●	Values show that boundary shear stresses are moderately higher than the critical shear stress
	SSPR ●	High values noted; channels here are more sensitive to erosion due to increased specific stream power values
	EC ●	Moderate number of erosion control structures noted in the reaches
	XS ●	Large changes noted in the cross sections over time during the current period
	RGA ●	RGA scores show stressed/transitional channels
	$\tau_o:\tau_{crit}$ ●	Values show that boundary shear stresses are moderately higher than the critical shear stress

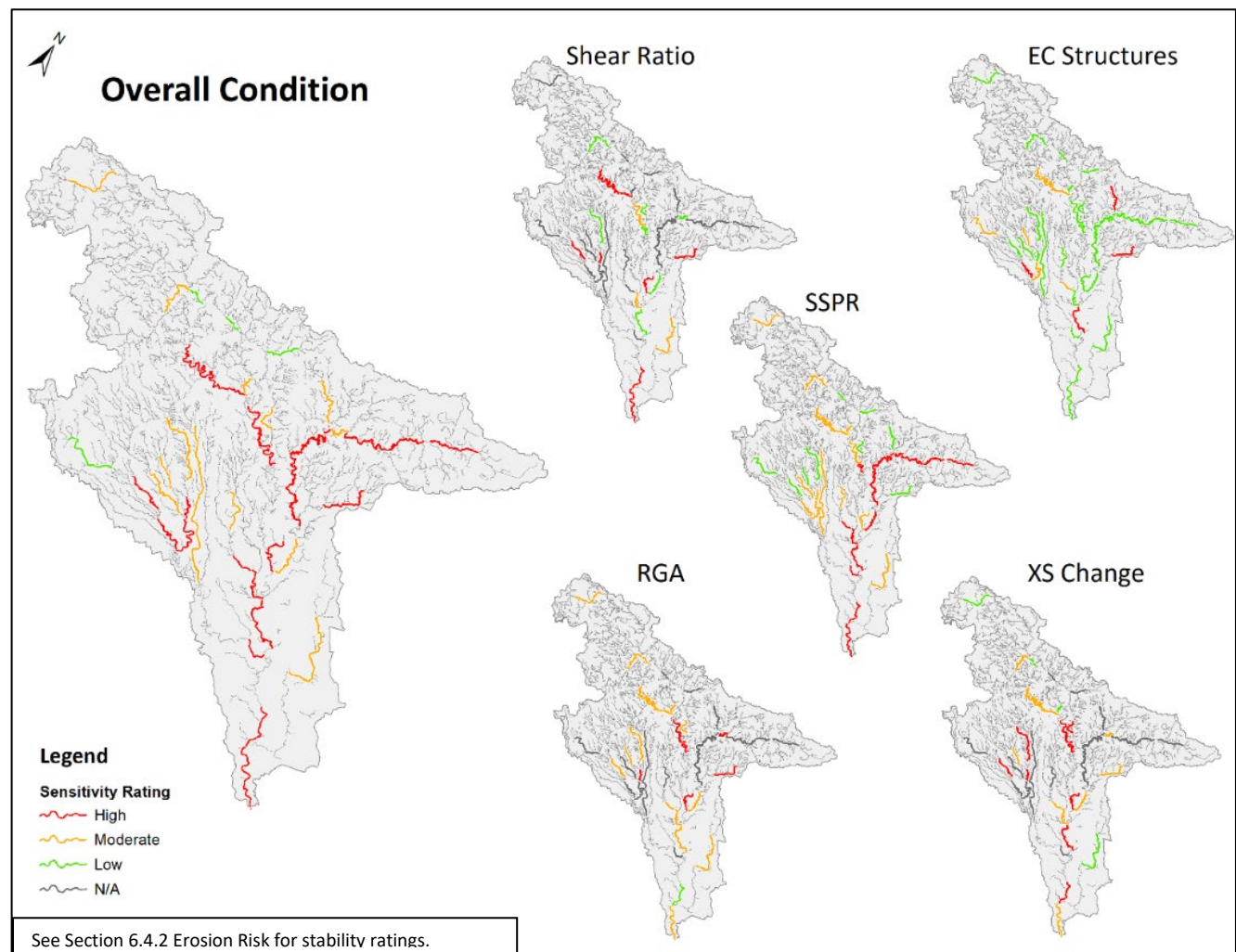


Figure 13 - Overall Reach Sensitivity Parameter Results (2021 data)

The following is a summary of the notable observations from the **sensitivity assessment**:

- The main branches of the East Humber and Lower Humber subwatersheds, and lower main branches of the Main Humber, West Humber, and Black Creek subwatersheds all show high values for SSPR indicating that urbanization has had the greatest impacts in these areas. In some places where urban settlements exist, parts of the main branches of the Main Humber and West Humber subwatersheds, the SSPR values have been noted to be moderate. The more rural parts of the watershed show the lowest SSPR values.
- The two subwatersheds with the highest SSPR values are Black Creek and Lower Humber, both of which contain the highest overall EC structure density by an order of magnitude.
- In general, the shear stress ratio values for all subwatersheds indicate that these channels are prone to erosion at bankfull flows. At bankfull flows the channels experience shear stresses that are larger than critical shear stress of the median sized substrate in the channel.
- In terms of the RGA, within the current period (2012 to 2021), the Lower Humber and the Main Humber subwatersheds have sites that are 'In Regime' (indicating the least amount of channel instability), in addition to one site in the lower part of West Humber subwatershed. This observation likely suggests that the smaller order streams and channels located further upstream in the watershed are still "Transitional/Stressed" or "In Adjustment" in terms of channel stability. Over time, a larger number of sites have been noted to trend towards being "In Adjustment". See [Section 6.4.2 Erosion Risk](#) for more details of the RGA assessment.

In general, based on the stability and sensitivity results, the lower parts of the watershed appear to be more resilient to the stressors on the watershed than those located in the upper parts of the watershed. The erosion control structure density in these lower subwatersheds (specifically the Black Creek and Lower Humber subwatersheds) is above average compared to the rest of the watershed. The separation of the Humber River into large subwatersheds with varying land uses makes it difficult to achieve similar results for all sites within a given subwatershed. Despite this limitation, some results across a subwatershed are similar for some of the parameters studied. Overall, the channels within most of the watershed are highly entrenched and show susceptibility to erosion under lower than bankfull flows. Although reach-wide evidence for channel widening and degradation was noted, an examination of the cross-sectional geometry changes at the monitored cross sections shows that the channels are predominantly deepening/incising and not widening. Geomorphic assessment also shows that the majority of the channels are either transitional/stressed or in adjustment, meaning that the channels have not achieved quasi-equilibrium. These watercourses are still adjusting, and many indicators of erosion are noted.

Erosion Hazard Sites and Erosion Control Structures Inventory

TRCA's Erosion Risk Management group conducts various monitoring programs within the Humber River watershed in order to assess erosion risk to infrastructure on both private and public property. These programs are funded in partnership with TRCA's municipal partners and include:

- Peel Infrastructure Hazard Monitoring Program (Peel Region)
- York Infrastructure Hazard Monitoring Program (York Region)

- Brampton City Wide Erosion Hazard Monitoring (City of Brampton)
- Toronto Water Steep Ravine Inventory (City of Toronto)

The inspection data from TRCA's Regional Infrastructure Hazard Monitoring Programs is collected at 603 infrastructure hazard monitoring sites within the Region of Peel and the Region of York at various frequencies based on the priority ranking of the infrastructure hazard site. [Map 30](#) shows the locations of the Regional Infrastructure Hazard Monitoring Programs monitoring sites in the watershed in Peel and York Regions. The priority ranking of a site is primarily based on the horizontal (proximity) or vertical (intersection) distance of an erosion scour as measured, surveyed, or approximated from the infrastructure pipe at the closest distance. The designated rankings are: *Critical, High, Medium, Low, and None*.

Of the 281 TRCA-owned or managed erosion control structures on public and private property, 4% (12) are high priority, 3% (nine) are medium priority, and the remaining 93% (260) are low priority (or none) (see [Map 31](#)).

[Map 27](#) shows the density of erosion control structures in the watershed (based on sweeping inventories collected over the years including erosion control structures owned by municipalities). The subwatersheds with the highest erosion control structure density include Black Creek and Lower Humber, by an order of magnitude. These subwatersheds represent areas of historical development density with fewer swaths of greenspace, or transportation and hydro corridors than the West Humber, East Humber, or Main Humber subwatersheds. Higher development densities appear to have triggered anthropogenic efforts to control erosion in close proximity to private property and buried essential infrastructure.

Targets and Progress from 2008 HRWP

The 2008 HRWP established the following three targets related to erosion: 1) Maintain or restore natural channel structure and rates of morphological change (baselines to be established for RWMP sites); 2) Maintain or restore pre-development erosion indices and stream flow regime (based on long-term stream gauge measurements and additional gauges recommended for installation); and, 3) Reduce or eliminate infrastructure, buildings and other property at risk (database of existing infrastructure and properties at risk to be developed).

For the first target, based on the geomorphic survey data of the monitored cross-sections, it appears that the channels in the Humber River watershed have undergone significant morphological changes between the baseline and the current period. [Figure 14](#) shows percent difference of the area, mean depth, and width between the baseline and the current time period. Increases over 10% fall in the area shaded in red. All subwatersheds (except for the site surveyed in the Black Creek subwatershed) show increases in channel area and depth. Select sites also show evidence of channel widening. These results indicate that the target to maintain or restore natural channel structure and rate of morphologic change has not been achieved.

For the second target (maintain or restore pre-development erosion indices and stream flow regime), a method of assessing if the channel was able to maintain or restore pre-development erosion potential and flow regime would be to compare the erosion threshold indices for the pre-development and the post-development scenario. However, this information is not available for the pre-development scenario for all fluvial monitoring stations in the watershed. Additionally, the post-development indices have not been developed at this stage of the HRWP. It is anticipated to be developed during the scenario analysis stage of this watershed plan. Another proxy for assessing the changes to erosion potential and flow regime would be to examine the Specific Stream

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Power Ratio (SSPR). In **Figure 15**, SSPR values of 1 or below indicate that the urban Specific Stream Power is not greater than the rural Specific Stream Power, suggesting that in these locations, the target to maintain or restore pre-development (rural) erosion potential and flow regime has been met (see **Section 6.4.2 Erosion Risk** for details on ratio values). As expected, these locations mostly occur in the relatively undeveloped portions of the watershed as well as in the Greenbelt. However, at all other locations (which is the majority of the watershed), this target has not been met.

The third target (reduce or eliminate infrastructure, buildings and other property at risk) could not be assessed as no baseline information regarding the number of public and private properties susceptible to risk is available.

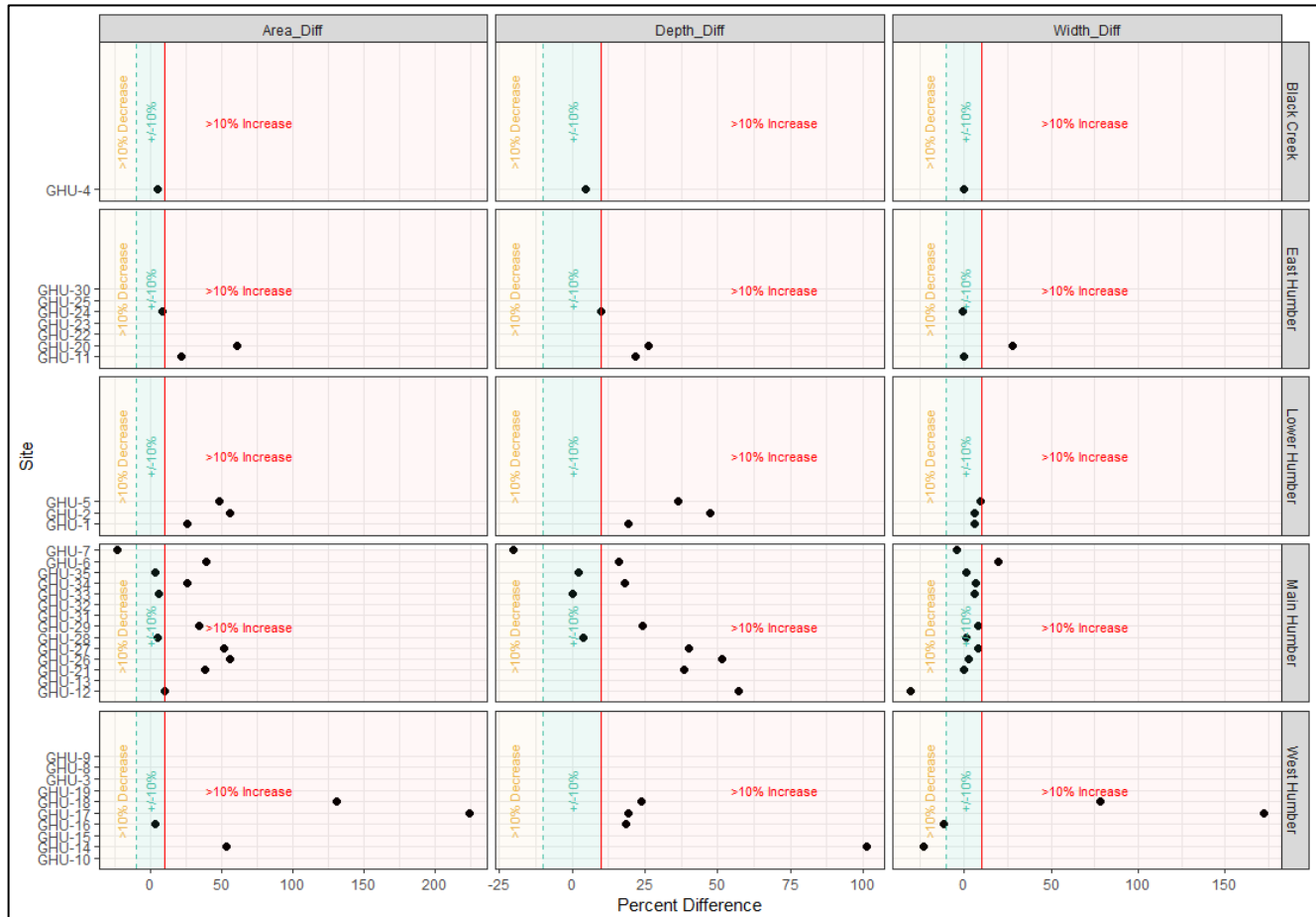


Figure 14 - Percent Difference in Cross Sectional Area, Depth, and Width Between the Baseline Conditions (2004-2010) and the Current Period (2021)

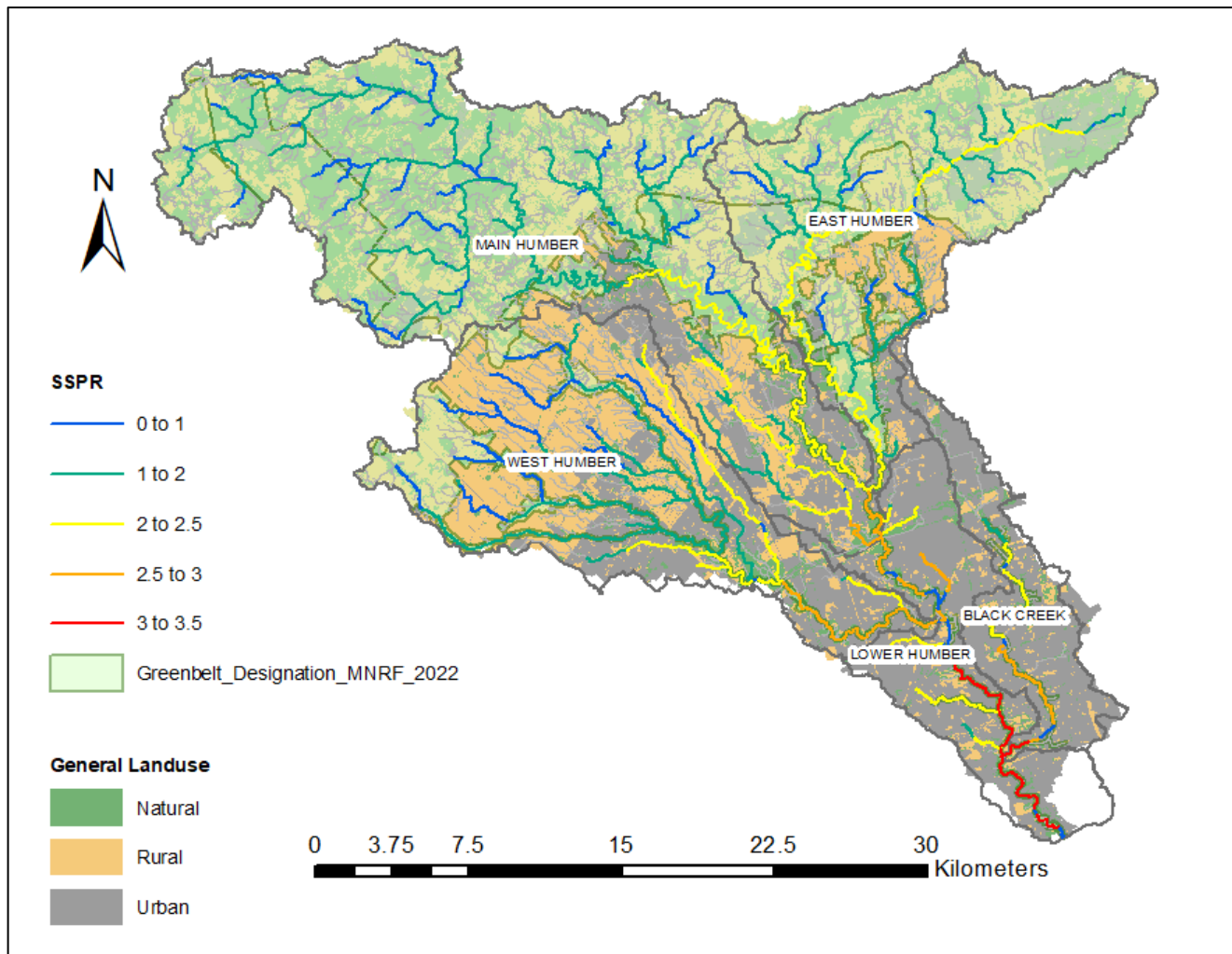


Figure 15 - Specific Stream Power Ratio (SSPR) Values (2020 Land Use Used for Urban Conditions)

2.5 Stormwater Management

Stormwater is the water that results from precipitation, such as rain or snow. The excess of what does not infiltrate or get taken up by vegetation, flows as runoff over land or impervious surfaces. As stormwater flows over surfaces, it can accumulate pollutants such as chemicals, litter, and sediment and, if left unmanaged, can contribute to water pollution, erosion, and increased streamflow/peak flow, and can cause flooding. Stormwater management involves strategies and practices to detain, retain, or reuse stormwater to protect public health and safety, prevent property damage, and preserve water quality and aquatic habitats. Prior to the 1980s, stormwater management focused solely on flood (quantity) control. Since then, stormwater management infrastructure has evolved to incorporate mitigation measures for water quantity, water quality, and erosion control.

Table 26 provides a summary of watershed/subwatershed area (in hectares) and the percentage of the area with stormwater quantity/flood control and stormwater quality/erosion control in the form of wet and dry ponds (in 2002, 2012 and 2020). The summary outlined in **Table 26** is based on the drainage area attributed to

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stormwater management facilities within TRCA's stormwater pond database and data supplemented by respective municipalities. While this data summarizes the majority of stormwater dry/wet ponds within the Humber River watershed, there are still data gaps that need to be addressed (e.g., ponds without date of construction, function, and/or drainage area). In cases where the year of construction was unavailable, the year of the stormwater management report was assumed to be the construction year.

Table 26 - Percentage of Watershed/Subwatershed with Stormwater Quantity and Quality Controls (Wet/Dry Ponds)

	Total Area (ha)	Percentage of Watershed / Subwatershed with Quantity / Flood Control (%)			Percentage of Watershed / Subwatershed with Quality / Erosion Control (%)			Number of Wet / Dry Ponds with Quantity and / or Quality Control		
		2002	2012	2020	2002	2012	2020	2002	2012	2020
Watershed	90,258	3.9	6.5	7.0	3.3	6.2	6.8	93	162	178
Main Humber	35,748	4.2	5.6	5.9	3.5	5.1	5.5	44	56	61
East Humber	19,607	3.3	6.5	6.9	2.7	5.7	6.2	17	33	34
West Humber	20,362	2.4	7.4	8.1	3.1	9.5	10.5	20	55	64
Lower Humber	8,267	6.3	6.3	6.3	3.2	3.2	3.2	6.0	6.0	6.0
Black Creek	6,274	6.4	8.8	10	4.7	7.2	8.4	6.0	12	13

As of 2020, 7% of the watershed had stormwater quantity/flood control (an increase from 3.9% in 2002). As of 2020, the Black Creek and West Humber subwatersheds had the largest percentage of area with stormwater quantity control (10% and 8.1%, respectively). The Main Humber, East Humber, and Lower Humber subwatersheds had stormwater quantity control in the form of wet/dry ponds for 5.9%, 6.9%, and 6.3% of the subwatershed areas, respectively. Between 2002 and 2020, the subwatershed with the largest increase in percentage of area with stormwater quantity control was the West Humber subwatershed (increase from 2.4% to 8.1%). Note that these percentages are calculated based on drainage areas with stormwater management control relative to the area of the (sub)watershed and does not normalize on the basis of urban cover.

As of 2020, 6.8% of the watershed had stormwater quality/erosion control (an increase from 3.3% in 2002). As of 2020, the West Humber and Black Creek subwatersheds had the largest percentage of area with stormwater quality/erosion control (10.5% and 8.4%, respectively). The Main Humber, East Humber, and Lower Humber subwatersheds had stormwater quality control for 5.5%, 6.2%, and 3.2% of their subwatershed areas, respectively. Between 2002 and 2020, the subwatershed with the largest increase in percentage of area with stormwater quality control was the West Humber subwatershed (increase from 3.1% to 10.5%). Note, again, that these percentages are calculated based on drainage areas with stormwater management control relative to the area of the (sub)watershed and does not normalize on the basis of urban cover.

There are a total of 178 wet/dry stormwater management ponds in the watershed as of 2020 which represents an increase from 93 in 2002 and 162 in 2012. [Map 32](#) shows a density map of wet/dry stormwater management

ponds within the watershed constructed by the year 2020. The increase in facilities is likely related to the increase in urbanization.

Table 27 summarizes how the percentage of effective impervious area within the stormwater infrastructure drainage areas has increased from 2002 to 2020 for the watershed and each subwatershed. Effective impervious cover is considered to be the subset of the total impervious areas with a direct hydraulic connection to a waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume. Effective impervious cover has increased at the watershed scale from 45% in 2002 to 54% in 2020 (with no change between 2012 and 2020). The Black Creek and Lower Humber subwatersheds had the highest effective impervious cover in 2020 (78% and 69%, respectively). The East Humber had the lowest effective impervious cover in 2020 (42%). The largest change in effective impervious cover was seen in the West Humber subwatershed (from 33% in 2002 to 58% in 2020).

During the period spanning from 2012 to 2020, minimal changes or even decreases in effective impervious cover, such as in East Humber, were observed. One possible explanation for this could be that while the increase of impervious cover has been represented, the addition of new ponds may have not been comprehensively added to the hydrology model and/or the number of ponds did not increase proportional to the amount of urban cover. It is crucial to consider this factor as the drainage area is not static but rather progressively growing each year. Moreover, although there are notable changes observed at the subwatershed level between 2012 and 2020, the values exhibit comparatively smaller fluctuations at the watershed scale. This can be attributed to the inclusion of larger areas in the calculation, which may not significantly impact the overall percentage.

Table 27 - Percentage of Effective Impervious Area within Drainage Areas of Stormwater Management Infrastructure by Watershed / Subwatershed

Subwatershed	2002	2012	2020
Watershed	45%	54%	54%
Main Humber	40%	55%	56%
East Humber	35%	43%	42%
West Humber	33%	51%	58%
Lower Humber	63%	69%	69%
Black Creek	67%	78%	78%

2.6 Restoration Planning

Restoration planning is a vital tool to improve watershed conditions in an urbanizing watershed like the Humber River.

TRCA uses a systematic approach to restoration planning that involves prioritizing catchments where the greatest ecological benefit is achievable and then recording site-level information for terrestrial and aquatic restoration opportunities. TRCA's Integrated Restoration Prioritization (IRP) framework considers multiple objectives related to ecosystem health and uses a comprehensive, consistent, and repeatable framework to guide restoration planning, resource investment, and implementation (Integrated Restoration Prioritization: A Multiple Benefit Approach to Restoration Planning, TRCA 2016 provides more information). The IRP methodology calculates results for a series of metrics and assigns a high, medium, low, or protection score at the catchment scale. In other words, a high priority catchment has multiple impairments and restoration could provide multiple benefits to the watershed. The protection score is a special designation given to high-value natural heritage areas where targeted restoration programs are beneficial to promote the recovery of high valued systems. See [Table 28](#) for a breakdown of IRP scores within the Humber River watershed and [Map 33](#) for the corresponding map.

TRCA uses site-level information to catalogue restoration opportunities to further guide specific restoration project implementation in support of TRCA and municipal partner objectives related to natural heritage, fisheries, climate change, previous watershed plans, and the Toronto Area of Concern Remedial Action Plan. Since 2002, there have been 4090 restoration opportunities catalogued in the watershed (933 during the historical period (pre-2002), 2004 during the baseline period (2002-2011), and 1153 during the current period (2012-2021)). See [Table 28](#) for a breakdown of the type of aquatic and terrestrial restoration opportunities catalogued and see [Map 34](#) for the corresponding map.

A total of 1669 TRCA restoration projects were completed in the watershed from 2002-2021 (388 during the baseline period (2002-2011) and 1281 during the current period (2012-2021)). Restoration at these sites was completed by TRCA and municipalities with some projects involving the participation of community members through stewardship events. The West Humber subwatershed had the greatest number of restoration projects at 556 sites followed by the Main Humber with 505 sites, Lower Humber with 306 sites, the East Humber with 251 sites, and Black Creek with 41 sites. Projects completed at these sites ranged in type from: wetland restoration, stream restoration, restoration plantings, shoreline restoration, green infrastructure restoration, and stewardship activities that included invasive species management, park clean-ups events, and habitat structures. See [Map 35](#) for a map of completed restoration projects. [Table 28](#) outlines the types of restoration projects completed.

As part of this watershed planning process, restoration opportunities are being updated to increase coverage and reflect current conditions.

Table 28 - Restoration Planning in the Humber River Watershed

Type of Opportunity / IRP Score		Number
IRP Catchments ⁵¹	High	103 (8.1% of watershed)
	Medium	467 (37.2% of watershed)
	Low	421 (27.2% of watershed)
	Protection	442 (27.5% of watershed)
Restoration Opportunity Sites (2002-2021)	Aquatic/Stream	
	Barrier	154
	Blockage/restriction	31
	Culvert	80
	Erosion	200
	Floodplain impairment	6
	Informal crossing	32
	Lack of watercourse shading	21
	Livestock	4
	Morphological issue	91
	On-line pond	20
	Outfall	151
	Sediment loading	8
	Riparian ⁵²	1250
	Terrestrial	
	Best management practices	385
	Forest	410
	Meadow	94
	Shoreline	5
	Wetland	425
	Wetland complex	723
	Total Restoration Opportunities	4090

⁵¹ The IRP catchment summary was primarily based on TRCA data from the baseline (2002-2011) and current conditions periods (2012-2021) with barriers data extending back to the historic period (pre-2002).

⁵² For restoration planning, riparian typically falls within terrestrial assessments, but can address aquatic issues. Since riparian zones are a transition area and were characterized as part of the Water Resource System, it has been included under aquatic within this table.

Type of Opportunity / IRP Score		Number
Completed Restoration Projects (TRCA and Municipal) by Type (2002-2021)⁵³	Wetland projects	229
	Stream projects	80
	Tree and shrub planting/meadow projects	1134
	Shoreline projects	3
	Green Infrastructure	4
	Stewardship Activities	219
Completed Restoration Projects by Subwatershed (2002)	Main Humber	505
	East Humber	251
	West Humber	566
	Lower Humber	306
	Black Creek	41
	Total Number of Sites	1669

A review of stream restoration assessments, strategies, and prioritization documents for the watershed was also undertaken to help inform where work was initiated to facilitate large scale stream restoration implementation projects. These reports are useful as they detail reach scale geomorphic issues that could be solved through various restoration solutions. Eleven geomorphic/stability assessments and other reports were completed from 2008-2021 for different locations within the watershed. These documents directly led to the implementation of restoration projects within the watershed. Many more reports and case studies for individual projects have been completed to support restoration throughout the watershed.

Targets and Progress from 2008 HRWP

Priority subwatershed regeneration plans/areas were identified for restoration work in the 2008 HRWP, but specific targets were not identified.

⁵³ The total number of Restoration Project Activity Types reflects yearly counts of restoration project types at sites with common names and locations (e.g., a site's activities would be counted and type categorized each year work was completed).

3.0 HISTORICAL CLIMATE TRENDS

Historical Climate Trends

A total of 49 climate variables were analyzed across nine parameters to characterize historical climate conditions and trends across the Humber River watershed for two historical 30-year periods: 1961-1990 and 1981-2010.

Appendix D – Additional Climate Information presents a detailed summary of the results for each of the 49 climate variables, including the 10th percentile, mean, and 90th percentile results for each period, averaged across data from seven climate stations located within or near the watershed. **Figure 16** shows the ECCC climate stations selected for the analysis of historical climate trends based on their location in or near the watershed.



Figure 16 - Environment and Climate Change Canada Climate Stations Used in Historical Climate Trends Analysis

Table 29 presents a high-level summary of the nine climate parameters analyzed for the two historical climate periods and the trends between the two periods. Overall, this analysis determined that the climate in the watershed has changed between the two historical periods and is affecting communities and natural systems in the watershed.

Table 29 - High-level Summary of Climate Parameters and Trends for Two Historical Climate Periods: 1961-1990 and 1981-2010

Climate Parameter	Trend Between 1961-1990 and 1981-2010
Air Temperature	Increasing
Extreme Heat and Cooling Degree Days	Variable
Extreme Cold and Heating Degree Days	Decreasing
Total Precipitation	Increasing ⁵⁴
Extreme Precipitation	Variable
Dry Days	Variable
Growing Season	Increasing
Agricultural Variables	Increasing
Freeze-Thaw and Freezing Rain Potential	Variable

Based on observed historical climate data obtained from seven climate stations in and around the watershed, mean annual air temperature has warmed by 0.7°C on average between the two time periods. Maximum and minimum air temperature has also increased between the two periods (0.6°C and 0.8 °C, respectively), with minimum temperature increasing more than maximum and mean temperature. This means that the coldest temperature in a day has gotten less cold, and the warmest temperature in a day has gotten warmer. The greatest temperature increases were observed in the winter, with minimum winter temperature increasing by 1.3°C, and maximum winter temperature increasing by 1.0°C. This has brought warmer winters, more hot days and nights, a longer growing season, and more precipitation as warmer air can hold more moisture. Some climate variables demonstrate a clear increasing or decreasing trend, while others show more variability (mix of increases and decreases). Within the Humber River watershed, the southern part of the watershed tends to be warmer than the northern part of the watershed and, over time, more of the southern part of the watershed has gotten warmer ([Figure 17](#)). This warming may be associated with increasing urbanization in the cities of Toronto, Brampton, and Vaughan over time and the Urban Heat Island Effect, where urban areas tend to be warmer than surrounding areas that have more natural land cover.

⁵⁴ Increase in total precipitation except for winter precipitation.

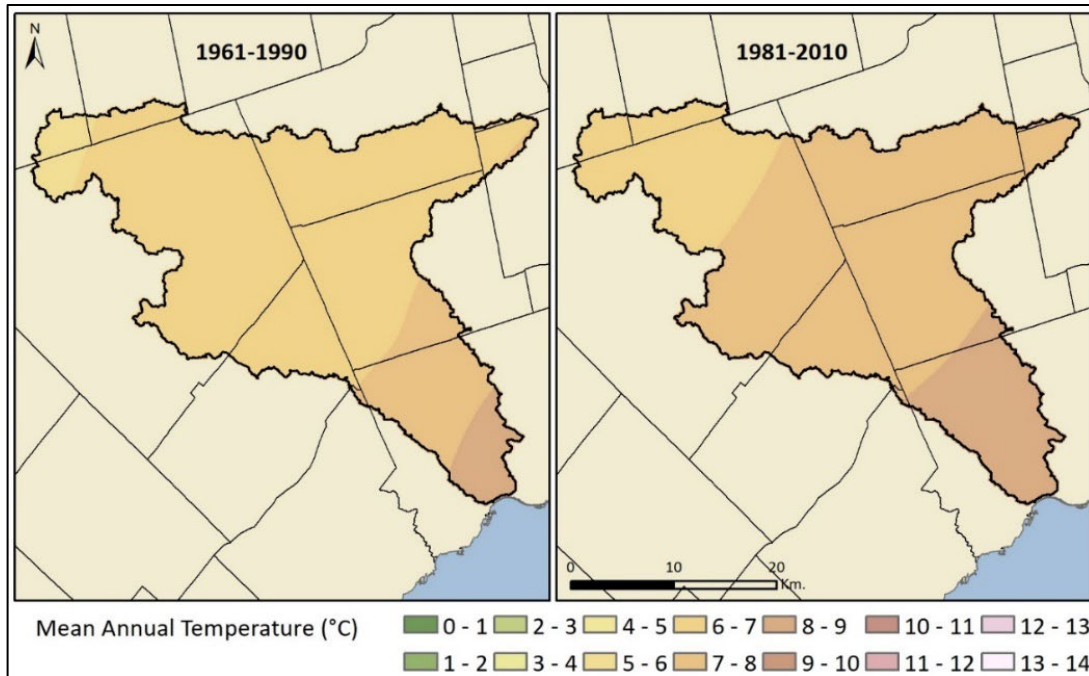


Figure 17 - Historical Mean Annual Temperature Across the Humber River Watershed for 1961-1990 (left) and 1981-2010 (right)

In terms of extreme temperature, very hot days above 30°C and 35°C have increased on average. Days with maximum temperature above 35°C have historically been rare in the watershed and have increased slightly by 0.1 day in a year between the two periods. Nights with minimum temperature above 20°C (also known as tropical nights) saw the greatest average increase, increasing by 2.2 nights a year. Heatwaves as measured by at least three consecutive days with maximum temperature above 30°C remained fairly consistent across the two periods. **Very cold days below -10 and -20°C** have decreased, and the number of **freezing days** (or days with minimum temperature below 0°C) also decreased over the two periods.

Days with mean temperature above 18°C is often used as a proxy for the number of **cooling degree days** requiring the use of air conditioning. In the watershed, the number of cooling degree days increased by 5.8 days a year. Conversely, days with mean temperature below 18°C serves as a proxy for the number of **heating degree days** requiring indoor heating. The number of heating degree days decreased by 10 days a year over the two periods.

With warmer air temperature, more moisture is available in the air to produce storms. The total annual precipitation has generally increased in the watershed by 3.3%. Seasonal precipitation has also risen, with the exception of total winter precipitation, which decreased by 1.1%. Unsurprisingly, total annual precipitation showed a greater spatial variation than temperature across the watershed. Across the two periods, the northwest and northeastern parts of the watershed received the most recorded precipitation (see [Figure 18](#)).

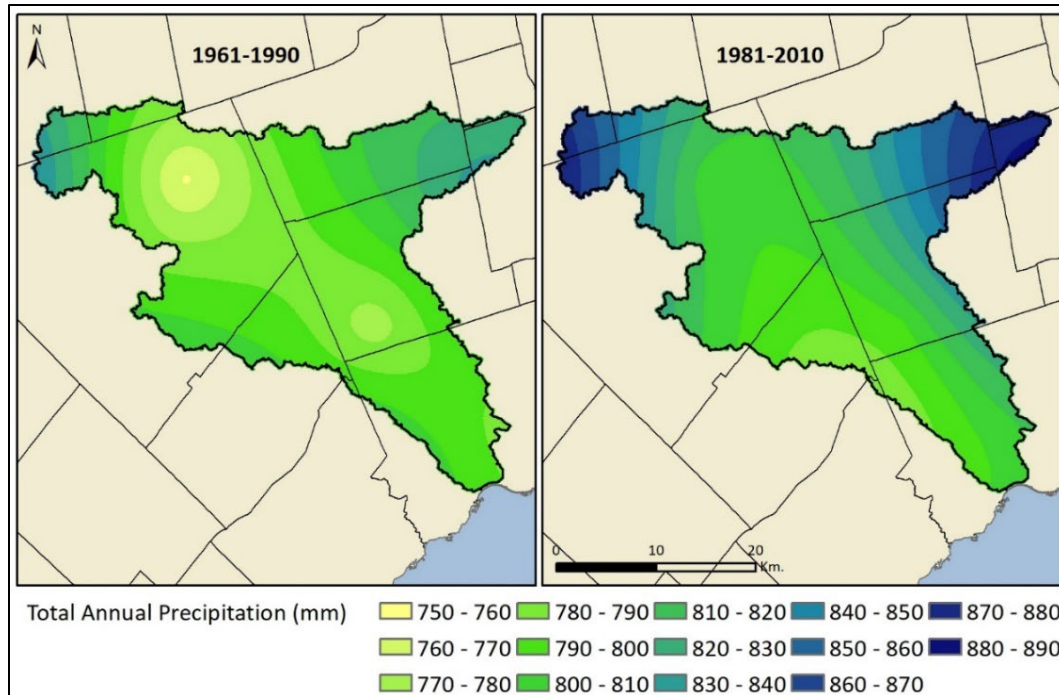


Figure 18 - Historical Total Annual Precipitation Across the Humber River Watershed for 1961-1990 (left) and 1981-2010 (right)

With increased precipitation, dry days with precipitation of less than 2 mm have decreased on average. Total annual dry days decreased by 8.5 days a year. **Extreme precipitation** (as measured by the top 5 and 1 percent of recorded precipitation values) saw some variation. Increases were observed on average and in the 90th percentile, but decreased in the 10th percentile. The top 5 percent of precipitation (or 95th percentile) increased by 1.9 percent, while the top 1 percent of precipitation (or 99th percentile) increased by 0.9 percent.

The **growing season** has gotten longer, increasing by 6.4 days between the two periods. On average, the growing season is starting earlier in April and ending later in October. The amount of favourable heat conditions for the growth of various crops is also increasing (e.g., for corn, cereals, and canola), as measured by **Growing Degree Days (GDD)** and **Corn Heat Units (CHUs)**. However, heat conditions that may be favourable to insect pests are also on the rise, which may outweigh the benefits of a longer growing season and increased GDDs.

The frequency of **freeze-thaw cycles** was estimated based on the number of days when air temperature fluctuates between freezing and non-freezing temperatures. Freeze-thaw cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting, and re-freezing of water can cause significant damage to roadways, sidewalks, and other outdoor structures over time. In the watershed, the number of freeze-thaw cycles per year was variable (decreased on average and in the 90th percentile and increased in the 10th percentile). **Freezing rain potential** is an estimate of the number of days when we can expect to see rain freeze upon contact with the ground surface when temperature is below freezing. In the watershed, the number of days with freezing rain potential was variable (also decreased on average and in the 90th percentile and increased in the 10th percentile).

The watershed's historical climate data (1961-1990 and 1981-2010) was also compared with TRCA-wide historical climate data (1971-2000) previously developed for TRCA to assess how the watershed's historical

climate trends might compare with the rest of the jurisdiction. Despite differences in the time period and data sources used, there was some alignment between the watershed’s *observed* historical climate trends and the *modelled* historical trends derived for the entire jurisdiction, particularly for temperature and agricultural variables. **Table 30** presents a summary of key similarities and differences.

Table 30 - Summary of Key Similarities and Differences between the Observed Historical Climate Trends (1961-1990 and 1981-2010) and TRCA-wide Modelled Historical Climate Trends (1971-2000)

Similarities	Differences
<ul style="list-style-type: none"> Mean annual, winter, and summer temperature trends are consistent. Maximum and minimum annual temperature trends are consistent. Agricultural variables are generally consistent (except Corn Heat Units). 	<ul style="list-style-type: none"> Mean spring temperature was higher for TRCA, while mean fall temperature was lower. Maximum and minimum seasonal temperature trends vary. Extreme heat and cold days were more frequent in TRCA than the Humber River watershed. Total and extreme precipitation were higher in TRCA, and the number of dry days were lower. Growing season length was longer for TRCA with an earlier start date and later end date.

Climate-Related Impacts in the Humber River Watershed

Through the HRWP Public Engagement Survey (accessible through the HRWP webpage from September 19, 2022 to October 31, 2022), watershed stakeholders, residents and the public were engaged to share climate or weather-related stories that they have experienced or heard about in the watershed. A total of 49 responses were received (or 25% of total survey respondents). **Appendix D – Additional Climate Information** presents the climate or weather-related changes/impacts highlighted by survey respondents (more than one impact could be highlighted by a respondent). The “Other” category included damages to trees and buildings from flooding and storms, increase in trash, and impacts on fish spawning and movement due to low water levels.

The top three climate/weather-related impacts that were highlighted the most by survey respondents included flooding, habitat loss/degradation, and spread of invasive species (see **Figure 19**). Specific events such as Hurricane Hazel, the July 2013 storm, past ice jams, and drier than normal conditions in 2022 were top of mind for many respondents.

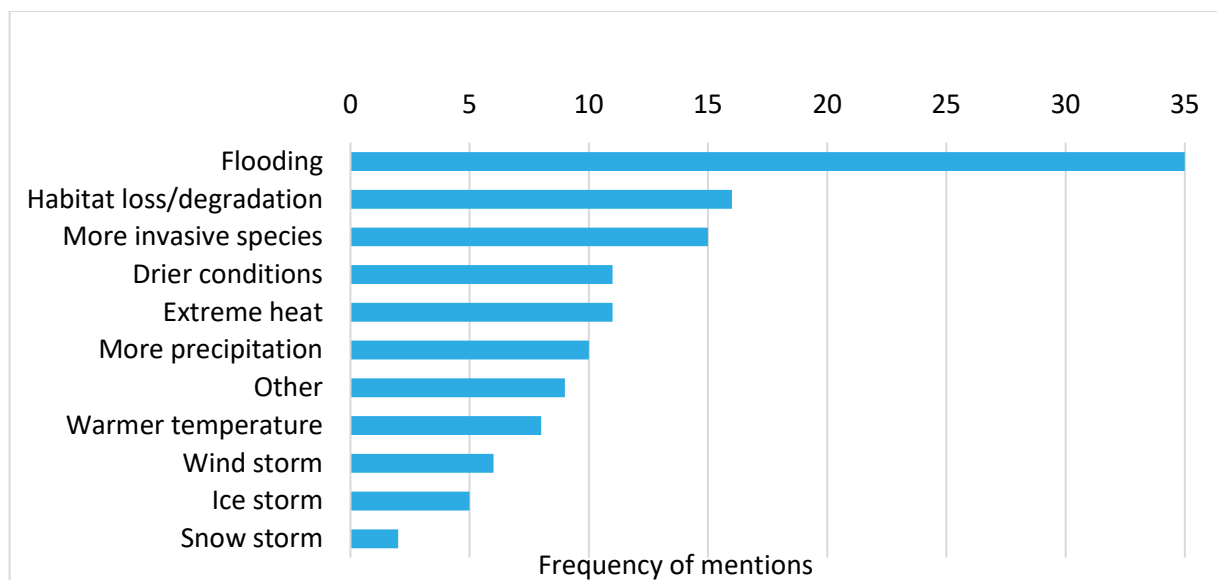


Figure 19 - Climate or Weather-Related Impacts Highlighted by Respondents to the HRWP Public Engagement Survey 2022

Municipal Climate Emergency Declarations, Action Plans/Strategies, and Targets

Within the Humber River watershed, eight out of the 14 single-tier, upper-tier, and lower-tier municipalities (or 54%) have declared a climate emergency including City of Toronto, Peel Region, City of Mississauga, City of Brampton, Town of Caledon, City of Vaughan, Township of King, and Township of Aurora. While not all municipalities have declared a climate emergency, most (i.e., 12 municipalities or 86%) have developed/are developing at least one comprehensive climate change action plan/strategy focused on climate change mitigation, adaptation, or both. Most plans and strategies focus on both mitigation and adaptation (eight municipalities or 57% have a plan/strategy that focuses on both). Through the Municipal Comprehensive Review process, municipalities are integrating consideration of climate change in accordance with provincial policy, including municipalities that currently do not have a comprehensive climate change plan/strategy. This often involves the development of policy discussion papers on the intersection between climate change and land use planning, which has a stronger adaptation focus but may also include benefits for mitigation (e.g., by reducing automobile dependence and increasing the use of public transit and active transportation).

[Appendix D – Additional Climate Information](#) provides additional information regarding municipal climate emergency declarations and comprehensive climate change action plans/strategies.

Many of the municipalities in the watershed have also adopted corporation or community-wide greenhouse gas emissions reduction targets. Half of the municipalities in the watershed have adopted/proposed a target of reaching net zero by 2050 (or earlier as in the case of the City of Toronto). Adaptation targets remain less well defined and a key knowledge and implementation gap. As the climate continues to change, understanding historical climate trends and impacts offers a baseline for comparison and improved understanding of potential future impacts.

4.0 POLICY INVENTORY

Provincial policies recognize watersheds as the most ecologically meaningful scale for integrated and long-term planning to protect, enhance, and restore the quality and quantity of water, and require/encourage municipalities to undertake watershed planning to inform the identification and protection of water resource systems and decisions related to planning for growth. As part of watershed characterization, TRCA, in collaboration with its municipal partners, has conducted an inventory of existing (and draft) municipal policies, strategies, guidelines, standards, etc., that are relevant to the Humber River watershed, and to watershed planning broadly. This inventory does not evaluate the effectiveness of these policies. Identifying opportunities to improve policies and their implementation will be conducted in subsequent stages of the watershed planning process. Within the framework of TRCA's regulatory authority, opportunities to ensure consistency and alignment between TRCA and municipal policies and guidelines will be explored.

As part of this inventory of existing (and draft) policies, municipal Official Plans, master plans, major strategies, secondary plans, development guidelines or standards, and bylaws were reviewed. [Table 31](#) and [Table 32](#) identify whether municipal Official Plans have, or propose to include, policies related to watershed planning components and identify relevant strategies, guidelines, standards, etc., for each municipality in the watershed. Since municipal policies and plans are routinely updated, this inventory is not intended to be comprehensive, but rather a general overview of the existing and proposed policy framework as it relates to the Humber River watershed, at the time this report was prepared. As the regional and local municipalities within the watershed are in various stages of updating their Official Plans as a component of provincial conformity exercises and Municipal Comprehensive Review requirements, draft policies may be subject to further change. Additionally, this inventory does not list studies or environmental assessments related to infrastructure planning or natural hazard mitigation. [Section 4.1 Natural Heritage System Comparison](#) compares current single-tier and upper tier municipal NHSs as identified in Official Plans (existing or draft) to TRCA's recently updated Regional Target NHS from 2022.

Table 31 - Policy Inventory – Single and Upper-Tier Municipalities

	City of Toronto		Region of Peel		Region of York		Dufferin County		Simcoe County	
Official Plans (OPs)										
	Previous	Current 2051 OP (OPA 583 - March 2022)	Previous	Current 2051 OP (April 2022)	Previous	Current 2051 OP (June 2022)	Current	Draft MCR (Phase I and II OPAs)	Previous	Current 2051 OP (OPA 7)
Water Resource System ⁵⁵	N	Y	Y	Y	Y	Y	N	TBD	Y	TBD
Natural Heritage System	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Urban Forest	Y	Y	Y	Y	Y	Y	N	TBD	N	TBD
NHS / WRS Contributing Areas	N	Y	N	N	N	N	N	TBD	N	TBD
Surface Water Quality	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Groundwater Quality / Quantity	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Natural Hazards	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Stormwater Management / Green Infrastructure	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Restoration Opportunities	Y	Y	Y	Y	Y	Y	Y	Y	Y	TBD
Source Water Protection ⁵⁶	N	Y	N	Y	Y	Y	Y	Y	Y	TBD

⁵⁵ Some Official Plan policies generally reference protecting water resources and their integration with the natural system but do not contain policies directly related to a water resource system comprised of integrated features, areas, and their functions as necessary for the ecological and hydrological integrity of watersheds. This is expected to change as municipalities update their OPs to conform to current provincial policies.

⁵⁶ Some OP policies include elements of source water protection (e.g., groundwater quality and quantity, wellhead protection areas, etc.) but do not directly relate to the requirements of source water plans under the *Clean Water Act*. This is expected to change as municipalities update their OPs.

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	City of Toronto	Region of Peel	Region of York	Dufferin County	Simcoe County
Master Plans / Major Strategies					
Site Specific / General Master Plans	Black Creek SNAP (2012)	Water and Wastewater Master Plan (2020)	Water and Wastewater Master Plan (2022)	N/A	N/A
	Rexdale SNAP (ongoing)				
WRS / NHS	Natural Environment Trail Strategy (2013) Toronto Biodiversity Strategy (2019) Ravine Strategy (2020)	N/A	One Water Action Plan (2017) Management Plan for the York Regional Forest (2019-2038) Greening Strategy (2022)	Dufferin County Forest Management Plan (2016-2036)	Water and Wastewater Visioning Strategy (2012)
Urban Forest	Sustaining and Expanding the Urban Forest: Toronto's Strategic Forest Management Plan (2012 – 2022)	Peel Region Urban Forest Strategy (2011) Peel Region Urban Forest Best Practice Guides (2021)	York Region Forest Management Plan (2016) Management Plan for the York Regional Forest (2019) State of the Forest Report (2021)	N/A	N/A
Stormwater Management	Wet Weather Flow Master Plan (Updated 2017)	<i>Region of Peel is developing Stormwater Servicing Master</i>	N/A	N/A	N/A

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	City of Toronto	Region of Peel	Region of York	Dufferin County	Simcoe County
		<i>Plan for regional roads</i>			
Climate Change (see Appendix D for supporting details)	Toronto's Resilience Strategy (2019) TransformTO Net Zero Strategy (2021)	Peel Climate Change Master Plan (2019 for 2020 – 2030)	Sustainability Strategy (2007) York Region Climate Change Action Plan (2022) York Region Community Energy and Emissions Plan (underway)	Dufferin Climate Action Plan (2021) Dufferin Corporate Climate Action Plan (underway)	N/A
Secondary Plans					
<i>Of relevance to Humber River watershed</i>	N/A	N/A	N/A	N/A	N/A
Guidelines / Standards					
<i>Of relevance to Humber River watershed / watershed planning</i>	Wet Weather Flow Management Guidelines (2006) Complete Streets Guidelines (Chapter 7 – Green Infrastructure) 'Greening' Surface Parking Lots Guidelines	N/A	N/A	N/A	N/A

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	City of Toronto	Region of Peel	Region of York	Dufferin County	Simcoe County
	Drought Tolerant Landscaping Guidelines Toronto Green Standard – Version 4 (2021)				
By-laws					
<i>Of relevance to watershed planning</i>	Toronto Green Roof Bylaw Tree Protection Bylaws Ravine and Natural Feature Protection Bylaw	N/A	N/A	N/A	N/A

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Table 32 - Policy Inventory – Lower-Tier Municipalities

	City of Brampton		City of Mississauga		Town of Caledon		City of Vaughan		Township of King		City of Richmond Hill		Town of Aurora		Town of Mono		Township of Adjala- Torsorontio	
Official Plans (OPs)																		
	Current	Draft 2051 OP	Current	Draft 2051 OP	Current	Draft 2051 OP	Current	Draft 2051 OP (TBD)	Current	Draft 2051 OP (TBD)	Current	Draft 2051 OP	Current	Draft 2051 OP	Current	Draft 2051 OP	Current	Draft 2051 OP
Water Resource System ⁵⁵	N	Y	N	Y	N	Y	N	TBD	Y	TBD	Y	TBD	N	N	N	TBD	N	TBD
Natural Heritage System	Y	Y	Y	Y	Y	Y	Y	TBD	Y	TBD	Y	TBD	Y	Y	Y	TBD	N	TBD
Urban Forest	Y	Y	Y	Y	Y	Y	Y	TBD	Y	TBD	Y	Y	N	Y	N	TBD	N	TBD
NHS / WRS Contributing Areas	N	N	N	N	N	N	N	TBD	N	TBD	N	TBD	N	N	N	TBD	N	TBD
Surface Water Quality	Y	Y	Y	Y	N	Y	Y	TBD	Y	TBD	Y	TBD	N	N	Y	TBD	N	TBD
Groundwater Quality / Quantity	Y	Y	Y	Y	Y	Y	Y	TBD	Y	TBD	Y	TBD	Y	Y	Y	TBD	Y	TBD
Natural Hazards	Y	Y	Y	Y	Y	Y	Y	TBD	Y	TBD	Y	TBD	Y	Y	Y	TBD	Y	TBD
Stormwater Management / Green Infrastructure	Y	Y	Y	Y	N ⁵⁷	Y	Y	TBD	Y	TBD	Y	TBD	Y	Y	Y	TBD	Y	TBD

⁵⁷ Stormwater management is addressed in relevant secondary plans for the Town of Caledon, but there are no broad directional policies within the current OP.

Humber River Watershed Characterization Report

	City of Brampton		City of Mississauga		Town of Caledon		City of Vaughan		Township of King		City of Richmond Hill		Town of Aurora		Town of Mono		Township of Adjala-Torsorontio	
Restoration Opportunities	Y	Y	Y	Y	Y	Y	Y	TBD	Y	TBD	Y	TBD	Y	Y	Y	TBD	N	TBD
Source Water Protection ⁵⁶	N	N	N	Y	N	Y	N	TBD	Y	TBD	N	TBD	N	N	N	TBD	N	TBD
Master Plans / Major Strategies																		
Site Specific / General Master Plans	Brampton Eco Park Strategy (2019) Brampton’s Environment (Grow Green) Master Plan (2020)		Dundas Connects Master Plan (2018)		West Bolton SNAP (2019)		Natural Heritage Network Study (2012) City-Wide Water and Wastewater Master Plan Class EA (2014) City-Wide Integrated Urban Water Master Plan (completion in 2024)		Water and Wastewater Master Plan Class EA (2020)		N/A		NA		N/A		N/A	

Humber River Watershed Characterization Report

	City of Brampton	City of Mississauga	Town of Caledon	City of Vaughan	Township of King	City of Richmond Hill	Town of Aurora	Town of Mono	Township of Adjala- Torsorontio
WRS / NHS	Natural Heritage and Environmental Management Strategy (2015) Parks and Recreation Master Plan (2017) Natural Heritage Restoration Program (2018)	Natural Heritage and Urban Forest Strategy (2014) Future Directions, Parks and Forestry Master Plan (2014)	N/A	N/A	Integrated Community Sustainability Plan (2012)	Greening the Hill – Environment Strategy Update (2022)	N/A	N/A	N/A
Urban Forest	Brampton One Million Trees Program Urban Forest Management Plan (2022)	Urban Forest Management Plan (2014) Natural Heritage and Urban Forest Strategy (2014)	N/A	Expanding the Urban Forest – One Tree at a Time	King Township Tree Management Plan (2022 Draft)	Urban Forest Management Plan (2020-2040)	N/A	N/A	N/A
Stormwater Management	N/A	Stormwater 2021 – 2024 Business Plan Stormwater Master Plan (under development)	N/A	Stormwater Management Master Plan (2014)	Comprehensive Stormwater Management Plan (2022)	Stormwater Master Plan (in development and anticipated in next two years)	N/A	N/A	N/A

Humber River Watershed Characterization Report

	City of Brampton	City of Mississauga	Town of Caledon	City of Vaughan	Township of King	City of Richmond Hill	Town of Aurora	Town of Mono	Township of Adjala- Torsorontio
Climate Change (see Appendix D for supporting details)	Brampton's Community Energy and Emissions Reduction Plan: Our 2040 Energy Transition (2019) Brampton's Climate Change Adaptation Plan (underway)	Living Green Master Plan (2012) Mississauga Climate Change Action Plan (2019)	Resilient Caledon – Community Climate Change Action Plan (2021 for 2020 – 2050)	Green Directions Vaughan (2009) Vaughan Municipal Energy Plan: Plug into a Smart Energy Future (2016)	Draft King Climate Action Plan	Richmond Hill's Climate Change Framework (2020) Richmond Hill's Community Energy and Emissions Plan/Richmond Hill's Path to a Low-Carbon Future (2021)	Town of Aurora Community Energy Plan (2021) Town of Aurora Climate Adaptation Plan (2022)	Mono Community Climate Action Plan (2022)	N/A
Secondary Plans									
<i>Of relevance to Humber River watershed</i>	N/A	N/A	N/A	VMC Secondary Plan New Community Areas Secondary Plan Weston Road and Highway 7 Secondary Plan	N/A	West Gormley Secondary Plan	N/A	N/A	N/A
Guidelines / Standards									

Humber River Watershed Characterization Report

	City of Brampton	City of Mississauga	Town of Caledon	City of Vaughan	Township of King	City of Richmond Hill	Town of Aurora	Town of Mono	Township of Adjala- Torsorontio
<i>Of relevance to Humber River watershed / watershed planning</i>	Sustainable Community Development Guidelines – Part 8 (2013) Sustainable New Communities Program (2023)	Green Development Standards (2012)	Green Development Program	Sustainability Metrics Program / Guidebook	Sustainable King: Green Development Standards	Sustainability Metrics Design and Construction Guidelines (2022)	Green Development Standards (new process underway)	N/A	N/A
By-laws									
<i>Of relevance to watershed planning</i>	Tree Preservation By-law 317 – 2012 Stormwater Charge By-law 82- 2020 By-law to Protect and Conserve Topsoil 30-92	Private Tree Protection By-law 254-12 Stormwater Fees and Charges By- law 0135-2015 Erosion and Sediment Control By-law 512-91 Storm Sewer By- law 0259-2005	Woodland Conservation Bylaw	Tree Protection By-law	By-Law To Provide for the Preserving of Trees and for Prohibiting the Injuring or Destroying of Trees	Tree Preservation By-law Water Use Conservation By- law Site Alteration By- law	Private Tree Protection By-law	Bylaw to Prohibit or Regulate the Destruction or Injuring of Trees	N/A

4.1 Natural Heritage System Comparison

The concept of protecting NHSs has been in place since 1994 with the Comprehensive Set of Policy Statements. The Provincial Policy Statement (2020) includes policies to maintain, restore, and, where possible, improve the diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of NHSs. According to the Provincial Policy Statement (Ministry of Municipal Affairs and Housing 2020), an NHS is defined as:

“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. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue.”

In 2022, TRCA updated its regional target NHS in consultation with municipal partners to incorporate new information on our natural systems to inform and guide TRCA and our municipal partners’ initiatives that aim to protect, restore, and enhance natural systems over the long term. TRCA’s updated regional target NHS uses the most up-to-date science and practice on integrated natural systems planning, consolidates municipal NHSs, and accounts for climate change impacts on natural systems, and uses TRCA’s large field data and analytical capacity. Overall, TRCA’s updated NHS provides science-based information on features and areas that are important for ecosystem function.

The identified areas for TRCA’s regional target NHS were classified into three tiers with different, yet related, future management based on their land use and land cover conditions, including: (1) Existing natural cover (ENC) that includes natural cover and other features and areas that are important for natural heritage functions that could be targeted for protection; (2) Potential natural cover (PNC) that includes expanded areas important for natural heritage functions that could be targeted for restoration and enhancement; and, (3) Contributing areas (CAs) that include additional areas important for natural heritage functions but where traditional protection and restoration are likely not feasible and could be targeted for low impact development and green infrastructure implementation. CAs are a new category introduced in TRCA’s updated regional target NHS that aims to account for the contribution of the entire landscape including the built portions to achieve the NHS objectives.

Comparing municipal NHS mapping (for single and upper-tier municipalities), as identified in Official Plans (as of June 2022), to TRCA’s regional target NHS (2022) is important to look for overlaps, differences, and opportunities to protect, restore, and enhance natural heritage features.

See [Table 33](#) for a comparison of municipal NHSs (for Toronto, Peel, York, Dufferin and Simcoe) and TRCA’s regional target NHS by the amount of overlap in the systems, features that are only present in TRCA’s NHS, features that are only present in municipal NHSs, and areas with no NHS. Both the area in hectares and the percentage of the watershed is presented in [Table 33](#). [Map 36](#) shows the municipal NHSs for Toronto, Peel, York, Dufferin, and Simcoe compared to TRCA’s updated regional target NHS 2022.

Combining 'overlap' and 'municipal only' NHS means that currently 48% of the watershed is included in a NHS from municipal Official Plans (single and upper-tier municipalities). The amount of overlap between the municipal NHSs and TRCA's regional target NHS (90% of the watershed) indicates some shared objectives around NHS planning. However, there were some areas only considered to be NHS by TRCA (TRCA NHS Only) or by municipalities (Municipal NHS Only) and these discrepancies demonstrate that there are still opportunities to improve NHS planning in the watershed. Currently, 33% of the watershed has no NHS.

TRCA NHS Only

TRCA NHS only (TRCA's regional target NHS) includes an additional 19% of the watershed not included in a municipal NHS. Of this additional 19% that could be incorporated into a municipal NHS, approximately 11% was in Peel, followed by York (6%), Toronto (2%), Dufferin (<1%), and Simcoe (<1%). These additional areas primarily consisted of CAs in TRCA's regional target NHS; however, several areas of PNC and ENC were also identified as TRCA NHS only.

In more rural areas of the watershed (e.g., areas of York, Peel, Dufferin, and Simcoe), TRCA NHS only included CAs in agricultural areas, and rural and estate residential properties. CAs were also found surrounding headwater streams in rural areas. PNC was identified in agricultural areas and surrounding headwater streams but to a lesser degree in rural residential areas. Within York, Peel, Dufferin, and Simcoe, several areas were identified as ENC in TRCA NHS only while Toronto appeared to have better congruency. These areas included forest, successional, and meadow natural features. In Peel and Dufferin, some of these areas fell within the Niagara Escarpment Commission planning areas and, as such, they would be protected under those policies. Some examples of areas identified as ENC in TRCA NHS only include considerable areas around the Claireville Conservation Area (Peel) and areas of forest near Concession Road 8 and Sideroad 15 (York). Several larger areas were considered TRCA NHS only including an area near Concession Road 3 between Highway 9 and Adjala Sideroad 5 as well as areas near Old Church Road and Mount Hope Road and areas north of Mayfield and South of Castlederg Sideroad. These areas could have been recently approved for future development.

In more urban areas of the watershed, TRCA NHS only included golf courses, hydro corridors, and some roadside verges. CAs extended slightly beyond the ravine boundaries in urban areas but this was mostly due to the methodology used for NHS delineation (hexagon-based). CAs also included some urban/built up areas such as residential areas. There were also some smaller areas of ENC identified as TRCA NHS only in more urban areas including small forests, successional forest, and open areas (meadow).

Municipal NHS Only

Areas considered to be municipal NHS only (5% of the watershed) varied based on location within the watershed. The more rural areas in York, Peel, Simcoe, and Dufferin considered some agricultural areas, rural residential areas (e.g., farms), water bodies, and estate residential as NHS. In more urban areas such as Toronto, parks (e.g., Downsview Park and surrounding areas), hydro corridors, and small areas that have already been developed were considered NHS. Waterbodies were commonly considered in municipal NHS only and included inland lakes/ponds, large man-made ponds, and also the Claireville Reservoir. Areas that had been developed such as residential subdivisions were also sometimes considered municipal NHS only. In York, active recreational areas were considered NHS including soccer fields and baseball diamonds. Other municipal NHS only areas

resulted from study area boundary differences. Some of these built-up areas and active recreation areas currently included in the municipal NHS only should not necessarily be considered natural heritage features.

Through the development of this watershed plan, there will be an opportunity to better align NHS goals and objectives and ensure existing natural heritage features are adequately protected in policy while identifying potential areas for restoration and enhancement.

Table 33 - Comparison of Natural Heritage Systems

Single-tier and Upper-tier Municipality	Number of Hectares (% of watershed)								
	NHS Overlap			TRCA NHS Only			Municipal NHS Only	No NHS	Total
	ENC	PNC	CAs	ENC	PNC	CAs			
Watershed	25,028 ha (28%)	8,221 ha (9%)	5,585 ha (6%)	2,957 ha (3%)	5,353 ha (6%)	8,751 ha (10%)	4,350 ha (5%)	30,011 ha (33%)	90,258 ha (100%)
Toronto	1,217 ha (1%)	354 ha (<1%)	1,200 ha (1%)	52 ha (<1%)	40 ha (1%)	1,192 ha (1%)	196 ha (<1%)	9,036 ha (10%)	13,287 ha (15%)
Peel	12,399 ha (14%)	3,364 ha (4%)	1,939 ha (2%)	1,500 ha (2%)	3,234 ha (4%)	4,382 ha (5%)	1,557 ha (2%)	10,343 ha (12%)	38,718 ha (43%)
York	9,606 ha (11%)	4,175 ha (5%)	2,106 ha (2%)	1,073 ha (1%)	1,883 ha (2%)	2,997 ha (3%)	2,308 ha (3%)	10,341 ha (12%)	34,489 ha (38%)
Dufferin	735 ha (<1%)	80 ha (<1%)	91 ha (<1%)	272 ha (<1%)	161 ha (<1%)	113 ha (<1%)	66 ha (<1%)	241 ha (<1%)	1,759 ha (2%)
Simcoe	1,071 ha (1%)	249 ha (<1%)	249 ha (<1%)	60 ha (<1%)	36 ha (<1%)	67 ha (<1%)	223 ha (<1%)	50 ha (<1%)	2,003 ha (2%)

Notes: ‘NHS Overlap’ refers to natural heritage features present in both single and upper-tier municipal NHS’s and the regional target TRCA NHS 2022. ‘TRCA NHS Only’ refers to natural heritage features that are only present in the regional target TRCA NHS 2022. ‘Municipal NHS Only’ refers to natural heritage features that are only present in a single or upper-tier municipal NHS. ‘No NHS’ refers to areas in the watershed with no NHS.

5.0 CULTURAL HERITAGE INVENTORY

Although a cultural heritage component is not formally included as part of the watershed planning process based on the provincial guidance, it is important to recognize the Humber River's cultural heritage significance and designation as a Canadian Heritage River alongside the technical components described throughout this report. During the fall 2022 HRWP engagement, recognizing the importance of Indigenous history and rights, and the protection of cultural heritage were raised as key issues numerous times by the public and watershed stakeholders. As a result, a cultural heritage summary has been included in this report to highlight the cultural heritage importance of the Humber River.

The Humber River has a rich human history. For millennia, it provided a home for Indigenous peoples along its banks and acted as a vital transportation route that later became known as the Toronto Carrying Place Trail (shown in [Map 37](#)). More recently, the Humber River became the site of many of Toronto's post-European settlement homes and industries. Over the years, the Toronto Carrying Place Trail was susceptible to agricultural uses, urbanization, and deforestation making the river less navigable in some areas, resulting in longer portage routes.

Toronto Carrying Place Trail

The Toronto Carrying Place Trail was the foundation of the Humber River's Canadian Heritage River System (CHRS) designation – a designation awarded to rivers that have made a significant contribution to the development of the country. Because of its significance, the Toronto Carrying Place Trail has also been designated as a National Historic Event under the *Historic Sites and Monument Act* (1985); however, this designation is currently under review. In addition, key elements of the Toronto Carrying Place Trail on the Humber River, including its use as a vital transportation route and the location of settlements, posts, and forts, contribute to the rich human heritage of this historic water way.

Conceptually, there are two branches of the Toronto Carrying Place Trail. The western branch follows the Humber River starting four kilometers upstream of Lake Ontario at the site of the Seneca village of Teiaiagon. The village was located in the area now known as Baby Point Road and Baby Point Crescent (Baby Post), north of Old Mill. The route traverses approximately 60 km north, including a portage of 45 km overland along the main and eastern branches of the Humber River connecting north to the west branch of the Holland River and beyond to Georgian Bay. The eastern branch follows the Rouge River starting two kilometers north of Lake Ontario at the Seneca village of Ganatsekwyagon and connects to the eastern branch of the Holland River. The Toronto Carrying Place Trail spans across TRCA's and Lake Simcoe Region Conservation Authority's jurisdictions, with a portion of the eastern route in Rouge National Urban Park.

In 1999, the Humber River was designated as a Canadian Heritage River based on its outstanding human heritage and recreational values and was officially included in the CHRS, Canada's national river conservation program. The CHRS program is a federal-provincial-territorial managed program which works with river managers across Canada to conserve and promote the natural, cultural, and recreational values of designated rivers. While the Humber River did not meet the natural heritage criteria requirements set out by CHRS, since the river includes an impoundment (Claireville Dam), features such as the Toronto Carrying Place Trail and the extensive recreational trail system found throughout the watershed, amplified the rationale to support the Humber River's CHRS designation for outstanding cultural and recreational values. The West Humber River (a tributary of the Humber) was not included as part of the formal CHRS designation due to the human impacts on the river as a result of the Claireville Dam.

CHRS has also developed a Strategic Plan (2023) setting out priorities for the program. According to this Strategic Plan, "[t]he Canadian Heritage Rivers System has matured into a valued nationwide program, which is recognized as a model of stewardship, cooperation, and participation; one that engages society in valuing the natural, cultural, and recreational heritage of rivers and river communities as essential to the identity, health, economic prosperity, and quality of life of Canadians" (p. 3).

Similarly, in 2008, TRCA developed the 2008 HRWP which set out strategies to protect, restore, and celebrate this historic waterway. Having a watershed plan for the Humber River is a key requirement for the Humber River's CHRS designation, showing commitment to protecting, restoring, and celebrating river values. Over the past twenty years, TRCA has continued to work with First Nations and Indigenous communities, the CHRS, government agencies, watershed residents, and community partners on implementing priorities from the 2008 HRWP.

Cultural Heritage Conditions and Trends

Although the Humber River watershed is rich in human history and cultural resources, the last century has witnessed a significant increase of urban development. While development has come at the expense of some cultural sites, there continues to be an effort to preserve and celebrate existing sites such as archaeological sites, built heritage resources, and cultural heritage landscapes. The identification of these cultural heritage resources (and the changes over time) will help observe trends in the protection and planning efforts of cultural heritage resources at the municipal and provincial levels.

As part of their work with partners and Indigenous communities, TRCA staff have discovered and protected archaeological sites as old as 12,000 years. [Table 34](#) and [Table 35](#) present a summary of the current (known) archaeological sites within the watershed by site type and by municipality, respectively. [Table 36](#) and [Table 37](#) present a summary of current (known) built heritage resources/properties within the watershed, by type and by municipality, respectively. [Map 38](#) illustrates clusters of cultural heritage resources and highlighted areas of interest. It was compiled using geospatial analytics, as well as internal expertise.

Table 34 - Known and Registered Archaeological Sites in the Humber River Watershed by Site Type

	1998	2008	2019	2022	Change from 1998 to 2022 (+ or -)
Paleo	14	14	14	13	-1
Archaic	70	101	129	137	+67
Woodland	47	69	71	80	+33
Historic	58	121	316	348	+290
Unknown	162	285	544	561	+399
Total	351	590	1074	1139	

Table 35 - Archaeological Sites in the Humber River Watershed by Municipality

Lower Tier Municipalities ⁵⁸	# of sites (1998 to 2022)
Adjala-Tosorontio	1
Aurora	2
Brampton	284
Caledon	215
King	90
Richmond Hill	60
Toronto	67
Vaughan	420
Total	1139

⁵⁸ Archaeological sites for the Town of Mono and City of Mississauga have not been reported due to the absence of sites.

Table 36 - Known Built Heritage Resources in the Humber River Watershed by Type⁵⁹

	1998	2008	2019	2022
Heritage Conservation District	0	2	NRO ⁶⁰	NRO
Designated	85	349	780	576
Listed	563	675	1067	1767
Burials/Cemeteries	108	156	48	48
Mills ⁶¹	33	33	NRO	NRO
Historic Plaques and Interpretive Markers	10	37	NRO	NRO
Total	799	1,252	1,895	2,391

Table 37 - Built Heritage Properties in the Humber River Watershed by Municipality

Lower Tier Municipalities ⁶²	# of sites (1998 to 2022)
Aurora	3
Brampton	53
Caledon	520
King	236
Richmond Hill	55
Toronto	771
Vaughan	891
Total	2529

Map 39 shows the location of the archaeological sites and built heritage properties in the watershed and depicts cultural heritage resources by densities. The heat map symbology in **Map 39** displays the relative density of points by aggregating the individual points into a cell, and then using a colour ramp to display values from high to low. Interestingly, both figures illustrate higher densities of cultural heritage resources along the main and eastern branches of the Humber River, conceptually where the Toronto Carrying Place Trail is believed to have traversed. **Map 39** also depicts a band of resources around the City of Toronto. The reason for this band of resources is due to legislative changes requiring archaeological assessments prior to development in more

⁵⁹ Due to time constraints imposed by Bill 23 on municipalities to work through their heritage registers, clarification on the discrepancies identified in the data provided by municipalities was not sought out.

⁶⁰ NRO means the data was not reported on (by municipalities) and/or was not available.

⁶¹ For mills, some information compiled was not registered.

⁶² Built heritage properties for the Township of Adjala-Tosorontio, Town of Mono, and City of Mississauga have not been reported due to the absence of sites/properties.

recent years. That is, the paucity of archaeological sites in the City of Toronto is not an indication of archaeological potential, but rather due to a lack of detailed surveys in the area prior to development. As urban development expanded from the City of Toronto, the registration of archaeological sites increased as witnessed in municipalities such as Vaughan and Brampton. This trend is occurring presently in the Township of King and is expected to extend into the Town of Caledon.

Map 39 also shows the location of the cultural heritage landscapes within the watershed. Cultural heritage landscapes are defined in the Provincial Policy Statement (2020) as:

“A defined geographical area that may have been modified by human activity and is identified as having cultural heritage value or interest by a community, including an Indigenous community. The area may include features such as buildings, structures, spaces, views, archaeological sites or natural elements that are valued together for their interrelationship, meaning or association. Cultural heritage landscapes may be properties that have been determined to have cultural heritage value or interest under the Ontario Heritage Act, or have been included on federal and/or international registers, and/or protected through official plan, zoning by-law, or other land use planning mechanisms (p. 42)”.

A few municipalities have recognized cultural heritage landscapes within their jurisdiction including the Town of Caledon and City of Vaughan as illustrated on **Map 39**. In the future, there may be an increased recognition of cultural heritage landscapes by municipalities as more municipalities adopt cultural heritage landscapes within their Official Plan policies.

Targets and Progress from 2008 HRWP

The 2008 HRWP identified two targets for cultural heritage: 1) Increase the number of known, Listed, and Designated archaeological and historical sites and built heritage features; and, 2) Increase watershed residents’ awareness that the Humber River is a Canadian Heritage River.

Regarding the first target, an increase in the number of known, Listed, and Designated archaeological and historical sites and built heritage features in the watershed have been documented and field verified. As shown in **Table 34**, approximately 549 archaeological sites were registered in the watershed between 2008 and 2022 (with 65 of these sites registered between 2019 and 2022). As shown in **Table 36**, the number of known built heritage resources in the watershed has also increased from 1,252 in 2008 to 2,391 in 2022 (with an increase in 496 built heritage resources between 2019 and 2022). It is important to note that some discrepancies were identified in the heritage data. With the knowledge of the limited resources available to staff at municipalities and their response to Bill 23, municipal staff were not engaged further regarding these discrepancies.

Regarding the second target, since the 2008 HRWP was published, cultural heritage in the Humber River watershed has changed from a built heritage, community awareness, and engagement and legislative perspective. There has been an increased focus on TRCA’s part in delivering programming and events to create awareness of the Humber River’s CHRS designation such as Celebrate the Humber which engages over 3,000 people in canoeing activities in the lower Humber each year. As part of this event, community members learn about the rich human history and recreational values of the Humber River and about its Canadian Heritage Rivers designation.

The Ontario land use planning policy landscape continues to evolve which also brings implications to cultural heritage resources and sites throughout the watershed. In 2022, Bill 23, a large omnibus bill brought about broad implications to legislation related to land use planning in Ontario, including the *Heritage Act* and the municipal responsibility to protect listed and designated heritage properties. The long-term implications of Bill 23 are still yet to be understood and presents an opportunity to monitor changes in trends related to cultural heritage resources, especially built heritage, within the watershed.

Moving forward, TRCA will continue to advocate for the protection, recognition, and celebration of the rich cultural heritage and legacy of the Humber River, including the Toronto Carrying Place Trail, by continuing to carry out, and seeking to further expand on, the following actions:

- Working with stakeholders to achieve a system of protected and conservation areas along the Toronto Carrying Place Trail through the Regional Trail Strategy.
- Advocating for the inclusion of the Toronto Carrying Place Trail through municipal and regional Official Plan Review processes.
- Advocating for the recognition and protection of heritage bridges across the watershed.
- Celebrating and recognizing the importance of the Toronto Carrying Place Trail through education, outreach, programming, and events (i.e., Humber by Canoe).
- Continuing to work with First Nations and Indigenous communities as well as federal, provincial, and municipal partners, Lake Simcoe Region Conservation Authority, and community members to identify opportunities to promote and celebrate the Humber's CHRS designation and significance of the Toronto Carrying Place Trail, and to continue efforts with partners to obtain funding to support these initiatives.

6.0 METHODOLOGY

This section provides an overview of the methods and approaches that were used to characterize the technical components of watershed planning discussed throughout this report. In 2022/2023, the following 15 internal technical reports were prepared by TRCA in support of this report and include more details about the results and methodology for each component:

- Water Resource System Technical Characterization Report
- Aquatic Ecosystem Technical Characterization Report
- Hydrogeology Technical Characterization Report
- Groundwater Quality Technical Characterization Report
- Hydrology Technical Characterization Report
- Terrestrial Ecosystem Technical Characterization Report
- Natural Heritage System Features and Areas Technical Characterization Report
- Urban Forest Canopy Cover Technical Characterization Report
- Surface Water Quality Technical Characterization Report
- Natural Hazards (Flooding) Technical Characterization Report
- Natural Hazards (Erosion) Technical Characterization Report
- Stormwater Management Technical Characterization Report
- Restoration Planning Technical Characterization Report
- Historical Climate Trends Technical Characterization Report
- Cultural Heritage Technical Characterization Report

6.1 Water Resource System

This subsection outlines methods associated with the WRS components, riparian cover, in-stream aquatic barriers, riverine fish community health, sensitive species habitat, estuary fish community health, benthic invertebrate community health, freshwater mussels, aquatic habitat quality, ecohydrology, groundwater conditions, and streamflow.

6.1.1 Water Resource System Components

For the components of the WRS (KHAs and KHF), a variety of methods were used to delineate each component, as outlined in [Table 38](#).

Table 38 - WRS Delineation Methodologies

Methods	
Key Hydrologic Features and Areas	<p>The WRS, consisting of KHFs (inland lakes, wetlands, and seepage areas/springs) and KHAs (SGRAs, ESGRAs, SSWCAs, and HVAs), were characterized by summarizing the total areas of these features within the watershed, each subwatershed, and land use area. For specific methods regarding how these features and areas were delineated refer to the following documents: TRCA Water Resource System: Methods and Analysis for Delineating Key Hydrologic Features & Areas (Ruppert et al. 2022), and Etobicoke Creek Watershed Characterization Report (TRCA 2021).</p>
Headwater Drainage Features	<p>Desktop review of potential HDF sampling sites was completed using 10 ha drainage lines based on TRCA's digital elevation model (DEM). Due to the large area of the Humber River watershed, HDF sampling locations were identified in the field using a modified sampling approach only at points where drainage lines occurred at road crossings over two years.</p> <p>Each HDF was assessed by characterizing the flow condition, type of feature, and the presence or absence of fish at the time of observation. Data was collected from a total of 447 sites in early spring, 229 in late spring, and 219 in late summer in 2021 and 2022. Only sites that were found to have flowing water were re-visited. Specific criteria used to characterize the flow and type of feature at each HDF sampling site are outlined in the Appendix of the Water Resource System: Features and Areas – Etobicoke Creek Watershed Plan Technical Component Characterization Report (Ruppert et al. 2020) or the Constrained Headwater Sampling Module of the Ontario Stream Assessment Protocol (S4. M10; Stanfield et al. 2017).</p>
Headwater Drainage Feature and Watercourse Characterization	<p>In the Humber River watershed, flow condition data were collected previously in 2012 and 2017, and for this characterization in 2021 and 2022. Additionally, baseflow data (2001-2022), 2021 orthophotography, wetland, and groundwater data were used to classify each HDF in the watershed as Permanent, Intermittent, or Unknown. These data were also used to update the permanency classification of segments of the regulated watercourses.</p> <p>Generally, features that were dry or had standing water at the early spring field visits were classified as unknown, due to a lack of information to confidently characterize the feature. Sites that had flowing water on the first visits but were dry or had standing water on the second visits were classified as intermittent. Sites that had flowing water on the first and second visits but were dry or had standing water on the third visits were also classified as intermittent. Any sites that had flowing water on all three visits were classified as permanent features, and some that had standing water on the third visit were also classified as permanent if previous years of flow data or other data sources supported this classification. Additional data sources were used to aid classification where field data was not available and in instances where current and past data or upstream and downstream data conflicted.</p>
Hydrology Functions Classification	<p>The same data sources that were used to classify permanency were also used to classify hydrology functions of the watercourses and HDFs. Based on these data,</p>

Methods	
	<p>each feature was classified as having Important, Valued/Contributing, or Limited/Recharge hydrology functions according to Credit Valley Conservation/TRCA's Evaluation, Classification and Management of Headwater Drainage Features Guidelines (Credit Valley Conservation & TRCA 2014).</p> <p>In general, features classified as permanent were deemed to have important hydrology functions. Features classified as intermittent were deemed to have valued or contributing hydrology functions. Lastly, features classified as unknown permanency were deemed either as valued/contributing or limited/recharge, using the wetlands and groundwater data to aid classification.</p>
Fish Data Collection	<p>At each HDF sampling site, incidental presence of fish was recorded. In 2021, observation and dip netting were completed at select sites that still had water on second or third visits. No fish dip netting was completed in the first field visit in May. Any fish obtained were identified to species, recorded, and photos were taken. Fish dip netting data were not collected in 2022 due to time limitations.</p>

6.1.2 Riparian Cover

The amount of riparian vegetation in the watershed was determined using a desktop GIS analysis. The amount of natural cover within the riparian corridor/zone was compared between the baseline (2002) and current (2012 and 2020) time periods. The riparian zone was calculated as the perpendicular distance from the centreline using the formula:

$$RC = 0.5(W_b) + 30$$

RC is the riparian corridor width in metres and W_b is the average bankfull width of the stream in metres. In order to evaluate the amount of riparian cover at the watershed scale, RC was calculated for each stream order type (as in Strahler 1964). To account for the riparian zones of lentic systems (e.g., ponds and lakes), a 30 m buffer was applied around the water polygon for areas identified as lacustrine. Lentic and lotic riparian zone areas were then combined to yield one estimate of the total area of the riparian corridor. Summaries of natural cover, meadow, forest, and wetland cover for the entire watershed and subwatershed were tabulated.

6.1.3 In-stream Aquatic Barriers

The number and passability of barriers in the Humber River were assessed by updating the unnatural barrier inventory records. This was completed through a combination of field work in 2020 and 2021, reviewing orthophotography, reviewing restoration and mitigation information, and comparison with historical records. In total, 128 barriers (91 completely impassable and partially passable) were surveyed in the Humber River. The number and passability of barriers in the current period were updated to reflect mitigation and or removal of barriers since 2008.

The passability of each structure was classified as impassable by all species (0), partially passable by jumping species only (0.5), and fully passable by all species (1). For barriers surveyed in 2020 and 2021, the physical height of the barrier along with velocity and pool depth were used to evaluate passability. For historical barriers or those not surveyed in 2020 or 2021, all barriers were assumed to be impassable to all species (0). For

mitigated barriers, updated passability was determined based on the restoration type completed, where removed, and mitigated barriers were considered fully passable and fishways became partially passable by jumping species.

6.1.4 Riverine Fish Community Health

To characterize the fish community in the Humber River, species presence was evaluated across three time periods (historical (pre-2002), baseline (2002-2011), and current (2012-2022)). Fish capture records from several monitoring programs were evaluated including TRCA's RWMP, the Lakefront Environmental Monitoring Program, and the Sea Lamprey and Asian Carp control programs, as well as provincial and literature records of the historical period. In 2020 and 2021, additional sites (N = 8 and N = 11 respectively) were sampled using the regional monitoring protocol to increase the spatial coverage of the watershed.

There are 39 established RWMP sites in the Humber River watershed; however, due to access challenges or annual site conditions, roughly 28 sites are surveyed every year on average. Surveys have occurred every three years from 2001 to 2022 using single pass electrofishing (without block nets) as described in the Ontario Stream Assessment Protocol (Stanfield 2017). For these analyses, the year 2001 was included in the baseline time period because there is no similar data collected using standardized methods prior to 2000. Eleven additional sites were sampled in 2020 and 2021 to increase the spatial coverage of sampling in the Humber River in support of the new HRWP.

The IBI score for each site in each year was calculated following a modification of the Steedman (1998) methodology. Modifications to the index calculation included removing the presence of blackspot disease as a sign of poor quality which reduced the maximum IBI score from 50 to 45. The IBI produces a score ranging from 10 ('poor') to 45 ('very good') using nine measures of fish community composition under four broad groups (species richness, local indicator species, trophic composition, and combined fish abundance; Steedman 1988). Average IBI scores at RWMP sites were assessed for differences between the baseline and current time period at the watershed, subwatershed, and site scale using a permuted t-test in R (R Development Core Team 2020). Four health rating classes were used to interpret the scores, including: 'poor' (IBI ≤ 20), 'fair' (IBI = 20-27.9), 'good' (IBI = 28-37.9) and 'very good' (IBI = 38-45).

6.1.5 Sensitive Species Habitat

To identify Redside Dace habitat, the meander belt width (MBW) was delineated following the methods outlined in [Section 6.1.2 Riparian Cover](#) along with delineation of contributing habitat following methods prepared for the West Humber subwatershed (Matrix Solutions Inc. 2017). The MBW, plus 30 m on either side of the stream, is considered contributing habitat. Further, potentially contributing habitat includes all flowing streams as well as HDFs or wetlands that augment or maintain baseflow, coarse sediment supply, or surface water quality of a part of a stream or other watercourse as per the regulated definition (ESA regulation 832/21). Finally, continuous forest and wetland patches that intersected with DFO's regulated Redside Dace Habitat layer were included as potentially contributing habitat. For wetlands, the entire wetland complex was included as potentially contributing habitat. For forest areas, ELC codes were used, and forests were excluded only if there was no hydrological connection to Redside Dace occupied habitat. This method results in a total contributing habitat area that is larger than simply the total area of MBW plus 30 m because continuous forest and wetland

patches can extend beyond the 30 m buffer. The analysis of natural cover type is presented relative to the total estimated contributing area. Maps produced are for screening purposes only and do not constitute legally enforceable regulated habitat; this responsibility lies with MECP and DFO. The amount of potentially occupied and contributing habitat was summarized by the amount of different types of natural cover (forest, wetland, successional, and meadow) found within Redside Dace potentially contributing habitat.

To estimate the area of potentially occupied and potentially contributing habitat of Rapids Clubtail in the Humber River, the definition of regulated habitat was compared to existing species occurrence data and land-use cover information. Species occurrence was based on verified records in the iNaturalist database as of December 2022 (NHIC 2022). The definition of regulated habitat includes areas in the Humber River that aligned with provincial regulation O. Reg. 832/21 s28 (1-5, 1-6), and s28 (2) including “The part of the geographic area of Peel composed of the lower-tier municipality of Caledon and the parts of the geographic area of York composed of the lower-tier municipalities of King and Vaughan.” Further to the regulation, and within the geographic areas listed above, any part of a river, stream or other body of water, up to the high-water mark, being used, or having been used in the last five years, by Rapids Clubtail was considered potentially occupied habitat. Areas of deciduous or mixed forest or of deciduous or mixed treed swamp that were adjacent to occupied or potentially occupied areas within 200 m of the relevant high-water mark were delineated and classified by natural cover type. Potentially contributing instream and terrestrial habitat was estimated using the 6th and 7th order stream segments connected to the potentially occupied habitat and including terrestrial habitat within 200 m of the high-water mark that was defined as deciduous or mixed forest or of deciduous or mixed treed swamp. Within the delineated area, natural cover type was summarized.

6.1.6 Estuary Fish Community Health

The state of fish communities within the estuary of the Humber River was characterized using electrofishing records of the Lakefront Environmental Monitoring Program from 1989 to 2021. Each transect consisted of approximately 1,000 electrofishing seconds and transects were conducted parallel to the shoreline to survey the nearshore (littoral) zone. The protocol for electrofishing followed Goodchild (1986) and Valere (1996). Surveys were completed across three time periods (historical: 1989-2001, baseline: 2002-2011, current: 2012-2021). Fish communities of inland lakes (e.g., Lake Wilcox) are not included in the analyses or results of this report due to inconsistent sampling of the lakes across time.

To assess differences within the estuary and changes through time, IBI, species richness, Shannon index (H), and the number of invasive species were summarized for each period. Fish community assemblages were also compared across time periods using a Principal Component Analysis of species presence-absence for the Humber River estuary. Using the ordination biplots of the Principle Component Analysis, community similarity was visualized across time (Legendre and Legendre 2012). Analyses were completed using the vegan package in R Software (Oksanen et al. 2019, R Development Core Team 2020).

6.1.7 Benthic Invertebrate Community Health

The FBI was used to assess the health of the BMI community at multiple sites in the Humber River watershed between 1999 to 2021. The FBI evaluates the presence and abundance of benthic invertebrate species collected in a sample to provide an estimate of the overall community health, where values scale from 0-3.75 (‘excellent

quality'), 3.76-4.25 ('very good'), 4.26-5.00 ('good'), 5.01-5.75 ('fair'), 5.76-6.5 ('fairly poor'), 6.51-7.25 ('poor'), to 7.26-10 ('very poor'). Low values are assigned to groups which are sensitive to organic pollution while high values suggest groups which are tolerant to organic pollution. Each tolerance value is used in a weighted average calculation, following:

$$FBI = \sum \frac{x_i * t_i}{N}$$

x_i is the number of individuals within a taxon, t_i is the tolerance value of a taxon, and N is the total number of organisms in the sample.

The average Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) taxa per site and percent tolerant species are also presented. Percent tolerant species was calculated as the total proportion of Chironomid and Oligochaeta organisms present at a site.

The data was evaluated across three time periods: historical (1999-2000), baseline (2003-2012), and current (2013-2021). In 1999 and 2000, sites were surveyed throughout the watershed but sampling was not spatially consistent between years, or consistent with RWMP sites established in 2003. From 2003 to 2012, a modified version of the Ontario Stream Assessment Protocol (Stanfield 2017) benthic collection method was used at RWMP sites. Since 2013, the Ontario Benthos Biomonitoring Network (Jones et al. 2007) protocol has been used at RWMP sites in the Humber River. These differences have been accounted for through data standardization to allow for a qualitative comparison of benthic community health between time periods. Temporal trends are evaluated quantitatively within each of the baseline and current time periods. A total of 31 to 36 sites were sampled annually during the current period. Methodological changes that occurred between 2012 and 2013 require that the year 2012 be included in the baseline period instead of the current period. Due to spatial sampling differences between 1999 and 2000, no temporal trend analysis is available for the historic period in comparison to the current period. In 2021, an additional 11 sites are included in the characterization of the benthic community with respect to the frequency of FBI categories, but not in temporal trend assessments. These sites were included to increase the spatial coverage of benthic data in the current period. BMI were collected using the standard Ontario Benthos Biomonitoring Network protocol at the additional sites in 2021.

Further, seven sites were also included in 2019 and 2020. These sites were surveyed as part of a detailed stormwater pond project and followed a 'keep and sweep' sampling approach. These data are included to increase the spatial coverage of the data but are not included in trend analyses. Three RWMP sites were removed from temporal analyses because they were only sampled once during the current period.

BMI community health metrics were calculated at the watershed and subwatershed scale for each time period. Interpretation of the BMI community health results are more informative at the subwatershed scale than at the watershed scale due to differences in stream order and environmental conditions among subwatersheds. Furthermore, sampling effort is not equally distributed across the subwatersheds on an annual basis where Black Creek is represented by only one site compared to the Main Humber subwatershed which contains 20 annual monitoring sites. The Ontario Benthos Biomonitoring Network collects three samples from a station: two riffles and one pool. The pool sample is excluded from this report and analysis because the FBI metric is not developed for pool species. Therefore, diversity and health of the BMI community may be under-represented by excluding the pool samples. The two riffle samples are averaged to calculate one metric per station per year.

Prior to analyses, the data residuals were checked for normality. In most cases, the data was considered normal based on a Shapiro test. A linear regression model was used to assess linear trends in FBI across the current time period at the watershed and subwatershed scale. Analyses revealed an interaction between the independent variables year and sampling month. Further evaluation demonstrated that sampling month significantly influenced annual trends, with May, June, and October having significantly higher FBI values and greater variability. To account for this, analyses were re-run excluding early and late sampling events; however, this data reduction resulted in a greatly truncated dataset for some combinations of years/subwatersheds. Therefore, all data was included except for the month of October which only occurred in one sampling event. To determine if the percent of sites in 'fair' or better condition has changed during the current period a Mann-Kendall trend test was used.

The frequency of each FBI classification level (e.g., 'very good' to 'very poor') was calculated for each year and subwatershed to investigate the number of sites in 'fair' or better condition. This metric was a target presented in the 2008 HRWP. Samples from the month of October were excluded from this summary, but sites with only one year of data were included.

All analyses and visualizations were carried out in the statistical program R using various packages (R Development Core Team 2020). To visualize the change in BMI community health over time, the average site-specific FBI value for each time period was calculated.

6.1.8 Freshwater Mussels

In 2022, two timed-search visual, qualitative surveys were completed in the West Humber subwatershed to assess the presence of Unionids at sites that were informally surveyed in 2007 (TRCA 2008b). The two sites were surveyed for a total of 4.5 and 4.75 person hours, respectively, and the sites differed in length (~730 m and ~230 m, respectively). Both sites occurred in small, meandering streams with pool/riffle habitat. Pools deeper than 1 m were not surveyed. Sites surveyed in 2005 and 2006 were not revisited in 2022 due to time and weather constraints.

6.1.9 Aquatic Habitat Quality

Habitat quality was measured using the percentage of landcover that is classified as impervious, where more impervious cover is associated with lower habitat quality. Impervious cover was calculated for the baseline and current period at the watershed, subwatershed, catchment, and RCA scales using a desktop GIS analysis. To do this, land use types for 2002, 2012, and 2020 were assigned an overall impervious value calculated by summarizing the area as a function of the runoff coefficient (i.e., Directly Connected Impervious Cover/Area or DCIA), such that:

$$A_{IC} = A_{LU} * DCIA/100$$

A_{LU} is the area of land use type in hectares for each scale of the analysis (e.g., catchment or RCA), DCIA is the runoff coefficient, and A_{IC} is the impervious area in hectares. The overall impervious cover (IC) percentage for each land use period is calculated by:

$$IC = (TA_{IC}/TA) * 100$$

TA_{IC} is the total area of impervious cover in hectares, TA is the total area in the watershed, and IC is the overall impervious cover percentage for the watershed. Changes in percent impervious cover were calculated for each time period based on land cover data (2002, 2012, and 2020) at each scale, and the overall change from historical (2002) to current (average of 2012 and 2020) period. Impervious results are interpreted using four classes of ecological health, including: 'sensitive' (<10%), 'urbanizing' (11-25%), 'non-supporting' (25-60%), and 'urban drainage' (>60%).

6.1.10 Ecohydrology

The IHA (Richter et al. 1996) were developed to allow scientists and managers to understand the hydrological impacts of human activities. For the Humber River watershed, the IHA were calculated using software developed by The Nature Conservancy of Canada (2009) and stream discharge data obtained from nine WSC gauges (02HC027, 02HC051, 02HC023, 02HC025, 02HC032, 0H2C047, 0H2C009, 02HC031, and 0H2C003). At least one gauge was located in each of the subwatersheds. The software produces 32 IHA parameters that can be used to compare the level of hydrological alteration between a "pre" alteration time period and a "post" alteration time period. Nine IHA parameters were selected as the best representatives of potential hydrological alteration in the Humber River between historic (late 1940's to mid-1980's depending on the gauge station to 2001), baseline (2002-2011), and current (2012-2020) time periods. The selected parameters included high pulse count, high pulse duration, low pulse count, low pulse duration, rise rate, the number of reversals, date of maximum flow, and date of minimum flow. These parameters describe the frequency and magnitude of peak and low flows in stream discharge.

6.1.11 Groundwater Conditions

Groundwater Recharge

Groundwater Modelling

The Tier 3 Water Budget represents improvements to the Tier 1 and Tier 2 Water Budgets in terms of the model simulation and more accurate estimates of groundwater movement between and across subwatershed boundaries. However, the Tier 3 Water Budget did not include the entire Humber River watershed (TRCA 2015). The Tier 3 model used GSFLOW. The surface water portion of GSFLOW is based on the Precipitation-Runoff Modelling System (PRMS). The GSFLOW version of PRMS also improves on the original PRMS code with the inclusion of a cascading overland flow algorithm that routes surface runoff along flow pathways toward streams and lakes, thus allowing for run-on and re-infiltration; and the ability to communicate with the groundwater model to account for water table feedback mechanisms that may reject potential recharge and add groundwater discharge to the surface water system (TRCA 2015).

Subsequently, the ORMGP worked with TRCA to extend the York Tier 3 model into the Humber River watershed to model ESGRAs across the entire TRCA jurisdiction (TRCA 2019). More recent model developments include Peel Region in collaboration with the ORMGP and the Credit Valley Conservation, initiating a program to develop a regional-scale numerical model of the groundwater and surface water flow systems in Peel Region. The groundwater analysis attempted to (1) delineate wellhead protection areas (WHPAs) for Peel Region municipal wells, (2) assess aquifer vulnerability and vulnerability scoring in the WHPA areas, (3) delineate cones of influences for each municipal well, (4) delineate highly vulnerable aquifers (HVA), and, (5) delineate ESGRAs in

the study area. The groundwater analysis also provides a foundation for additional model improvements and more complex assessments under the Phase 2 work program. The buffer around Peel Region is sufficient to encapsulate the Etobicoke Creek watershed and parts of the Humber River watershed, as well as allowing for greater coordination between Credit Valley Conservation and TRCA (EarthFx 2020). The ORMGP model was used to determine the recharge rates presented in this report which is informed not only by TRSPA/CTC source protection modelling but also by neighbouring source protection areas/regions.

The GIS exercise evaluated the effectiveness of any particular ESGRA mapping scenario in protecting groundwater-dependent ecosystems, and a layer describing the most highly groundwater-dependent ecosystems in TRCA watersheds was created. Since it is difficult or impossible to know which particular streams and wetlands receive the highest proportion of groundwater without extensive site-scale studies, this layer of highly groundwater dependent ecosystems represents those areas in which TRCA staff have the highest degree of confidence that the area's ecology is essentially defined by its reliance on groundwater inputs. Three types of highly groundwater dependent ecosystems were defined as indicators of a highly groundwater-dependent ecology; these consisted of the following layers:

- Groundwater-obligate wetland flora, defined by highest concentrations of species records.
- Coldwater aquatic habitat, defined by the highest concentrations of species records.
- Fen wetland communities, defined by ELC mapping.

Groundwater Discharge to Watercourses

The hydrogeological information presented in the groundwater discharge layer is derived from hydrogeological modelling and contains inherent uncertainty. This layer is an output from the CAMC regional numerical GSFLOW integrated groundwater/surface water model. This particular model was selected for the following two reasons: (1) The CAMC regional model extends beyond the TRCA's jurisdiction and, (2) Every model has a different interpretation of streams making it difficult to reconcile one model to another. The decision to update the groundwater discharge layer using the CAMC regional model provides greater consistency with adjacent conservation authorities and clarity.

To predict impacts on groundwater and surface water, ORMGP developed a regional flow model that extends across most of the ORMGP domain and a sub-regional model for the GTA core. MODFLOW was used to represent an area extending from the Niagara Escarpment eastward to the Trent River and southward from Lake Simcoe to Lake Ontario. 100-m wide cells were used in the subregional model to better represent stream/aquifer interaction and well drawdowns. The regional model was based on the Geological Survey of Canada's 5-layer stratigraphic model; this was further refined to eight layers for the core model. Models were calibrated to observed heads and baseflow and provide regional water balances, refined recharge and aquifer property estimates, wellhead capture zones, and valuable insight into the sensitivity of the groundwater and surface water systems to development-induced change.

MODFLOW uses several types of head-dependent discharge boundaries to simulate groundwater/surface water interaction where water is gained from (or lost to) a partially penetrating stream as leakage across a low permeability streambed. MODFLOW "drains" were used in the regional model to simulate discharge to the

groundwater-fed streams. The key assumption regarding “drains” is that leakage occurs in only one direction, (i.e., from the aquifer to the drain).

Leakage is proportional to the head-difference across the streambed. The “drain conductance”, a MODFLOW parameter equal to the streambed hydraulic conductivity divided by the streambed thickness times the wetted perimeter, was specified for each drain segment passing through a cell. Map lines representing stream reaches were each given a Strahler classification and assigned an average width and bed thickness. Hydraulic conductivities were assigned based on the parent soil material. Lengths of the drain segment within a finite difference cell were obtained by “intersecting” the model grid with each line segment representing a reach. Control elevations were assigned to each reach based on digital elevation data. VIEWLOG calculated the drain conductance values and created an input data file with over 270,000 drain segments. Drain conductances were adjusted during model calibration to better match observed baseflows.

Uncertainty

The headwaters area of the watershed generally functions as a groundwater divide for all three aquifer systems in the Humber River watershed. However, this divide is less pronounced along the Schomberg – Nobleton corridor, and there are several areas where groundwater moves in or out of the watershed. Where the Niagara Escarpment and Oak Ridges Moraine meet, there is uncertainty regarding groundwater divides and flow direction. The York Tier 3 Model suggested that there are significant inflows of groundwater from the Credit River watershed to aquifers in the northwestern part of the Humber River watershed, in the vicinity of Caledon East and Bolton, due to the influence of a meltwater or tunnel channel and bedrock valley aquifer system. However, it is also worth noting that the modeling undertaken by Credit Valley Conservation around the same time indicated inflows of groundwater from TRCA to Credit Valley Conservation (personal communication with Don Ford 2022). The 2021 Peel Model may answer some of the questions raised by earlier models; however, at the time of the writing of this report, the 2021 Peel Model has not entered the ORMGP model custodian program. It is further worth noting, that in the vicinity of the Village of Nobleton, there is some inter-basin flow of groundwater from the Lake Simcoe watershed into the Humber, and in the vicinity of Palgrave there is groundwater flow from the Nottawasaga River watershed into the Humber River watershed.

Groundwater Discharge

Baseflow Index

With respect to groundwater discharge within the Humber River watershed, the ORMGP has developed a surface water and climate analysis tool in the Shiny application, which allows for evaluation of trends. The Shiny application calculates Boxplots and Baseflow Index with 14 separation methods. Boxplots follow the method of McGill et al. 1978, where box represents the 25% to 75% quantile, while the center line represents the median (50%). Monthly BFI given by the monthly median of calculated baseflow are bounded by the 95% confidence interval.

Groundwater Discharge to Watercourses

The TRCA extended groundwater model was rerun and the discharge output was provided to GIS staff to include in TRCA’s corporate dataset. Groundwater discharge to watercourses was last mapped in 2006 so the science

had advanced significantly in the intervening 16 years. In the 2022 update, more watercourses are mapped, and average discharge mapped is significantly higher.

Permits to Take Water (PTTW)

PTTW data was obtained from the ORMGP that in turn obtained it from MECP. The data was last updated April 11, 2022. Any permit that was active on April 11, 2022 was assumed active for the purposes of this assessment. It was noted that the Caledon East and Palgrave municipal systems were not included in the download despite staff being aware that the systems have operated continuously from the last HRWP until present. The PTTW information for these two systems was obtained from the Provincial Source Protection Atlas and was included in the dataset.

Wellhead Protection Areas

The TRCA corporate dataset was updated to reflect the recent Section 51 and Section 34 updates which amended the TRSPA Assessment report to include the capture zone for the Orangeville wells and Aurora wells extending into the Humber River headwaters. It should be noted that the only Issue Contributing Area (chloride) within the Humber River watershed covers the same areas as the Orangeville WHPA-D which extends into TRCA's jurisdiction.

Groundwater Quality

The overall goal for groundwater quality in the Humber River watershed is for water to be safe for people and fish. TRCA collects data on over 50 water quality analytes at each groundwater quality station and a subset of these parameters was selected for analysis based on their relevance to common water-use concerns. [Table 39](#) outlines the selected indicator analytes, their expected impacts on the aquatic environment, their potential sources, and the applicable groundwater quality guideline for reference.

Table 39 - Groundwater Indicator Analytes, Significance, Potential Sources, and Applicable Groundwater Quality Guideline for Reference

Indicator Analyte	Significance	Potential Sources (examples)	Guideline/Objective
Total phosphorus (TP)	In excess, phosphorus can have unfavourable effects such as eutrophication (enrichment of a waterbody with nutrients). Phosphorus stimulates plant and algae productivity and biomass. Past a certain point, this can cause reduced biodiversity, changes in the dominant biota, decreases in ecologically sensitive species, increases in tolerant species, anoxia, and increases in toxins (e.g. cyanobacteria).	<ul style="list-style-type: none"> Fertilizers Animal wastes Sanitary sewage 	N/A
Nitrate (as N)	Nitrogen compounds are nutrients with sources and effects similar to phosphorus. Nitrate serves as the primary source of nitrogen for aquatic plants in well oxygenated systems, and as	<ul style="list-style-type: none"> Fertilizers Septic tanks Animal wastes 	CWQG: chronic 13 mg/L; acute 550 mg/L

	nitrate levels increase, there is an increasing risk of algal blooms and eutrophication.	<ul style="list-style-type: none"> • Municipal wastewater 	ODWS: 10 mg/L
Unionized ammonia (all forms of ammonia except NH_4^+)	Ammonia commonly enters the environment as a result of municipal, industrial, agricultural, and natural processes. Unionized ammonia is extremely toxic to aquatic life and toxicity is affected by pH and temperature.	<ul style="list-style-type: none"> • Fertilizers • Decomposition of organic waste • Industrial discharge 	CWQG: 0.019 mg/L
Chloride	Chloride can be toxic to aquatic organisms with acute (short-term) effects at high concentrations (e.g., mortality) and chronic (long-term) effects at lower concentrations (e.g., decreased reproductive output; CCME 2011).	<ul style="list-style-type: none"> • Road salt application • Fertilizers • Industrial discharge 	CWQG: chronic 120 mg/L; acute 640 mg/L ODWS: 250 mg/L
Metals	Several heavy metals are toxic to fish and other aquatic organisms at varying concentrations. Most metals enter waterways through surface runoff. Metals bind to sediment and can affect fish (e.g., clogging of gills) and benthic invertebrates (e.g., habitat changes, smothering food sources).	<ul style="list-style-type: none"> • Urban runoff • Industrial discharge • Sewage treatment • Fertilizers / pesticides • Atmospheric deposition • Soils 	O. Reg. 153/04 (Table 1): <ul style="list-style-type: none"> • Copper – 5 µg/L • Iron – n/a • Zinc – 160 µg/L

For the groundwater quality assessment, data were collected through TRCA's Hydrogeology Group who monitor groundwater quality monthly at 44 stations across TRCA's jurisdiction (with 21 of these stations being monitored in partnership with the PGMN administered by the MECP). Within the watershed, there is one TRCA groundwater monitoring station, one ORMGP groundwater monitoring station, nine PGMN groundwater monitoring stations, and 41 municipal groundwater monitoring stations. For the groundwater quality assessment, data was assessed from 2011 to 2021 for the current time period (using data collected through ORMGP database), and from 2001 to 2010 for the baseline time period (using data from the nine PGMN stations).

For the spills assessment, in the absence of current data, information was included from a past report that examined spill occurrence within the jurisdiction, the Toronto and Region Area of Concern, and information specific to the Humber River watershed.

6.1.12 Streamflow

All geospatial analyses used for the hydrology analysis were completed using ArcGIS Desktop 10.7.1 software. Unless otherwise specified, all geospatial data is from TRCA internal sources. The catchment area for each of the

eight stream gauges (see [Map 15](#)) used in streamflow and baseflow analysis was generated using the HRWP study area boundary layer in combination with the Humber River hydrology model catchments geospatial layer. In most cases, the hydrology model catchments aligned precisely with stream gauge locations, since data from these gauges were used to calibrate the model. Catchments from among the 280 local catchments in the hydrology model were selected using the “select by lasso” tool in ArcMap; some minor manual modification and post-processing was necessary to ensure alignment with the HRWP study area boundary. The TRCA watercourse layer was overlaid onto the model catchment layer to make clear the upstream-downstream relations of catchments.

To determine the distribution of precipitation over the watershed for different climate periods, precipitation data was downloaded from the ORMGP. Climate stations included both ECCC stations as well as TRCA gauges. To interpolate the values between these stations, a geospatial layer was created for each decade using the kriging method. Only stations with more than four years of data within each 10-year period were used. The 10-year spatial layers were then averaged to create the 30-year climatic period maps. This approach allows for the inclusion of more stations and greater accuracy in understanding changes in climatic conditions over each decade.

Daily streamflow data for both WSC and TRCA stream gauges was downloaded from the ORMGP website (oakridgeswater.ca). Data was downloaded from ORMGP because it is automatically put into a standard three-column .csv format (date, flow, flag) with standardized date formatting. Subdaily flow data from TRCA gauges was not used, as the amount of data quality control and the difficulty of analysis increases greatly, with only marginal gains to understanding of watershed hydrology. Generally, such data are only used for estimating flood flow return periods and for calibration of hydrology models to specific rainfall-runoff events. As climatic conditions can be quite variable from year to year and even on decadal scale (National Research Council 1998), a minimum 30-year streamflow record was used to describe historical and current conditions. For the purposes of this section, the historical period was defined as 1961-1990, while the period from 1991-2021 was taken to represent current conditions. These periods were selected on the basis of the period of record at the two WSC gauges, to ensure at least 30 years of data from both gauges, and also to maximize the ability to detect long-term trends in streamflow and baseflow within the available data. Most data analysis was completed in R Studio, a graphical user interface for R, using R version 3.6.2 as well as a series of external packages (jsonlite, lubridate, date, zoo, xts, broom, plyr, dplyr, tidyr, formattable, lmomco, caTools, ggplot2, dygraphs, scales, segmented, DT, RSQLite, cvequality). Analyses used tools modified from oakridgeswater.ca (M. Marchildon, *pers. comm.*, December 4, 2020). Additional analyses of low flow return periods, and of long-term average streamflow and baseflow, were completed using tools on the ORMGP website in the Surface Water and Climate Analyses section.

Daily baseflow values were estimated for each stream gauge using 14 different baseflow separation techniques (Linsley et al. 1975; Lyne & Hollick 1979; Institute of Hydrology 1980; Chapman 1999; Boughton 1993; Jakeman & Hornberger 1993; Chapman & Maxwell 1996; Sloto & Crouse 1996; Rutledge 1998; Clarifica 2002; Eckhardt 2005; Piggot et al. 2005; Tularam & Ilahee 2008). This analysis was completed using the Low Flow Frequency tool within the Surface Water and Climate Analyses tools from oakridgeswater.ca. The median among this ensemble of different methods was then taken to be the best estimate of baseflow, in line with standard practice in hydrology. Daily baseflow values were then used to estimate long-term average annual and monthly baseflow at each gauge.

6.2 Natural Heritage System and Urban Forest

This subsection outlines methods associated with habitat quantity, habitat quality, terrestrial biodiversity, habitat connectivity, climate vulnerabilities, carbon storage, and the urban forest. Methods associated with the NHS comparison (municipal and TRCA regional target NHS 2022) are also described.

6.2.1 Habitat Quantity

Natural cover within the watershed boundary was determined by using TRCA's 2017 existing natural cover layer and making updates based on imagery collected in 2020 flown by First Base Solutions. Quality assurance and quality control was conducted on the combined layer. The amount of natural cover (in hectares) and the percent cover within the study area boundary (%) of (1) total natural cover and, (2) each type of natural cover (forest, successional forest, wetland, meadow, and beach/bluff), was determined.

6.2.2 Habitat Quality

The LAM used the refined natural cover layer (2020) to determine habitat quality within the watershed. LAM ranks habitat patch quality based on a scoring and ranking system that classifies patches from 'poor' to 'excellent' quality based on their size, shape, and matrix influence. Each polygon of different natural cover types was considered a patch (i.e., no natural cover types were merged to create a patch).

6.2.3 Terrestrial Biodiversity

TRCA's Terrestrial Inventory and Monitoring Program collects data on flora, fauna, and vegetation communities using both inventory surveys and long-term monitoring plots (LTMPs).

Inventory surveys are conducted by biologists between April and October depending on species phenology. Biologists map the point locations of species detections and vegetation communities using ELC polygons. These data are a good representation, or snapshot, of the species present at the time of the surveys but are not a complete list and therefore likely underestimate both species richness and abundance. Inventory data collected between 2000 and 2021 was used for vegetation communities, and between 2012 and 2021 for fauna. These surveys focus on terrestrial and semi-aquatic vertebrates.

The Local Rank (L-rank) System is a species scoring and ranking system (similar to provincial/federal species ranks) developed by TRCA to provide guidance for natural heritage protection and management within the jurisdiction (TRCA 2017). Fauna L-ranks are based on scores for six criteria including local occurrence, population trends, habitat dependence, area sensitivity, mobility restriction, and sensitivity to development. For example, species ranked L1 would have: a limited local occurrence, declining population trends, habitat specialist and area sensitive requirements, restricted mobility, and a sensitivity to development. Species ranked L5 would have: a widespread local occurrence, increasing population trends, habitat generalist and non-area sensitive requirements, no mobility restrictions, and a tolerance to development. These are extreme examples and species can be ranked L1, L2, L3, L4 or L5 based on the scores associated with this combination of ecological needs and population status assessments. Species ranked L1, L2, or L3 are considered by TRCA to be species of concern regionally and species ranked L4 are considered species of concern in the urban land use zone. Vegetation communities (ELC) are scored only on local occurrence and habitat dependence, which reflects basic

geophysical requirements (TRCA 2017). LV means Sporadic breeder ("Vagrant") and these species have not been recorded in the region in the past 10 years.

6.2.4 Habitat Connectivity

Areas important for habitat connectivity were 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 (D'Eon et al. 2002, Van der Grift and Pouwels 2006).

Regional connectivity refers broadly to connectivity among all high-quality habitat patches in a particular region. Higher quality habitat patches (L1-L3) from the target terrestrial natural heritage system strategy (TRCA 2007) were selected as the targets for maintaining and, if possible, enhancing regional connectivity based on future land use conditions.

The focus for local connectivity was amphibians since they are most susceptible to road mortality (Regimbal et al. 2021, TRCA 2021). Connectivity that would support movement of amphibians between (1) forest and wetland, and, (2) wetland to wetland was assessed. The Humber River watershed refined natural cover layer, the 2017 natural cover layer, a 2 km buffer around the jurisdictional boundary, and additional natural cover data from SOLRIS was used in the local habitat connectivity assessment. For wetland-wetland connectivity, any wetland was considered a node. For forest-wetland connectivity, forests were considered low resistance (not a node), and roads were considered high resistance. The passability of roads was assessed using TRCA's Crossing Guidelines for Valley and Stream Corridors (TRCA 2015c), bridges (erased), culverts (scale of passability input into resistance), HDFs (may include culverts), and road widths (also incorporated into resistance). The resulting habitat network layers were identified as priority areas for habitat connectivity.

6.2.5 Climate Vulnerabilities

Each of the five climate vulnerability indicators was assigned a score of low (0), medium (1), or high (2) vulnerability based on the criteria outlined in [Table 40](#).

Table 40 - Climate Vulnerability Indicator Scoring Methods

Vulnerability Indicator	Scoring Method
Ground surface air temperature (mid-afternoon)	Score is based on percentile rankings into three equal abundance classes (low = 13-28°C; medium = 29-36°C; high = 37-47°C) after removing cells falling outside the land area (i.e., Lake Ontario).
Climate sensitive vegetation	Score considers hydrology, fertility, and dynamics (i.e., interaction between factors). For the jurisdiction analysis, the hydrology column was removed to account for the fact that it was considered 'double counting' of the hydrological vulnerability of wetlands, which was considered to be captured in layer E. Wetland ELC communities were scored only using fertility and dynamics: 0-low, 1-med, 2-high. Non-wetland ELC communities were scored using hydrology, fertility and dynamics: 0-low, 1-med, 2 or 3-high.
Habitat patch quality	Score is based on habitat patch L-rank from the LAM model (low = L1 or L2, medium = L3, high = L4 or L5) deriving from the Terrestrial Natural Heritage System landscape assessment model.

Vulnerability Indicator	Scoring Method
Soil drainage	Score is based on combined soil drainage classifications from provincial data (low = well drained, medium = imperfectly drained, high = very poorly drained; areas with urban cover are considered high).
Wetlands	Score is based on number of potential water sources (low/least vulnerable = all three potential sources (precipitation, groundwater, and surface water), medium = precipitation plus one of the other two sources, high = only precipitation).

6.2.6 Carbon Storage

In addition to climate vulnerabilities, the amount of carbon stored in the various natural cover types under current conditions was also assessed. Resources used included Wilson (2008) and Woodrising Consulting Inc. and ArborVitae Environmental Services Ltd. (2011) to estimate the total amount of carbon stored in each natural cover type. The total amount includes a summation of carbon storage estimates aboveground, belowground, in soils, and in dead material.

6.2.7 Urban Forest

The percent canopy cover in the Humber River watershed was assessed using i-Tree Canopy and leaf-on Google Earth imagery from 2021 and 2009. A total of 7,000 random sample points were generated across the watershed by i-Tree Canopy v.7.1. An analyst classified these points as tree/tall shrub, herbaceous/low shrub, bare ground, impervious buildings, impervious roads, impervious other, or agriculture. The proportion of canopy cover in the watershed was estimated as the ratio of the number of tree/tall shrub points to the total number of sample points. The same sample points were also used to estimate the canopy cover percentage for each subwatershed, municipality, and land use type. Standard errors and 95% confidence intervals were estimated using standard statistics for proportions. A net canopy cover change was obtained by subtracting the baseline canopy cover percent from the current canopy present. The significance of change was tested using the McNemar's test for paired nominal comparisons (Kaspar et al. 2017).

It can at times be difficult to distinguish tall shrubs/trees from lower shrubs and tall herbaceous. Where possible and necessary, Google Street view was consulted. Ambiguous points were discussed amongst expert staff to come to a conclusion. Another limitation of this method is that the Google Earth imagery available in 2009 varied in quality at times and there were small positional shifts between 2009 and 2021 imagery. To account for these challenges, the analyst used local geometry and reference information to infer the correct position of the sample point on the 2009 imagery relative to 2021. In addition, points that were hard to interpret were also examined from multiple perspectives by looking at Google Earth imagery a year before or after, TRCA's 2009 ortho-image layer (unfortunately, leaf-off), and Google Street view.

A canopy cover map for the current period was prepared by combining existing land cover maps for Peel Region, York Region, and the City of Toronto. A draft land cover layer was created for Peel Region by Caslys Consulting at a resolution of 1 metre in 2022, while the City of Toronto updated their land and forest cover map in 2018 (KBM Resources Group et al. 2018), and York Region updated their land cover with data from 2019 in 2021 (O'Neill-Dunne 2021). The tree canopy land cover class from each land cover dataset was extracted, as well as the shrub

category for Peel as it represents woody plants 1-4 metres tall, and was merged into a single tree canopy map. A 50 m x 50 m grid was created for the watershed and the percentage canopy cover per grid cell was computed.

Urban forest structure, composition, and health were not comprehensively assessed for the watershed due to the lack of available information for all municipalities in the watershed. A scan of municipal urban forest study reports was conducted to determine the availability of data and results for the baseline and current period. Urban forest studies utilize data collected through i-Tree Eco software, methods, and field procedures. i-Tree Eco was developed through a cooperative effort to assess the state of urban forests and to quantify the ecosystem service benefits and values provided by them based on plot-based field data. For the baseline assessment, urban forest studies were reviewed in Brampton (TRCA 2011a), Caledon (TRCA 2011b), Richmond Hill (TRCA 2012a), Vaughan (TRCA 2012b), King (Lake Simcoe Region Conservation Authority 2016), and Toronto (City of Toronto 2013b). For the current period, data and reports were only available for Toronto (KBM Resources Group et al. 2018), Vaughan, Richmond Hill, and King. Data for Vaughan, Richmond Hill, and King was collected in 2021 and 2022 by TRCA and is being analyzed and reported on in the 10-year update to York Region's urban forest studies. Information on the proportion of trees in the two smallest size classes, the percentage of the top three dominant species by leaf area and population, and the percentage of trees in good or excellent condition were compiled and summarized in [Appendix C – Urban Forest Quantity and Quality](#).

However, urban forest studies present findings based on data collected across an entire urban forest in a municipality. Therefore, the compiled results were not compared because only a proportion of each municipality falls into the Humber River watershed so extrapolating trends based on the limited available data could cause a mischaracterization of the quality of the urban forest in the watershed. Due to the gaps and the scope of the available information, the current conditions and trends in the urban forest quality could not be reported for the Humber River watershed.

6.2.8 Natural Heritage System Comparison

TRCA's Updated Terrestrial Natural Heritage System (TNHS) 2022

TRCA's Terrestrial Natural Heritage System Strategy (TRCA 2007) was originally developed, through the support of TRCA's municipal partners, to establish, protect, and restore a network of natural cover (e.g., forest, wetland, meadow) across TRCA's jurisdiction. The core principle of the TNHS is to increase the quantity, quality, and distribution of terrestrial habitat and biodiversity across the entire jurisdiction.

Over time, TRCA has partnered with its municipalities and neighbouring conservation authorities to refine the TNHS with new information, mostly through watershed plans and other municipality-specific projects. In 2022, TRCA updated its regional target NHS in consultation with municipal partners to incorporate new information on our natural systems to inform and guide TRCA and our municipal partners' initiatives that aim to protect, restore, and enhance natural systems over the long term (see [Section 4.1 Natural Heritage System Comparison](#) for more details).

Municipal NHS

Municipalities play the lead role for local and regional land use planning decisions. An identified NHS helps to ensure land use planning decisions are not compromising natural areas and the benefits they provide (e.g., providing wildlife habitat, controlling flooding). Municipal Official Plans lay out the rules and policies that direct

land use decisions and are key guidance documents that are developed with public input and are approved by Municipal Council. Lands within a NHS can be owned or maintained by various entities (government, institutions, private landowners); however, the municipality has the responsibility for its protection from detrimental uses or other alterations through its Official Plan. Municipalities are also responsible for the Municipal Class Environmental Assessment process in which they use NHS policies of their Official Plan to guide the siting, alignment, and design of public infrastructure.

The most up to date, municipal NHS mapping from current Official Plans (as of June 2022) was collected from the City of Toronto, Region of Peel, York Region, Simcoe County, and Dufferin County. NHS mapping was also obtained from municipal open data websites or through direct correspondence with a municipal contact.

Comparison of Municipal NHSs to TRCA's Updated TNHS

Municipal NHSs were compared with TRCA's updated TNHS spatially using a GIS overlay analysis. Distinct classes were identified through mapping including (1) areas of overlap between municipal NHS and TRCA's updated 2022 TNHS (overlapping NHS), (2) areas present in municipal NHS only, and (3) areas present in TRCA's updated TNHS only (TRCA NHS only). Overlap, or lack thereof, with the different components of TRCA's updated TNHS including existing natural cover, potential natural cover, and contributing areas was also considered.

6.3 Water Quality

Water quality data collected through TRCA's RWMP was used for the water quality analysis. The RWMP currently monitors water quality monthly at eleven stations within the Humber River watershed (see [Map 25](#)) five of which are monitored in partnership with the PWQMN administered by MECP (including PWQMN; 6008300902/83009, 6008301802/83018, 6008301902/83019, 6008310302/83103, 6008310402/83104).

Two additional RWMP stations were added in 2006: HU010WM (in the upper reaches of the Lower Humber) and HU1RWMP (in the upper reaches of Black Creek). Data from 2012-2021 from all 11 stations were used for the current time period assessment. Due to baseline data availability, a subset of the current period (2016-2021) was compared to the baseline years (2006-2011) at nine stations (83002, 83004, 83012, 83009, 83018, 83019, 83020, 83103, 83104) to examine changes in samples meeting targets. Metal lab detection limits were variable over the baseline and current time periods and, at times, exceeded water quality guidelines. These data, therefore, could not be included in the assessment of exceedances and comprised up to 18% of the data. Data (e.g., % samples meeting targets) from the current period and the current period subset did not always align, therefore, concentration trends were assessed in combination with exceedance changes to assess trends. Concentration trends on a station-by-station basis were assessed using a Mann-Kendall trend test, taking into account non-detect data, using the *censeaken* function in the NADA2 package of R.

Data were plotted using *cenboxplot* in the R package NADA and take into account left-censored non-detect data modeling the distribution below detection limits. Thirteen additional (temporary) stations on previously unmonitored tributaries were sampled monthly for approximately one year between December 2019 and November 2020 (excluding March and April 2020 due to COVID-19 related restrictions) for the same parameters as analyzed by TRCA. Lab detection limits for copper, lead, chromium, cadmium, and nickel were higher than guidelines, and therefore could not be assessed.

A draft PWQMN comprehensive guide has been created and details field sampling protocols, data management, and laboratory analytical methods for sampling PWQMN stations (MECP 2020). Water samples for PWQMN stations were analyzed at the MECP Rexdale Laboratory while standard RWMP samples were analyzed at the City of Toronto Dee Avenue Laboratory, the York-Durham Laboratory, and Maxxam. Fourteen water quality parameters were compared including TSS, chloride, TP, nitrate, unionized ammonia, copper, iron, zinc, lead, chromium, cadmium, nickel, dissolved oxygen, and *E. coli* to provincial or national water quality objectives.

6.4 Natural Hazards

This subsection outlines methods associated with flooding and erosion risk.

6.4.1 Flooding

Land use change between the baseline and current time periods results in changes to hydrologic response, which may affect flows to the FVCs and associated risk. Developing baseline and current conditions hydrologic models from a calibrated base model and applying a set of design storms matched to statistical flood frequency is an efficient method for quantifying watershed hydrology under different land use scenarios.

The 2015 Humber River Hydrology Update and its 2017 addendum (Civica Infrastructure Inc.) was selected as the base hydrologic model for characterizing riverine flood risk. The model was developed on the Visual OTTHYMO (VO) platform. To ensure that the model is grounded in the physical characteristics of the watershed, the predictive capability of the model was tested through rigorous calibration and validation. Flood frequency analyses were performed on the calibration streamflow gauges to determine an appropriate set of return period design storms. The base hydrologic model used topographic information and sewershed data to discretize the watershed into 714 subcatchments ranging in size from about four ha (e.g., urban drainage boundaries) to about 860 ha (e.g., lumped homogenous areas), averaging around 126 ha. Stormwater quantity control ponds for which information was available at the time were incorporated using the appropriate model commands.

For the HRWP, the base hydrologic model was modified to reflect the development conditions and contemporaneous stormwater management (SWM) facilities for the years 2002, 2012, and 2020 using land use mapping, historic orthographic imagery, and SWM information from municipal sources and TRCA's database. There is some variation in the number of catchments in each modelled year, which reflects the amount of development occurring over time. For example, a large rural catchment in 2002 that is partially developed in 2020 would be split into its rural and urban components for the 2020 model, especially if stormwater from the urban component is managed by a pond and the design information is available.

Based on total imperviousness (TIMP), the subcatchments are assigned computational routines in VO for estimating urban or rural runoff response. As a general practice, subcatchments with a TIMP of 20% are considered urban and assigned the STANDHYD command, so it is possible for the model to have a lower imperviousness than observed. The STANDHYD command requires users to input the portion of the TIMP that is directly connected to a drainage system (XIMP), which is the effective impervious area. TIMP is typically estimated or measured using orthographic imagery and XIMP is estimated as a fraction of TIMP based on land use. To account for the variation of similar land uses across municipalities and over time, conservatism is typically built into land use mapping and can result in higher TIMP values than direct measurement.

The baseline and current conditions vector files contain attributes for TIMP and XIMP based on land use maps. Before these attributes can be used in the model, they are preprocessed in ArcGIS by intersecting the vector file of the model subcatchments with each land use condition. This discretizes the land uses along the subcatchment boundaries and assigns the respective subcatchment name attributes. The resultant attribute table is then exported to Microsoft Excel where subcatchment average TIMP and XIMP is calculated using look-up and summation formulae. Computational routines are assigned based on TIMP; borderline cases (e.g., +/- 1% TIMP) are verified based on contemporaneous orthographic imagery. TIMP and XIMP values are then imported into the VO environment using its native batch assign function.

SWM facilities, flood control dams, and other hydraulic features that behave like reservoirs during flood events (e.g., large embankments) can be represented in VO using the RouteReservoir command, which uses a discharge-storage relationship to calculate the amount of inflow attenuation going downstream. The input information is generally derived from design reports and summary inventory sheets, but can be approximated from design standards (e.g., TRCA SWM Criteria, MOEE SWM Planning and Design manual, etc.) if an identified facility is missing design information but deemed significant, such as through professional judgement of estimated drainage area and pond footprint, or for future scenario analysis for which no design information would be available.

The base hydrologic model included 79 SWM ponds, as well as Claireville Dam on the West Humber and Lake Wilcox on the East Humber. For the HRWP, historic orthographic imagery was used to determine which SWM ponds to include in each year of the baseline and current periods; where information was missing or out of date from the base model, available information from the municipal and TRCA sources was used. Lastly, several online hydraulic features that are expected to behave like reservoirs in flood events were added. One example is the Black Creek Dam located southeast of Jane Street and Sheppard Avenue West; two discharge-storage relationships were used to reflect the change in capacity from 2002 to 2020 (i.e., sediment accumulation).

After modifying the base hydrologic model for the years within the baseline and current periods, the models were simulated with available data from contemporaneous rain events to verify that the hydrologic parameters are reasonable. After parameter verification, design storms with the standard return periods of 2-, 5-, 10-, 25-, 50-, and 100-year can be simulated with a 6- or 12-hour AES distribution. Since the baseline and current period models are very structurally similar to the base model, the flows can be extracted from the same nodes for a relative comparison.

6.4.2 Erosion Risk

Reach Stability and Reach Sensitivity

The reach stability calculations were based on the method established previously during the 2001 geomorphic characterization of the geomorphic monitoring sites in the Humber River watershed (Regional Monitoring Program – Fluvial Geomorphology Component Etobicoke Creek, Mimico Creek and Humber River Watersheds; Parish Geomorphic, 2002). Based on this method, the reach stability is a function of Channel Entrenchment, Bank Angles, Inter-Pool Slopes, Width to Depth Ratio, and Substrate Sorting. The methods to determine each of these parameters (except for Substrate Sorting) in 2001 were replicated using the geomorphic survey data obtained in 2021. The Substrate Sorting formula was updated based on Geometric modified Sorting formula by

Folk and Ward (1957) as noted in Blott & Pye (2001) because the Substrate Sorting values noted in the 2002 Parish report could not be replicated using the description provided in the 2001 report.

The Reach Sensitivity calculations are based on the methods previously established during the Etobicoke Creek Watershed Characterization study (Etobicoke Creek Watershed Characterization Report; TRCA 2021). The individual components that make up the Reach Sensitivity rating, such as SSPR, Shear Ratio, Erosion Control Structure Density, and Cross-Sectional Changes, are described below.

As mentioned in [Section 2.4.2 Erosion Risk](#), parameter rating thresholds and weights were assigned to values for erosion sensitivity parameters (including erosion pin results and shear stress, SSPR, erosion control structure density, RGA, and cross-sectional changes). Based on the thresholds, an overall value was assigned to each sensitivity parameter: low = 1, moderate = 2, and high = 3. [Table 41](#) outlines the rating thresholds assigned to each erosion sensitivity parameter.

Table 41 - Parameter Rating Thresholds for Reach Erosion Sensitivity

Sensitivity	Shear Ratio	SSPR	EC Density	RGA	XS	Overall Value
Low	<1	<1.5	<5	≤ 0.2	<10	≤4/3
Moderate	≥ 1, ≤2	≥1.5, <2.1	≥5, <10	>0.2, <0.4	≥10, <30	>4/3, <2
High	>2	≥ 2.1	≥ 10	≥ 0.4	≥ 30	≥2

[Table 42](#) shows the weights for each erosion sensitivity parameter.

Table 42 - Parameter Weights for Reach Erosion Sensitivity

Scenario (Data Availability)	Weights				
	Shear Ratio	SSPR	EC	RGA	XS
All data available	0.3	0.2	0.1	0.1	0.3
No XS data	0.4	0.3	0.15	0.15	0
No RGA data	0.3	0.2	0.1	0	0.4
No XS, No RGA	0.5	0.3	0.2	0	0
No Shear Ratio data	0	0.4	0.1	0.1	0.4
Only EC & SSPR data available	0	0.67	0.33	0	0

Parameter rating thresholds were also assigned to values for erosion stability parameters (including Entrenchment Ratio, Bank Angle, Inter-Pool Ratio, W:D Ratio, and Substrate Sorting). Based on the thresholds, an overall value was assigned to each stability parameter. [Table 43](#) outlines the rating thresholds assigned to each erosion stability parameter.

Table 43 - Parameter Rating Thresholds for Reach Stability

Stability	Entrenchment Ratio	Bank Angle	Inter-Pool Ratio	W:D Ratio	Substrate Sorting	Overall Value
Low	1 to 1.99	>50	>50	<5 or >35	>2	0 to 4
Moderate	2 to 3.99	35 to 50	25 to 50	19 to 35	≥1.41, <2	5 to 7
High	>4	<35	<25	8 to 18	<1.41	8 to 10

Stream Power Index Networks (SPIN) Tool

The Stream Power Index for Networks (SPIN) tool (Ghunowa et al. 2021) is used to assess the changes in hydraulic forces of channel beds and banks on a watershed-scale. Using a coarsely discretized DEM, the SPIN tool utilizes regional curves for rural channels in Southern Ontario and the resulting slopes extracted from the coarse DEM to determine stream powers of the 2-year flow. This “rural” condition specific stream power (assumed to be very low impervious area) is then compared to the values determined under various land use scenarios based on current TRCA land use data. An increase in stream power based on land use changes is linked to erosion risk as there is potential for the increased energy to cause channel enlargement through erosion of the bed and banks (Vocal Ferencevic & Ashmore 2012). The specific stream power (SSP) values derived from various land use scenarios were compared to the SSP values for the “rural” land use conditions in the form of a ratio referred to as SSPR (SSPLANDUSE : SSPRURAL). The SSPR becomes a measure of erosion sensitivity of the SPIN tool stream segments (Ghunowa & MacVicar 2018), where values of 0-1.5 are Low, 1.5-2.1 are Medium, and greater than 2.1 is High. Because SPIN is a watershed-scale tool, it was understood that SSPR values should be aggregated where possible. For the purposes of this erosion characterization, the SSPR was calculated for each reach containing a field monitoring station (see [Map 27](#)) for each subwatershed based on SPIN tool segment length and over the entire watershed itself using a sum of the product method in the general form shown in the equation below.

Equation - Specific Stream Power Ratio based on Land Use:

$$SSPR_{LANDUSE} = \frac{\sum_{i=1}^n SSPR_i \times L_i}{L_{TOTAL}}, \text{ where}$$

SSPR_{LANDUSE} : SSPR_{YEAR}:SSPR_{RURAL},

n : number of segments in specified area

SSPR_i : SSPR of each individual segment

L_i (m) : length of each individual segment

L_{TOTAL} (m) : total length of segment in specified area

(specified area is the specific reach or subwatershed)

Geomorphic Assessment

The data required for the primary analyses undertaken to determine the changes in channel geometry and the overall morphologic changes were informed through detailed geomorphic assessments. These assessments were undertaken over a course of about 20 years at various sites across the watershed.

Map 27 shows the location of these sites. In general, the field methods used to collect data at these sites aligned with the methods described in TRCA's Stormwater Management Criteria Manual (TRCA 2012). Not all sites were surveyed consistently through the past 20 years. Some sites were established as early as 2001 and then surveyed in 2004/2005, 2007/2008, 2010, 2013, and 2021. However, not all 35 sites established in 2001 as part of TRCA RWMP's long term geomorphic monitoring network were surveyed in the subsequent years. More information on these sites can be found in the Humber River State of the Watershed Report – Fluvial Geomorphology (TRCA 2008) and the supporting report (Parish 2002).

The detailed geomorphic assessment that was carried out in the various sites included the undertaking of Rapid Geomorphic Assessments, cross-sectional and longitudinal surveys, erosion pin assessments, and characterization of channel substrates. Additional documentation included field notes and site sketches as well as a photographic record of the channel conditions, particularly at channel cross sections. There are also separate records of bank characteristics for some of these sites.

A Rapid Geomorphic Assessment (Ministry of the Environment 2003) was conducted at the RWMP sites. As part of this assessment, various geomorphic characteristics that indicate channel widening, aggradation, and degradation, as well as planimetric form adjustment, are noted. An average value is determined for each of these geomorphic processes to obtain the geomorphic indices of channel widening index (WI), aggradation index (AI), Degradation Index (DI), and Planimetric Form Adjustment Index (AI). The average of these four indices provides an overall Stability Index. An interpretation of the Stability Index is as follows:

- Stability Index ≤ 0.2 : Classified as 'In Regime' meaning the channel morphology is within a range of variance for streams of similar hydrographic characteristics (evidence of instability is isolated or associated with normal river meander propagation processes).
- Stability Index $0.21 \leq SI \leq 0.4$: Classified as 'Transitionally or Stressed' meaning channel morphology is within the range of variance for streams of similar hydrographic characteristics, but the evidence of instability is frequent.
- Stability Index $SI \geq 0.4$: Classified as 'In Adjustment' meaning channel morphology is not within the range of variance and evidence of instability is widespread.

At each monitoring site, the monumented cross sections were also surveyed. Channel cross section characteristics such as cross-sectional area, top of bank width, and channel mean depth were determined at the top of bank elevation for each year the cross sections were surveyed. Longitudinal profiles were measured at all the sites, for some of the years. The longitudinal profile was used to determine the general bed slope and slope of the riffle crests as well as the bankfull slopes where the bankfull stage was noted. The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne & Leopold 1978). For channels and watersheds unaffected by anthropogenic changes, the bankfull stage could mean the stage at which flow fills up the channel and spills on the adjacent floodplain. However, in the case of degraded streams where channels have down cut either by natural processes or through anthropogenic effects, the bankfull stage does not always correspond to the top of bank. In such cases, the bankfull stage indicators were noted during some of

the surveys. The in-channel substrate sizes were determined through a modified Wolman pebble count (Wolman 1954). No bulk samplings of sediment were taken.

Erosion Threshold Assessment

An erosion threshold assessment was undertaken to define the theoretical hydraulic conditions at the various monitoring sites at which sediment can be expected to be entrained and transported within the channel and thus contribute to erosion. The threshold flow represents a critical discharge at which substrate of a defined size class (typically the median grain size) can potentially be entrained. Similarly, a threshold velocity and threshold hydraulic radius and depth can also be defined. To determine the threshold flows (or critical discharge), a critical shear stress and/or critical velocity first needs to be determined. Depending on the substrate characteristics, a number of methods can be used (listed below):

- Modified Shields Method based on Julien (1995)
- Permissible Shear Velocities (Chow 1959)
- Komar (1987)
- Fischenich (2001)
- Wilcock & Crowe (2003)

The method that suited the substrate characteristics the most was chosen for each site. The critical discharge was then determined from the critical shear and/or critical velocity. In addition to the critical shear stress (τ_{crit}), the mean boundary shear stress (τ_o) was also determined for the bankfull channel. The shear stress ratio (i.e., the ratio of the mean boundary to the critical shear stress ($\tau_o:\tau_{crit}$)) was then determined. When the shear stress ratios are above 1, it indicates that the substrate of median grain size can be expected to be entrained by bankfull flow. The threshold flow and stress values were used to determine erosion indices.

Erosion Hazard Sites/Erosion Control Structures and Inventory

TRCA's Erosion Risk Management monitoring team inspected approximately 9200 geomorphic monitoring sites between 2004 and 2021. However, it was determined that the Reach Inventory (23 reaches) and the Erosion Hazard Site (233 sites) subsets did not provide sufficient information that would inform broader geomorphologic change. The Erosion Control Structure and Inventory inspections (along with the Toronto Water Steep Ravine Inventory sites) were used as the most comprehensive set of sites where anthropogenic change could likely impact erosion within the watershed.

The erosion control structures and inventory site inspection data is collected as per Erosion Risk Management's Field Manual. Most of this data was collected as part of two sweeps of inventory inspections completed in 2012 and 2015 to 2017. The data collected is a comprehensive inventory of every piece of infrastructure within sight of the inspectors as they walk up each watercourse and tributary within the watershed. Each inspection record is stored in Erosion Risk Management's Stream Erosion and Infrastructure Database. It was determined that the best use of this data was as a list of existing infrastructure potentially impacting erosion within the watercourses in the watershed. At the minority of sites where repeated inspections took place in different years, the data was not specific enough to quantify geomorphologic erosion changes in a useful manner for the purposes of this

reporting. Therefore, the dataset of the most recent inspections of unique sites that impact geomorphologic erosion were used to represent the existing anthropogenic changes within the watercourses of the watershed. Some of the inventoried structures are not within watercourse limits and do not impact geomorphologic erosion directly and were removed from further comparative analysis (e.g., risers (stormwater management facilities), fords (handful of informal vehicular crossings), etc.). The following erosion control structure types were included in the final data subset for this report: revetment, toe protection, buttress, bank treatment, vane/deflector, spillway, retaining wall, bed control, and weir. The general distribution of these inspection sites is shown in [Map 27](#).

This dataset of inventoried erosion control structures was used to determine the density of erosion control structures within the watercourses of the Humber River on three scales: watershed, subwatershed, and within reaches containing geomorphologic field monitoring stations. The structure density was calculated where erosion control structure inventory points (representing the upstream end of a structure) were located within 10 m of the TRCA watercourse layer (available for use from the GIS team in 2022). Calculated on a watershed and subwatershed scale, the erosion control structure density can be compared to the SPIN tool results; whereas, on a geomorphologic reach scale, the density can be compared to fluvial geomorphologic parameters determined using the field monitoring data. The general form of the erosion control structure density is shown in the equation below.

Equation – Erosion Control (EC) Structure Density

$$EC_{DENSITY} = \frac{\#EC}{L_{WATERCOURSE}} \times 1000 \text{ m/km},$$

where

$EC_{DENSITY}$: EC structure inventory per kilometre

EC : Number of EC structures in specified area

$L_{WATERCOURSE}$: Length of watercourse in specified area

(specified area is the specific reach or subwatershed)

This density data, based on the most recent inventory inspection of each site, is assumed to represent the current state of erosion control structures relevant to geomorphologic erosion within the Humber River watershed.

6.5 Stormwater Management

Data on stormwater management facilities were extracted from TRCA SWMSOft database, which included the majority of the wet/dry ponds within the watershed. This data was supplemented with data provided by the respective municipalities within the watershed. Drainage areas, pond function (quantity/quality control), and year of construction of each facility were derived from attributes data. The contribution of effective impervious area was derived from the Humber hydrology model and by iteratively tracing nodes contributing flow to stormwater facilities within the model. While the number of ponds within the hydrology model may be slightly different (due to available information at the time of model development), the numbers will be relatively similar.

The analysis may not include every facility but would be representative of the general trends. It is important to mention that the hydrologic model primarily aims to predict flood hazards, which means our emphasis is on infrastructure intended for flood attenuation. Consequently, quality ponds are typically excluded from the model unless we can prove a substantial routing effect. This conservative approach allows us to estimate different levels of flood risk cautiously. However, it is possible that by relying solely on the "directly connected impervious area" connected to ponds, we might result in the underestimation of the effective imperviousness cover in the watershed.

6.6 Restoration Planning

TRCA's IRP methodology is outlined in *Integrated Restoration Prioritization: A Multiple Benefit Approach to Restoration Planning* (TRCA 2016). This document details TRCA's use of the IRP tool for restoration planning activities. The methodology for collecting, cataloguing, and prioritizing restoration opportunities planning data is outlined in TRCA's *Restoration Opportunities Planning Primer* (TRCA 2019).

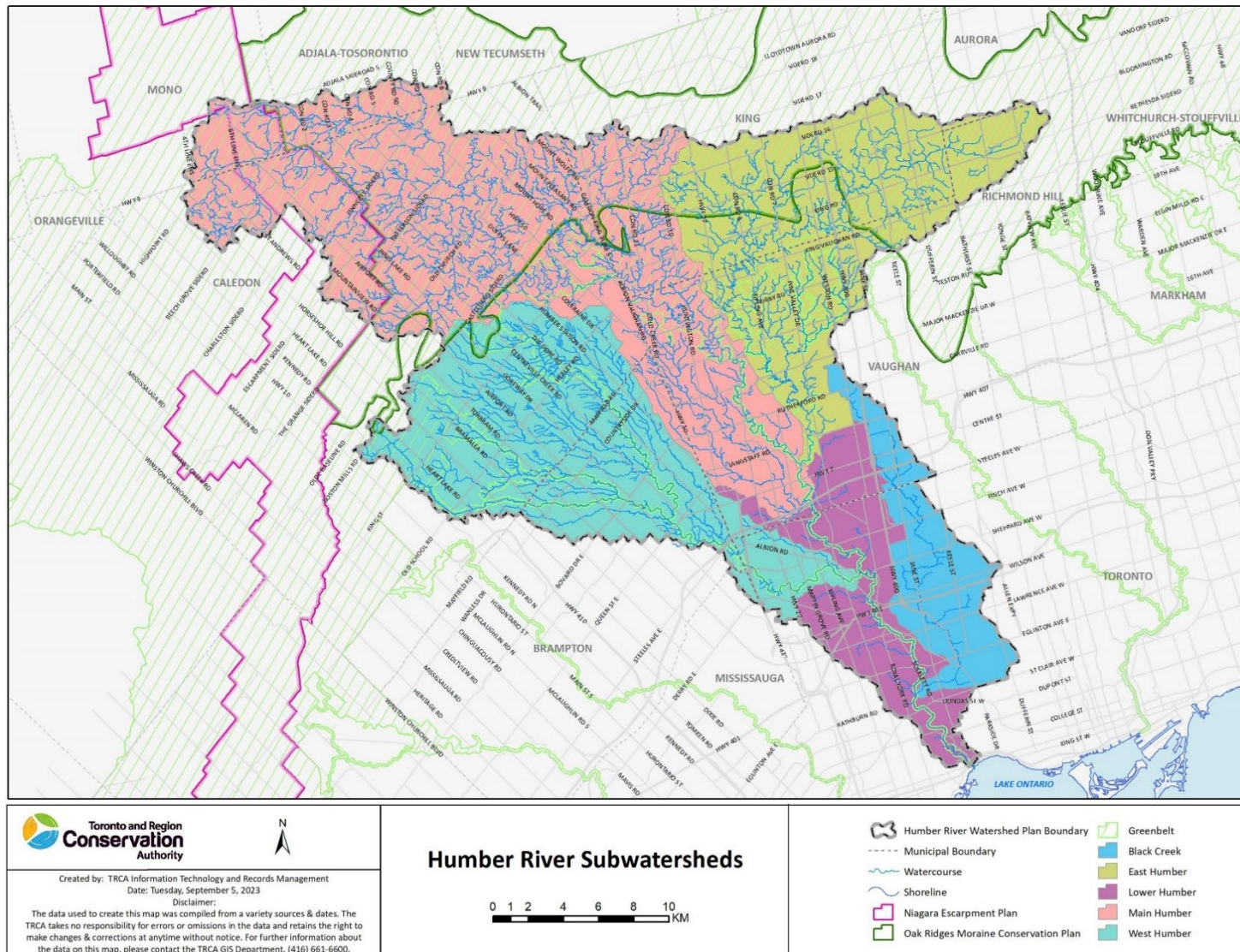
Methodologies for tracking completed restoration projects varied across TRCA and municipalities. Multiple datasets and shapefiles were combined to generate the best possible overview of work completed within the Humber River watershed. These were compared against recommendations and priority areas identified in the 2008 HRWP.

A collection of reports prepared by consultants for TRCA were compiled that have specifically been used to identify existing conditions, make recommendations, and prioritize future restoration activities. Detail design reports for individual implemented projects were omitted from this review as they are included in the details of completed projects.

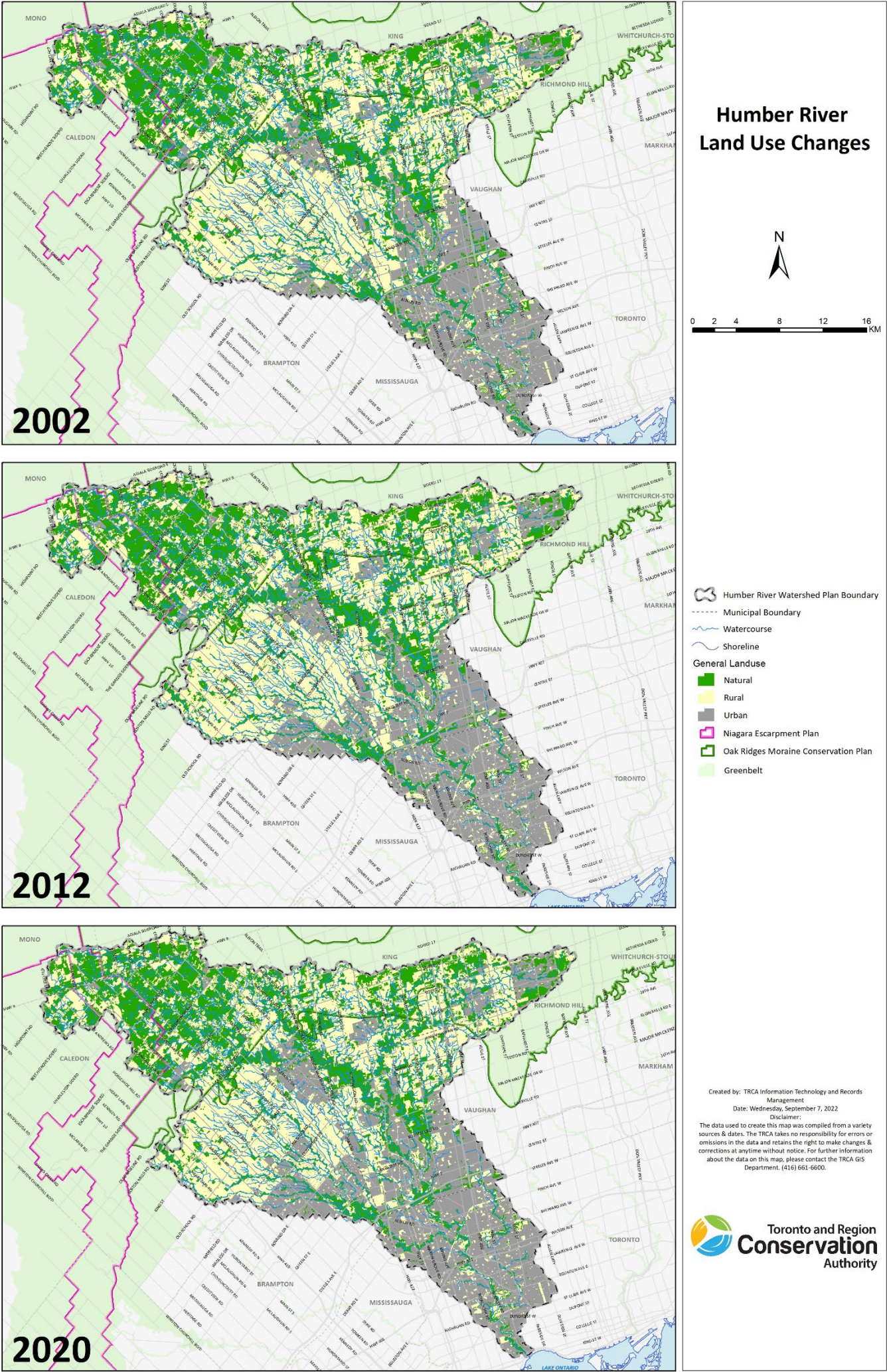
6.7 Cultural Heritage

Data and information for this report was assembled through staff knowledge, a review of TRCA programs relevant to the Humber River watershed, and location specific requests to municipal partners for heritage data. For built heritage resources and cultural heritage landscapes, available data was downloaded from municipal open data portals. Where open data was not available, municipal heritage planners were contacted via email, which requested geospatial data regarding heritage assets within their municipality. This included designated and listed properties, heritage conservation districts, cultural heritage landscapes, and any other resource of heritage value such as bridges, mill sites, and historic cemeteries. For archaeological sites, the Ministry of Citizenship and Multiculturalism was contacted to provide a geospatial update of registered archaeological sites throughout TRCA's jurisdiction. Using ArcMap, archaeological sites located within the watershed were filtered out and organized by time period. An examination of archaeological sites and built heritage properties by municipality was also undertaken as was the identification of cultural heritage landscapes. In the future, any additional updates will help identify trends and areas of high cultural heritage value.

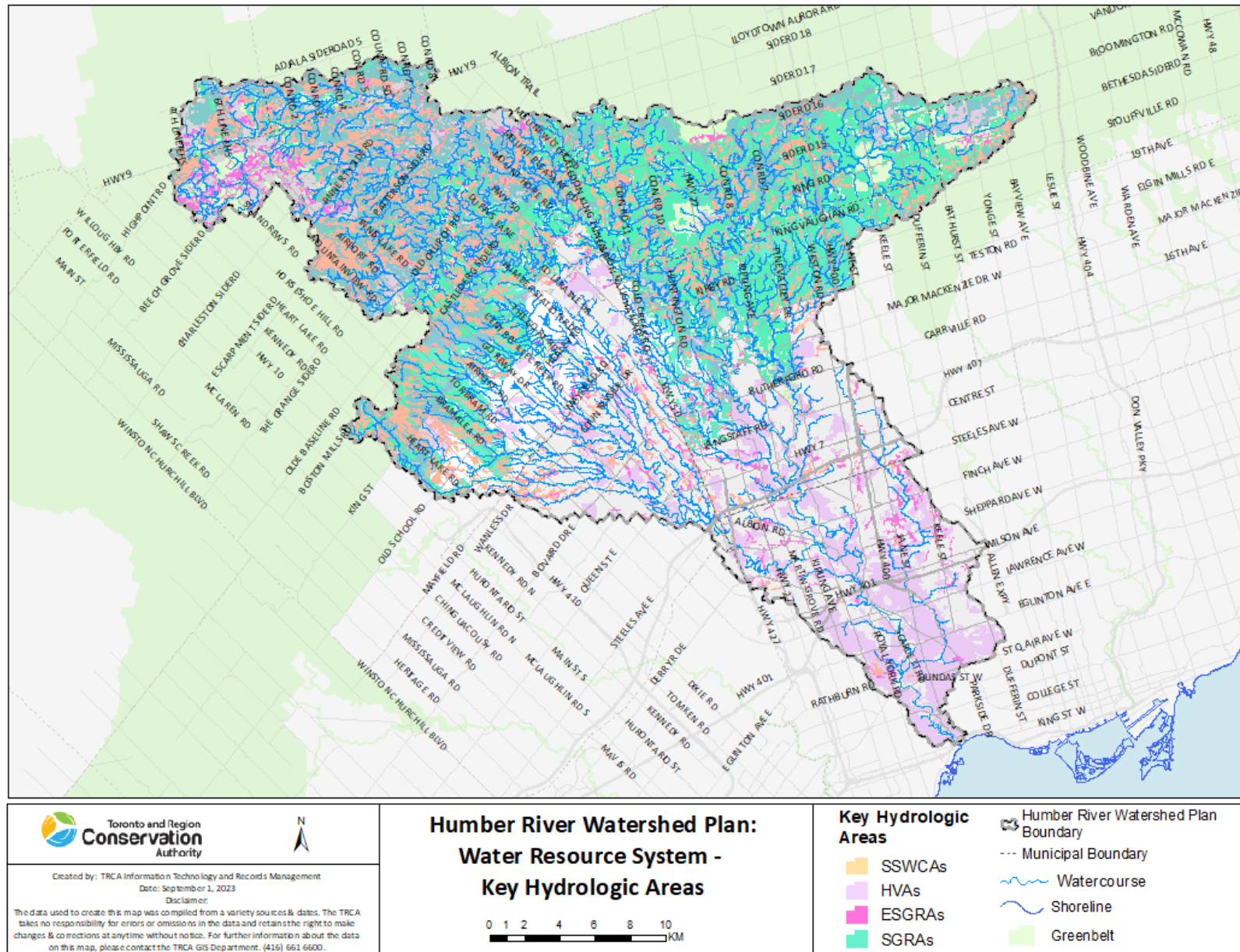
7.0 MAPS



Map 1 - Humber River Subwatershed

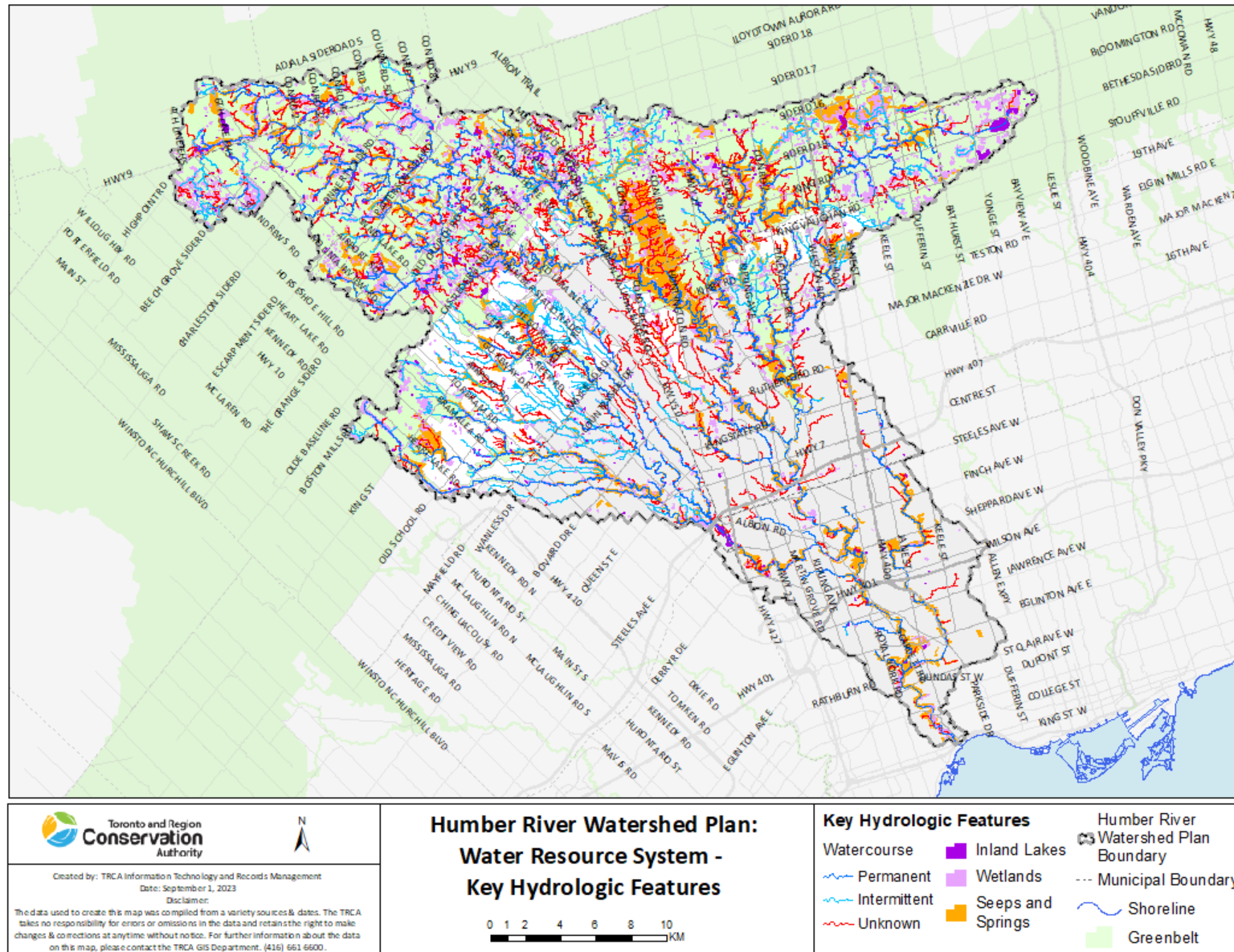


Map 2 - Progression of Land Use Change (from 2002 to 2012 to 2020)



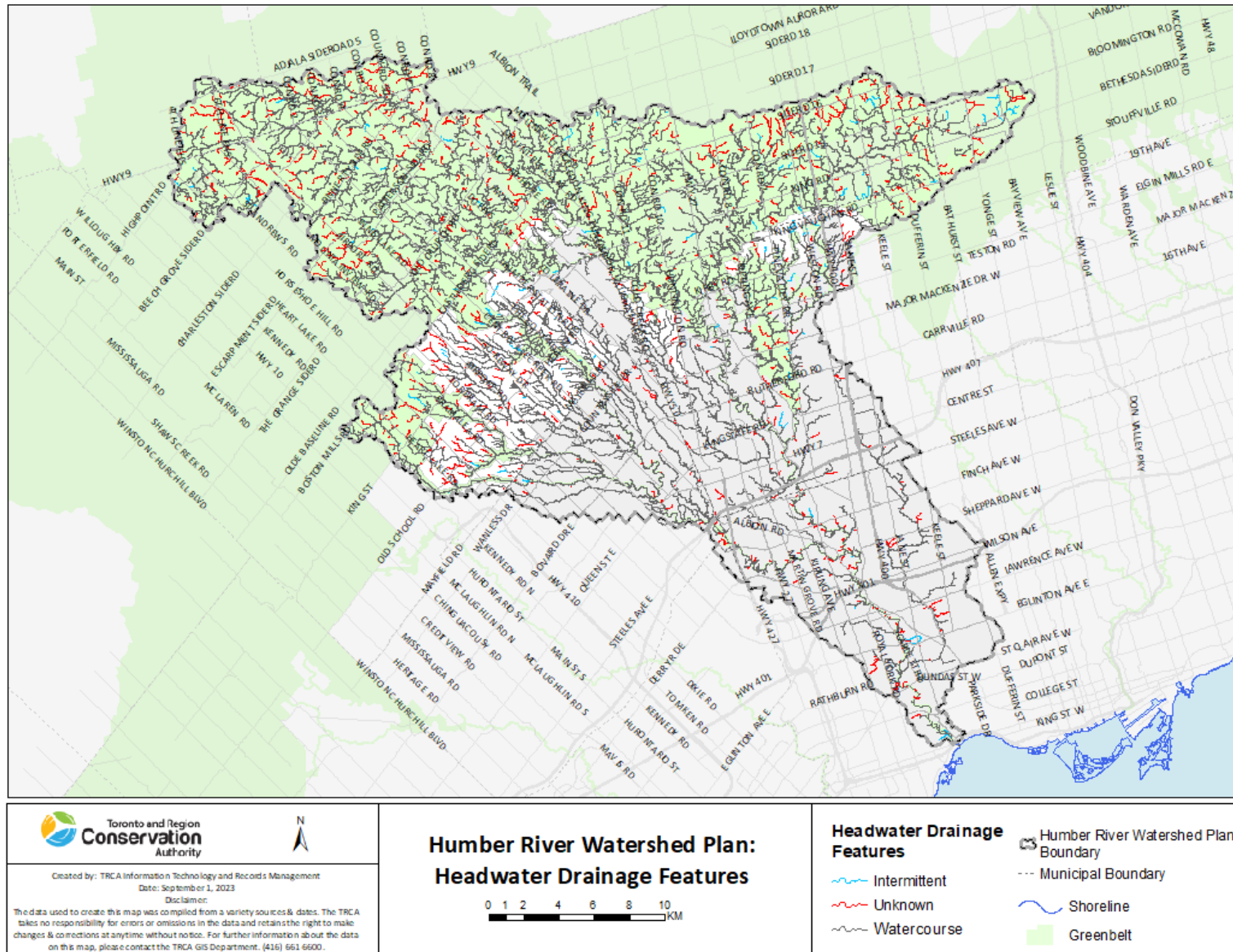
Map 3 - Water Resource System - Key Hydrologic Areas

Humber River Watershed Characterization Report



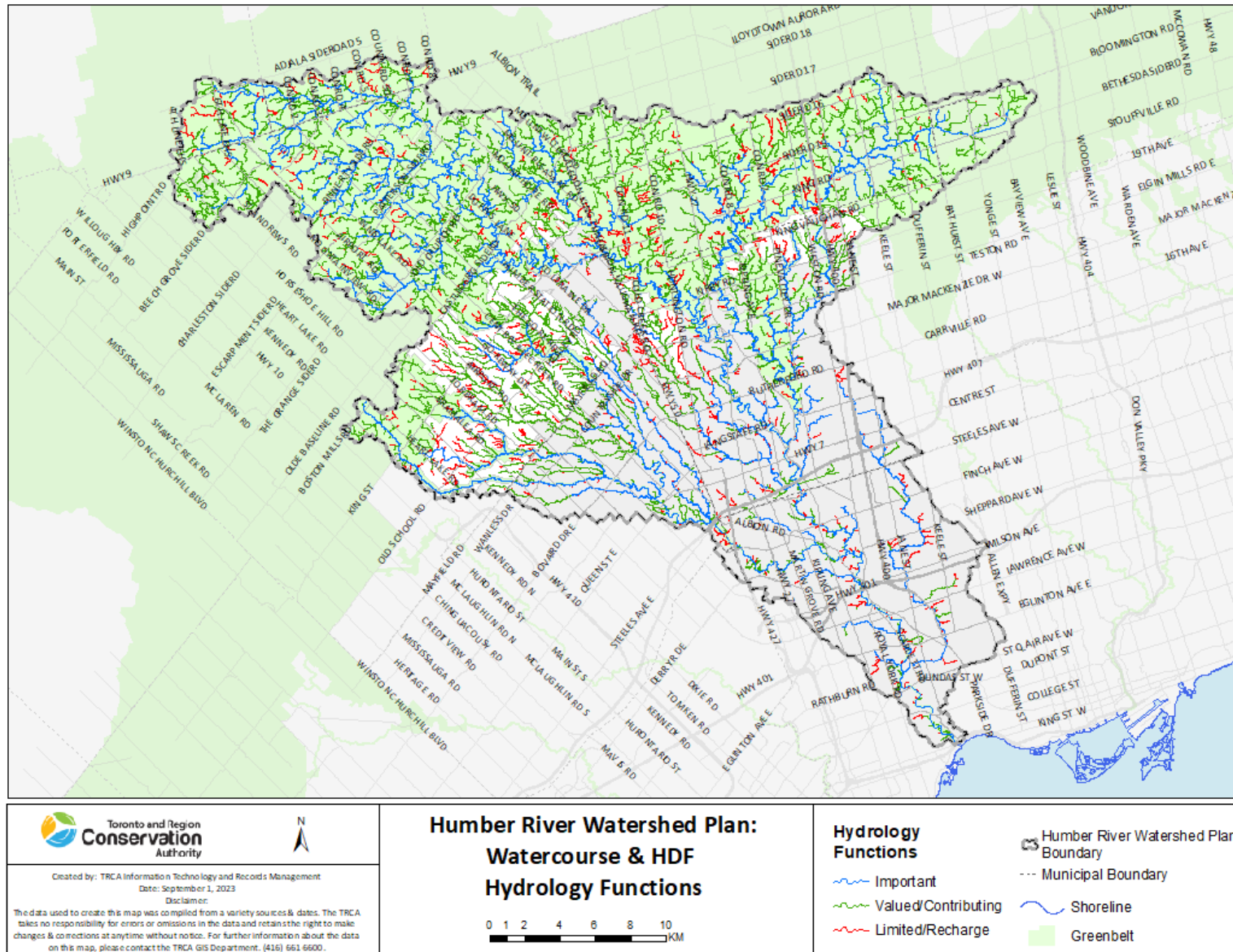
Map 4 - Water Resource System - Key Hydrologic Features

Humber River Watershed Characterization Report



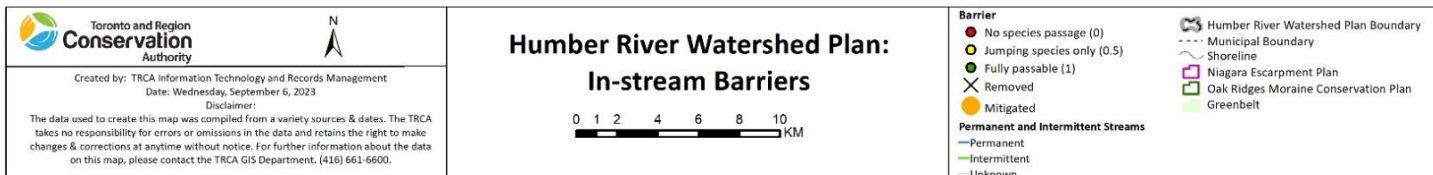
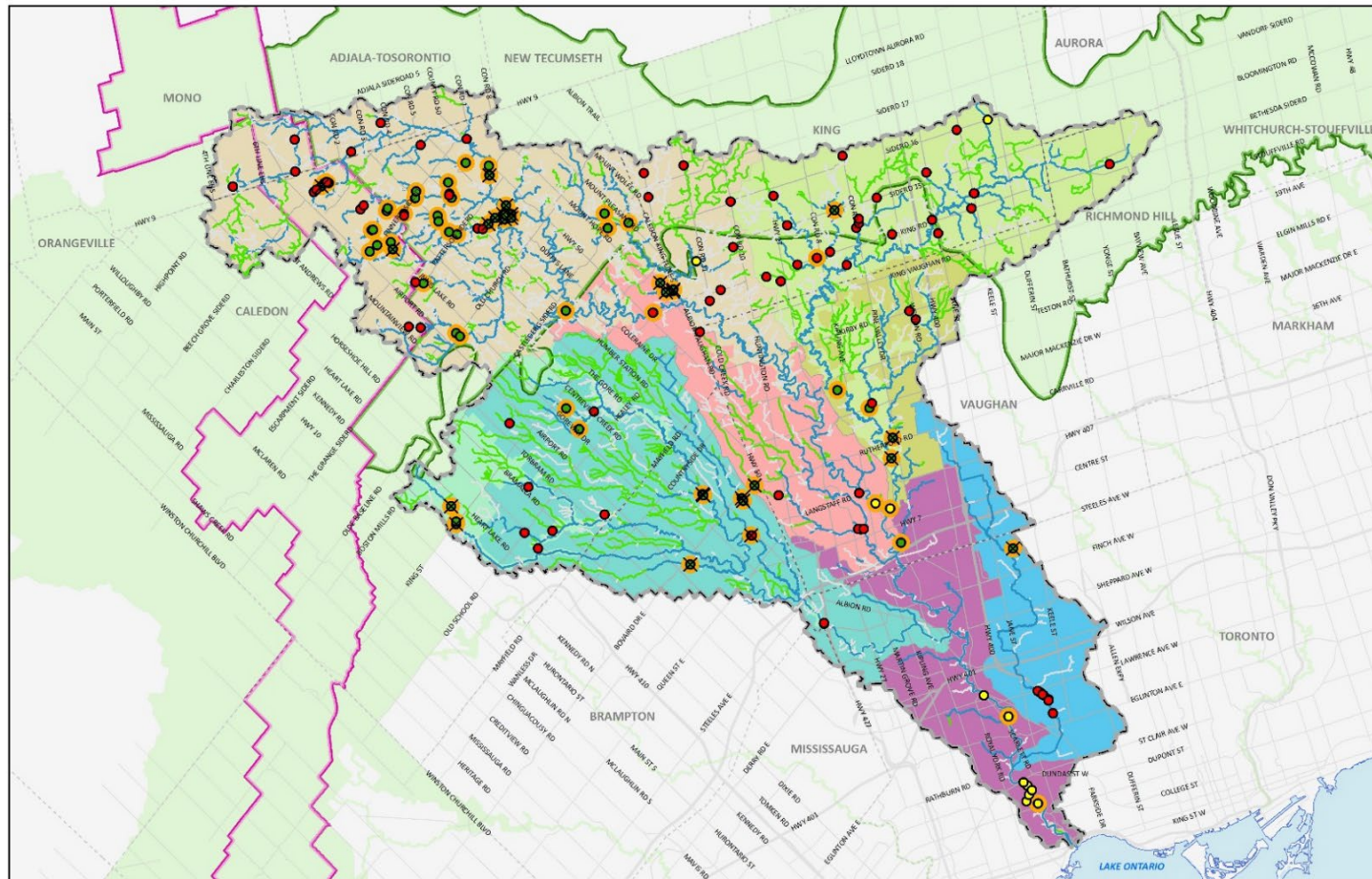
Map 5 - Location and Classification of Potential Headwater Drainage Features

Humber River Watershed Characterization Report



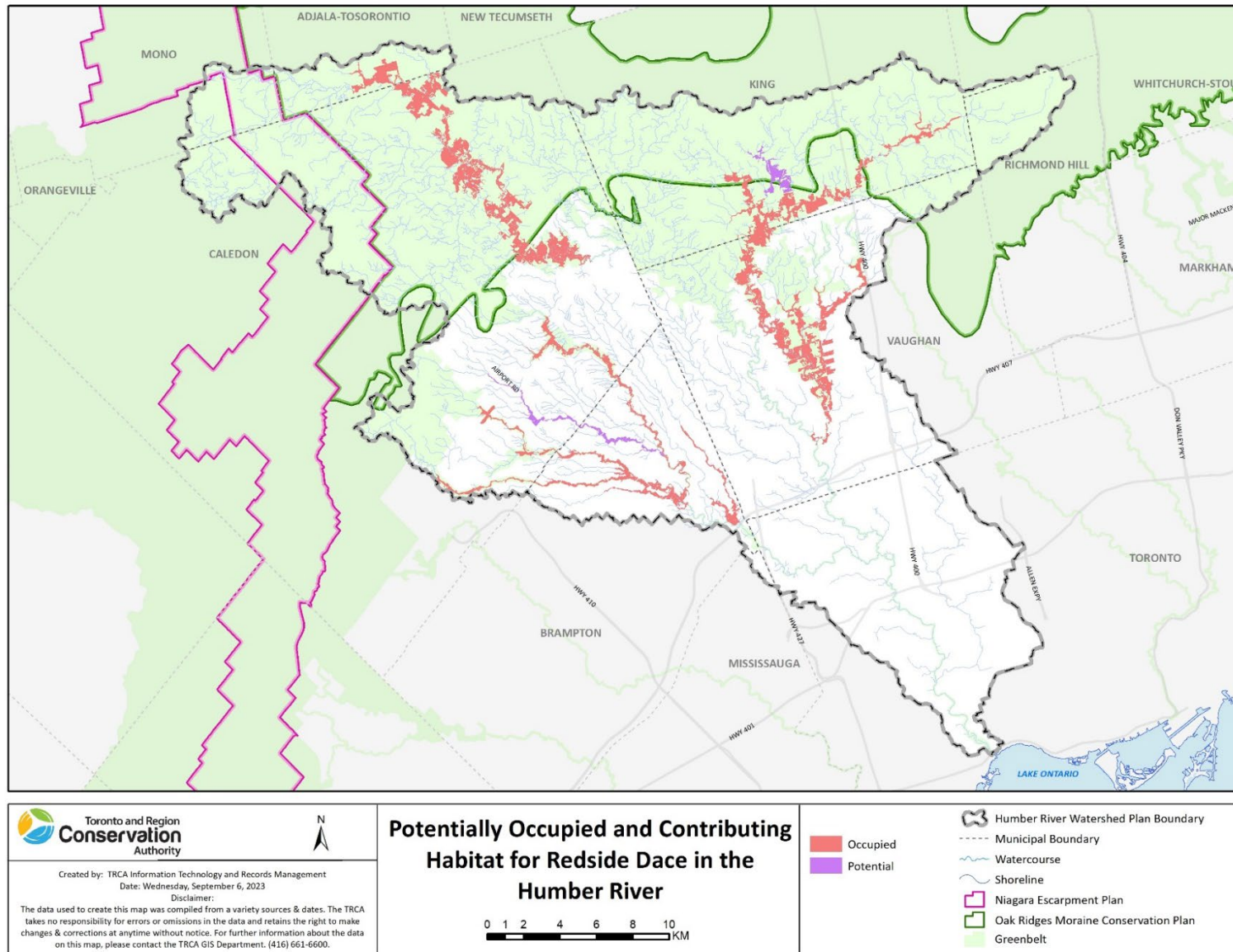
Map 6 - Watercourse and Headwater Drainage Feature Hydrology Function Classification

Humber River Watershed Characterization Report

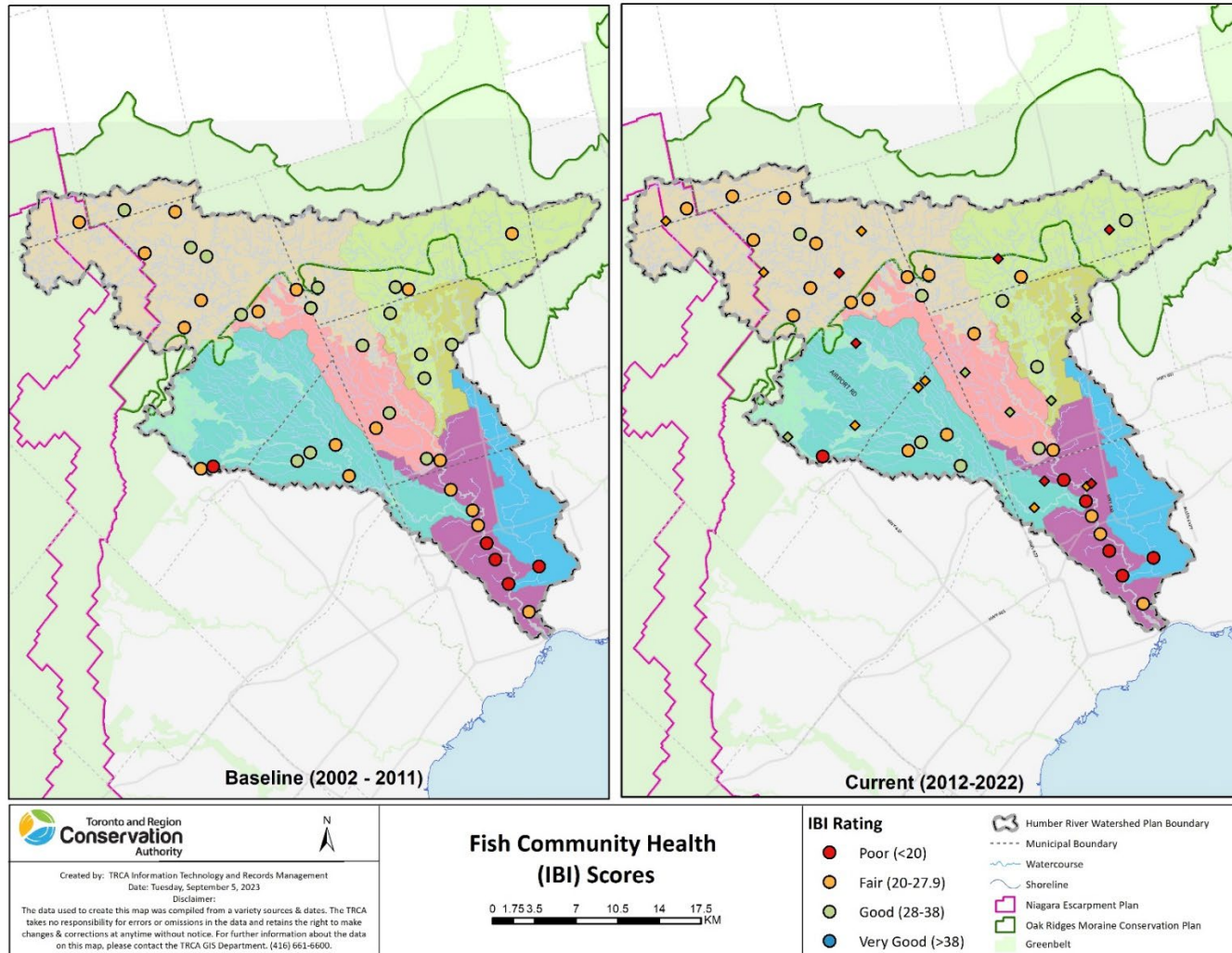


Map 7 - In-stream Barriers (not passable for any species (N = 79; red circles), passable for jumping species only (N = 12; yellow circles), and fully passable by all species (green circles))

Humber River Watershed Characterization Report

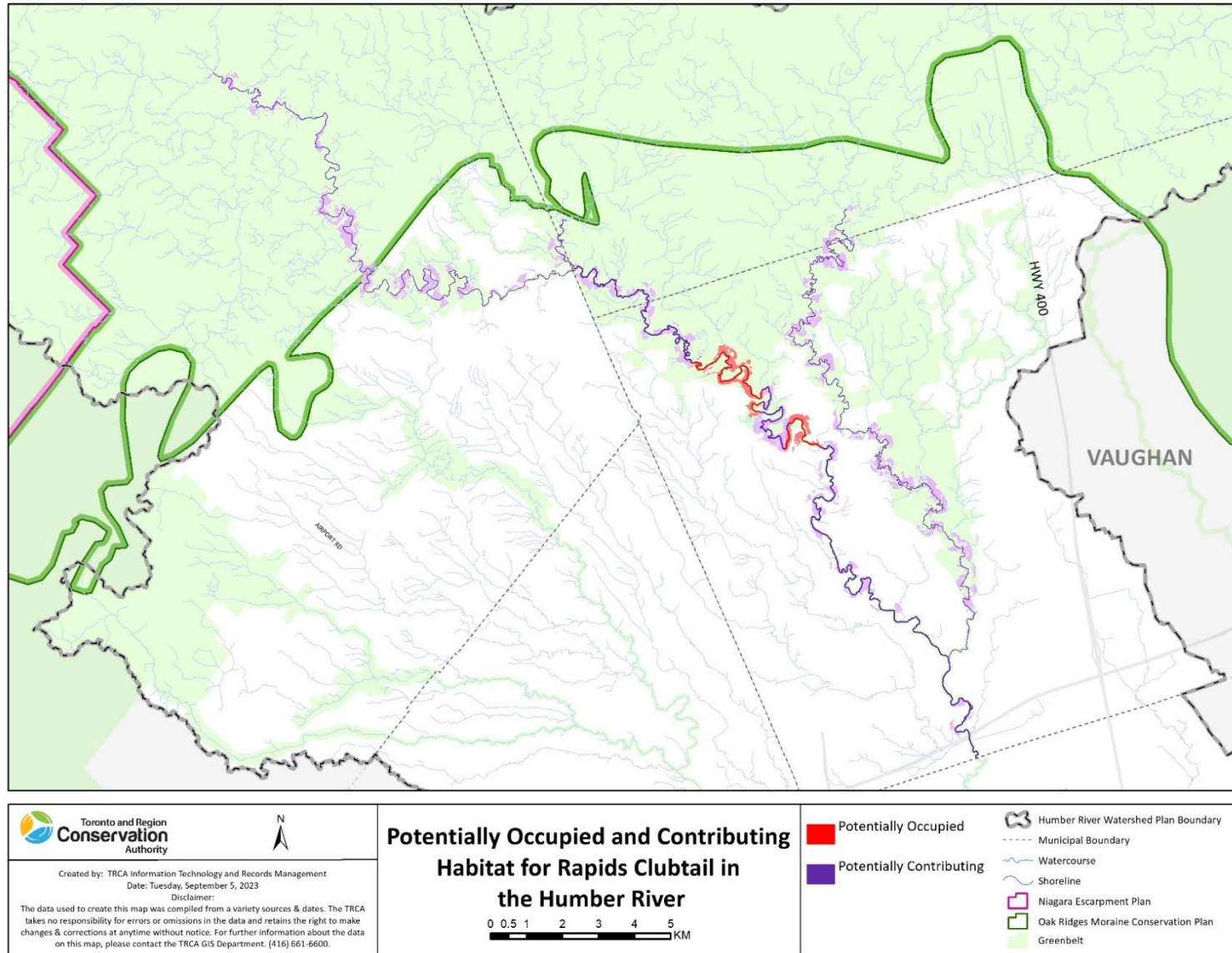


Map 8 - Potentially Occupied and Contributing Habitat for Redside Dace in the Humber River (not a finalized or approved/regulated layer and intended for screening purposes only)



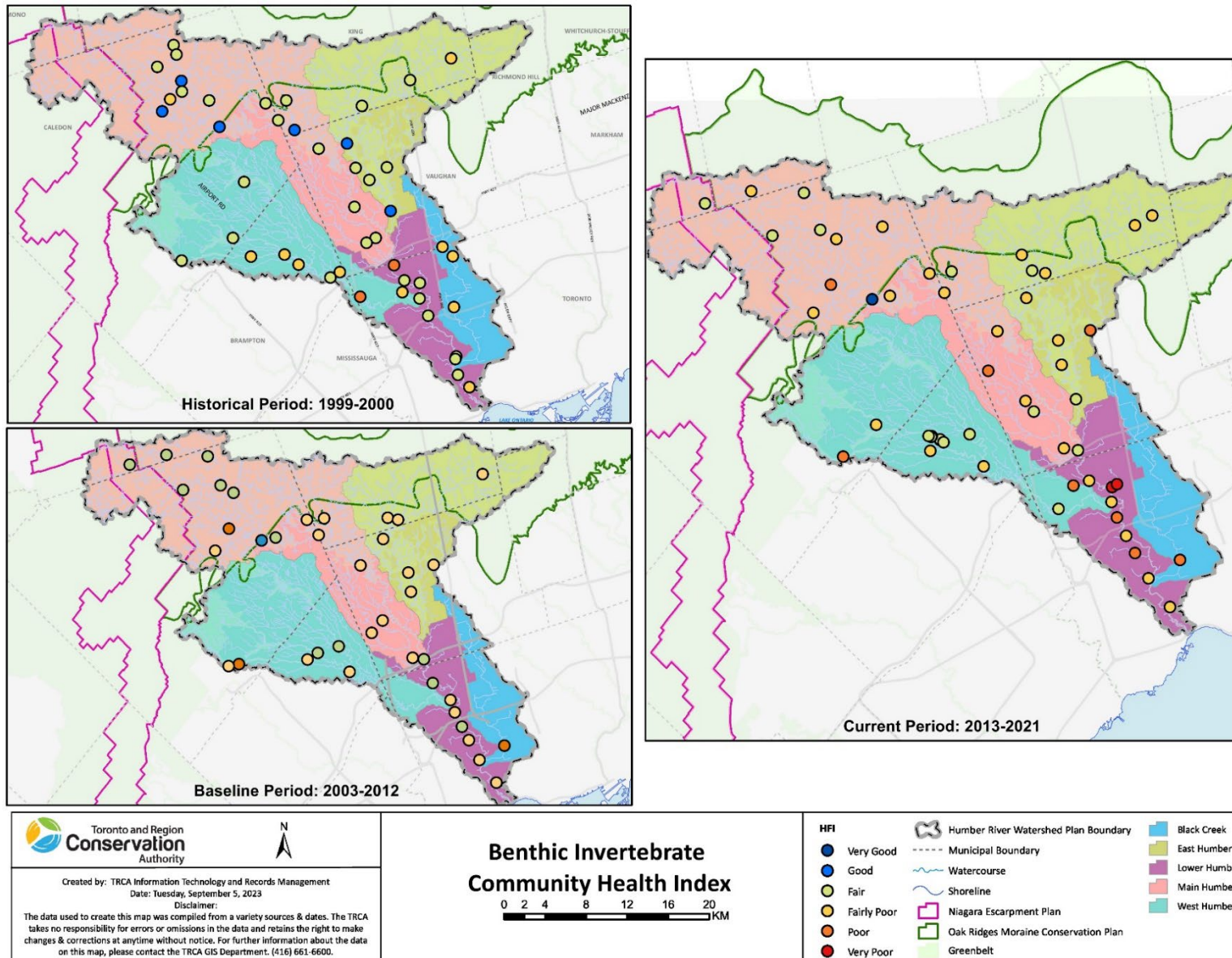
Map 9 - Mean Index of Biotic Integrity (IBI) Health Ratings for Fish Communities (N = 28 to 39 sites per year)

(The circles represent RWMP long-term monitoring sites and the mean health score based on samples collected from one to four times during each period, and triangles represent a single datum for extra sites sampled in 2020 and 2021)



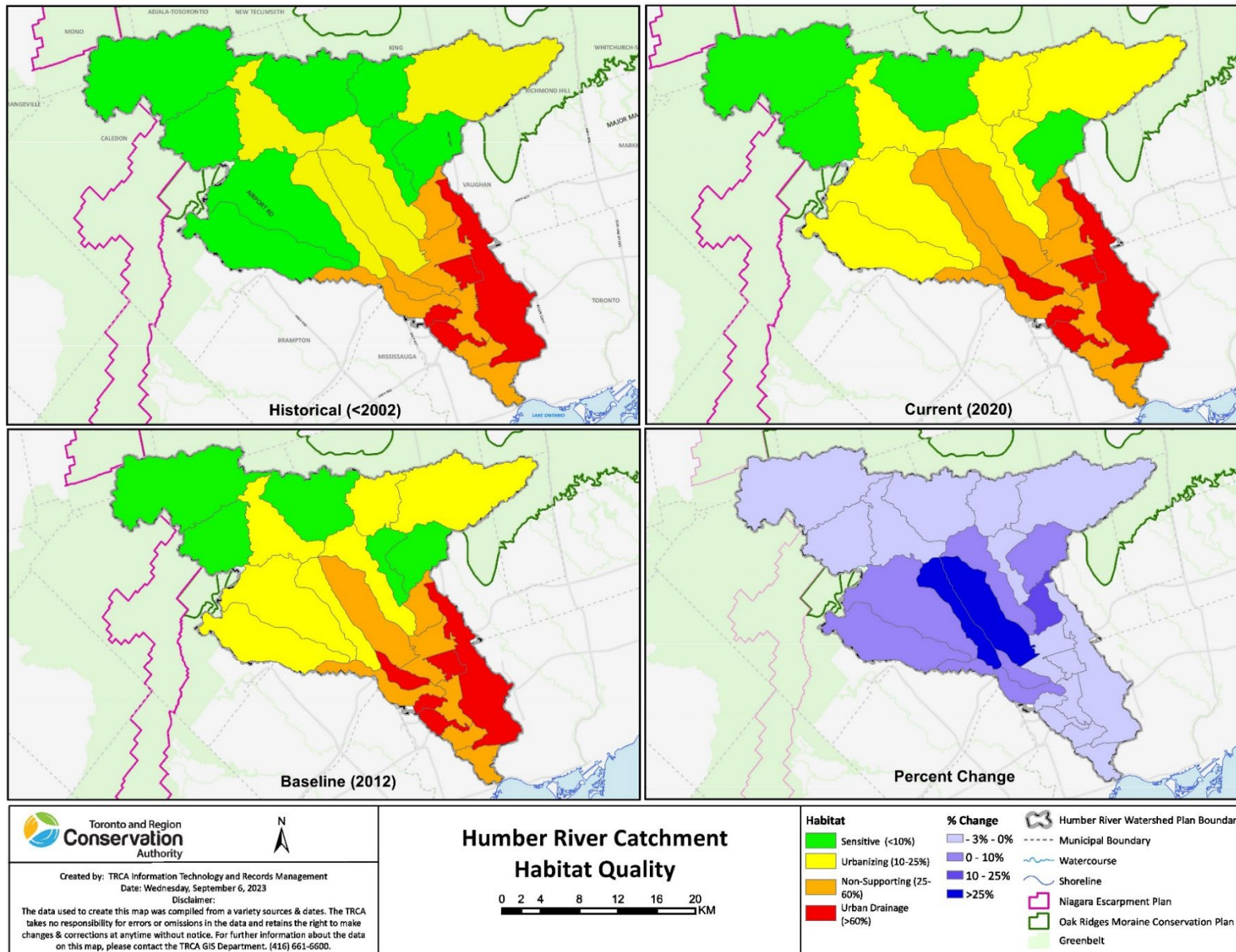
Map 10 - Potentially Occupied and Contributing Habitat for Rapids Clubtail in the Humber River (not a finalized or approved/regulated layer and intended for screening purposes only)

Humber River Watershed Characterization Report



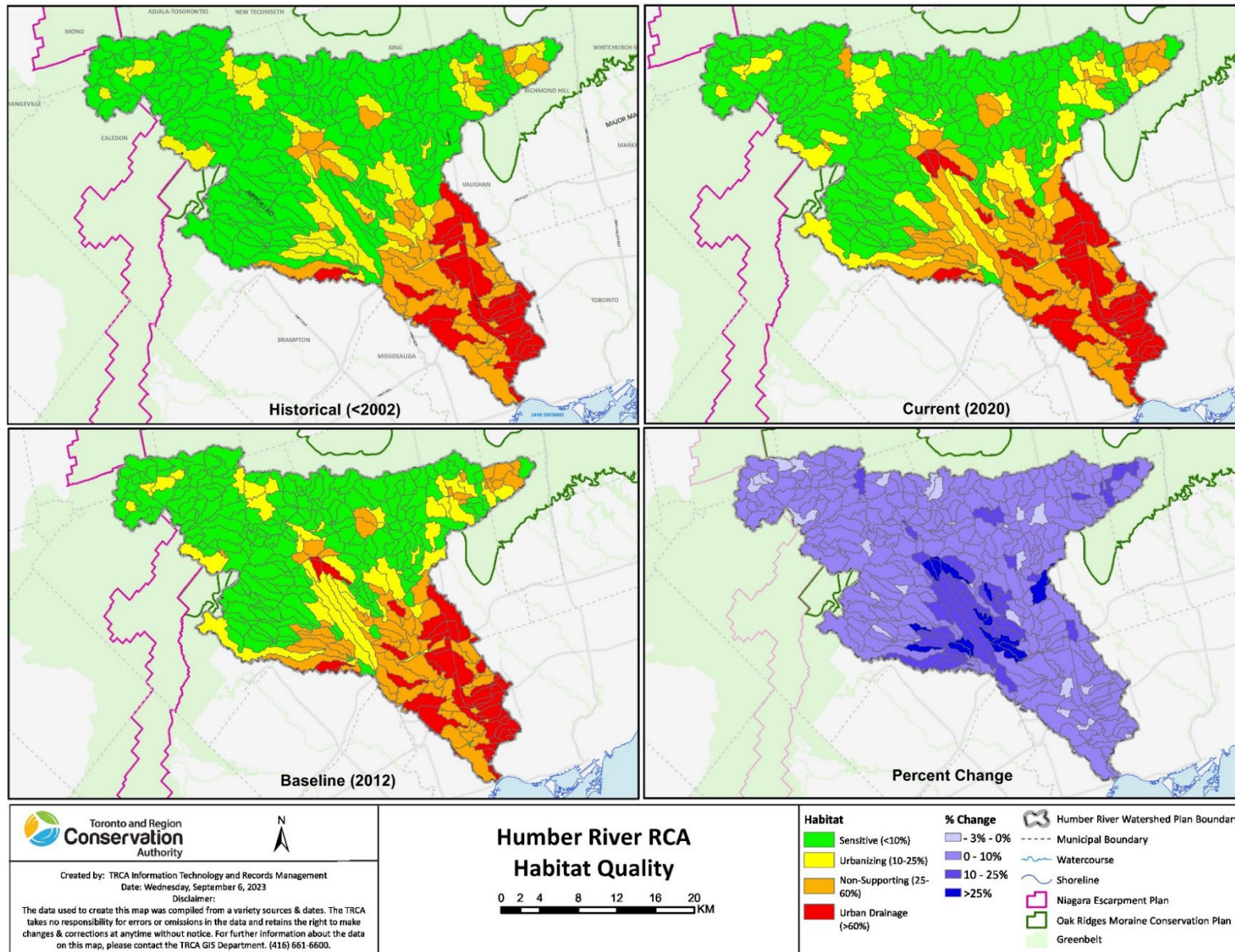
Map 11 - Average Family Biotic Index (FBI) Ratings for Benthic Invertebrates (number of sites per year: historical N = 45 in 1999 and 6 in 2000; baseline period N = 35-38; current period N = 31-36).

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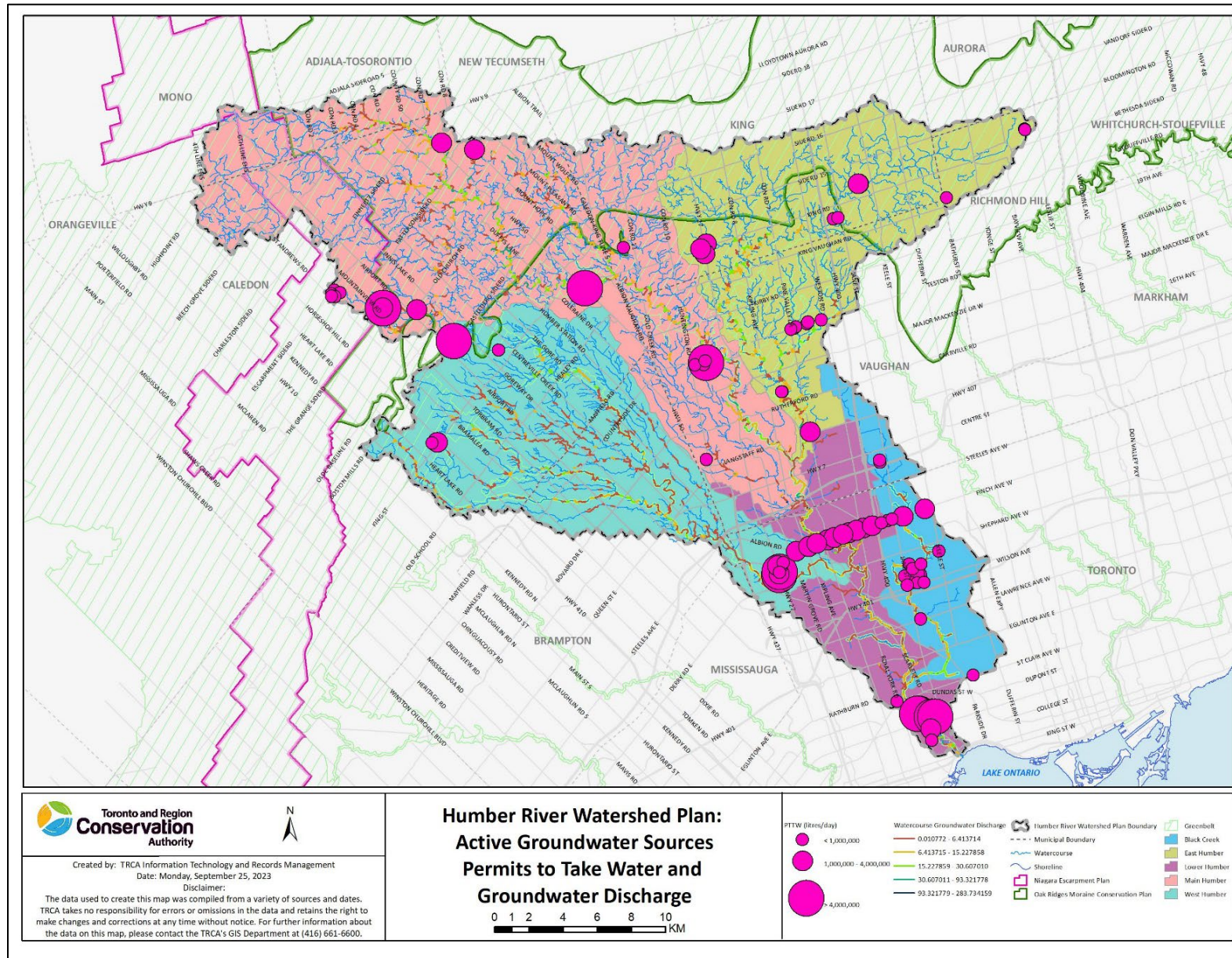
Map 12 - Percent Impervious Cover within 24 Subwatershed Catchments Shown as Habitat Quality in 2002, 2012, and 2020 (% change in impervious cover also shown from baseline (2002) to current periods (2012 + 2020))

Humber River Watershed Characterization Report



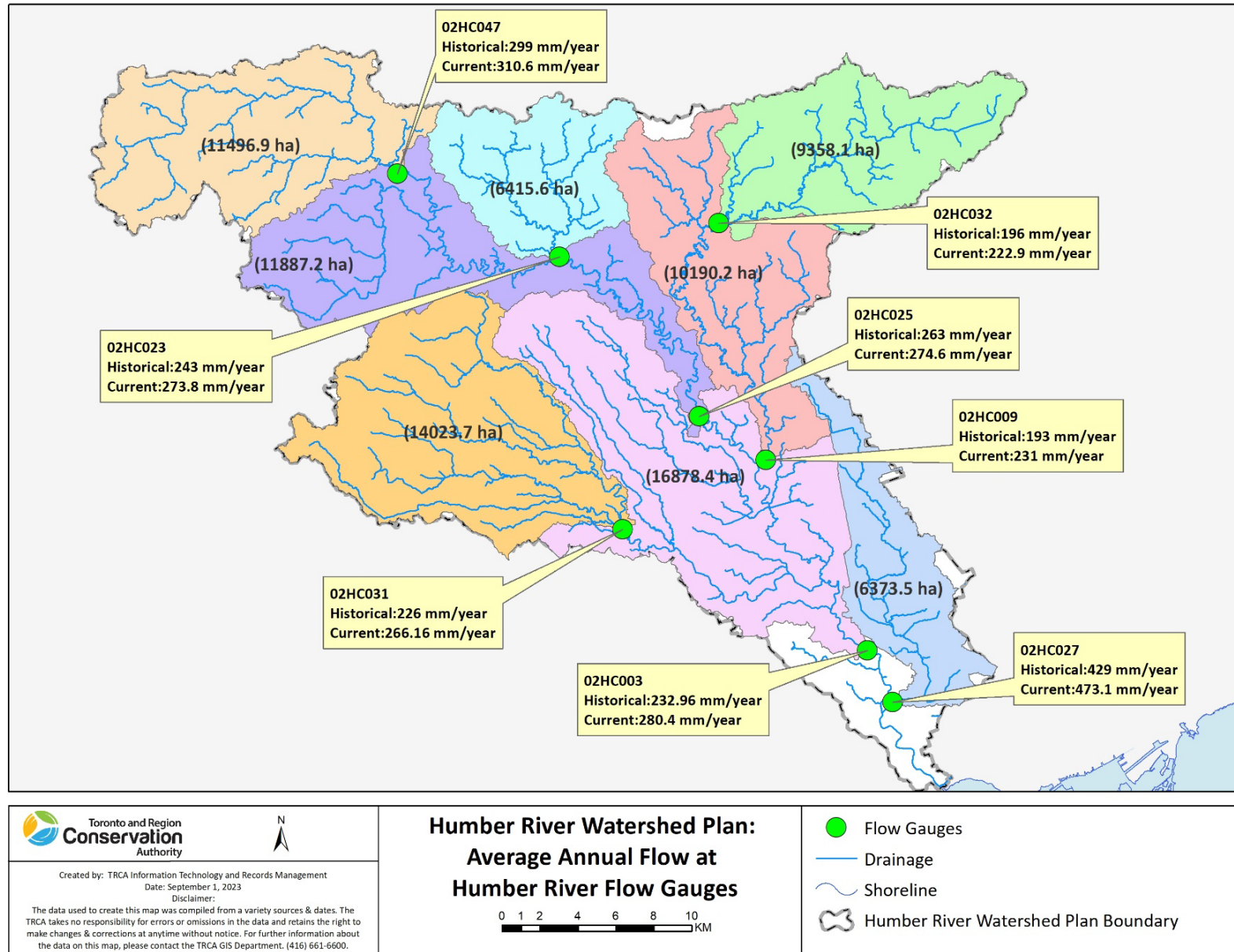
Map 13 - Percent Impervious Cover within 204 Reach Contributing Areas (RCAs) Shown as Habitat Quality in 2002, 2012, and 2020 (% change in impervious cover also shown from baseline (2002) to current periods (2012 + 2020))

Humber River Watershed Characterization Report



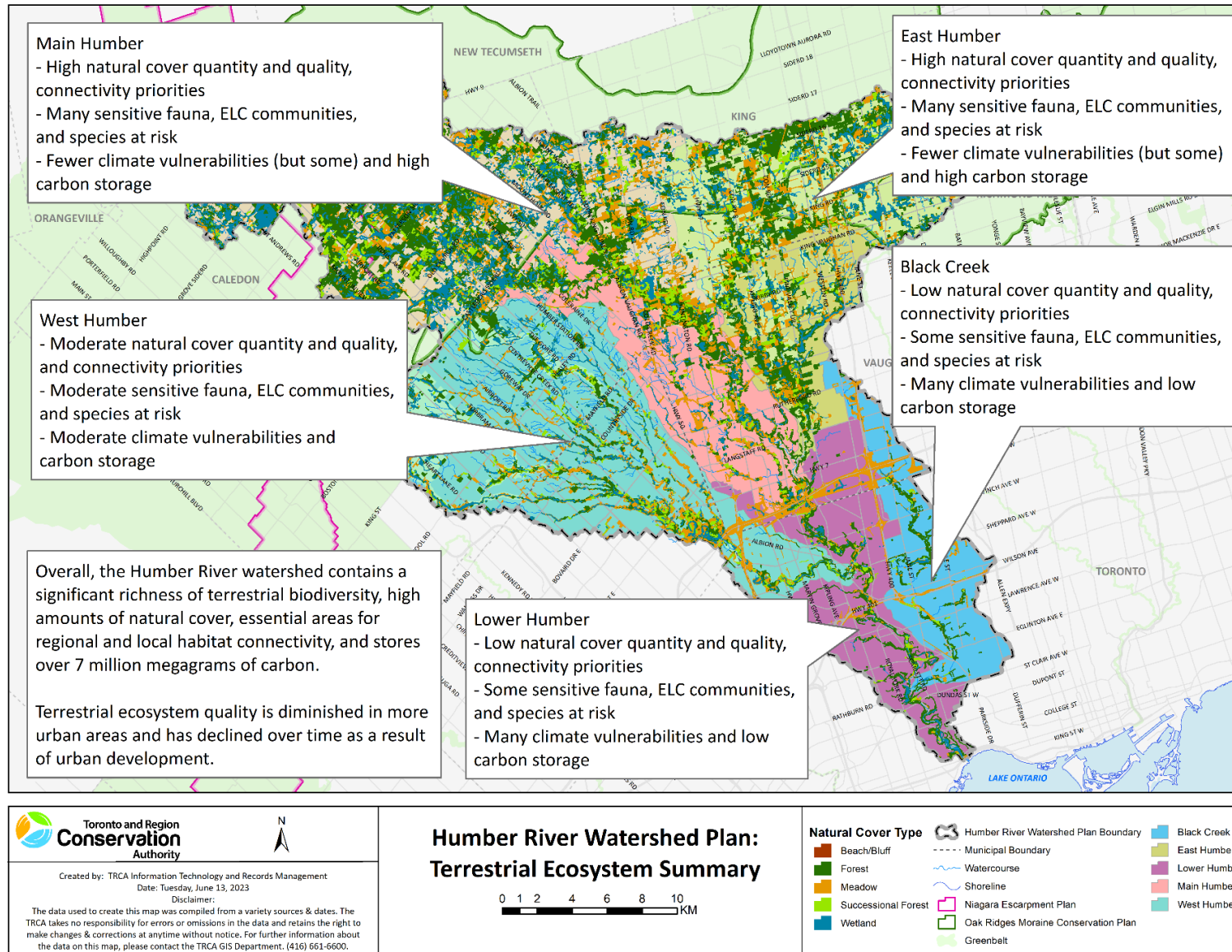
Map 14 - Active Groundwater Sources Permits to Take Water and Groundwater Discharge

Humber River Watershed Characterization Report



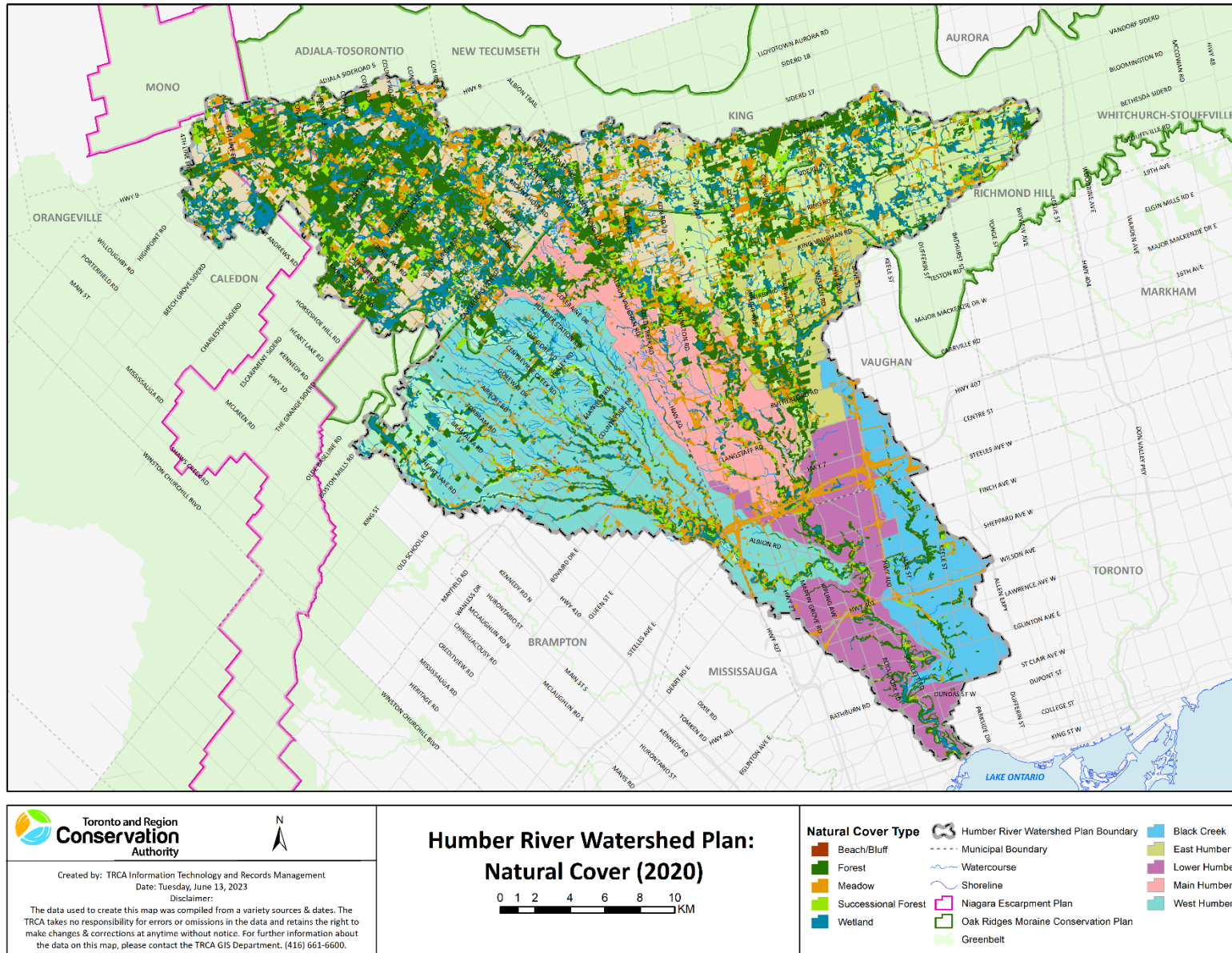
Map 15 - Average Annual Streamflow at Humber River Flow Gauges (30-year period) and Gauge Catchment Areas

Humber River Watershed Characterization Report



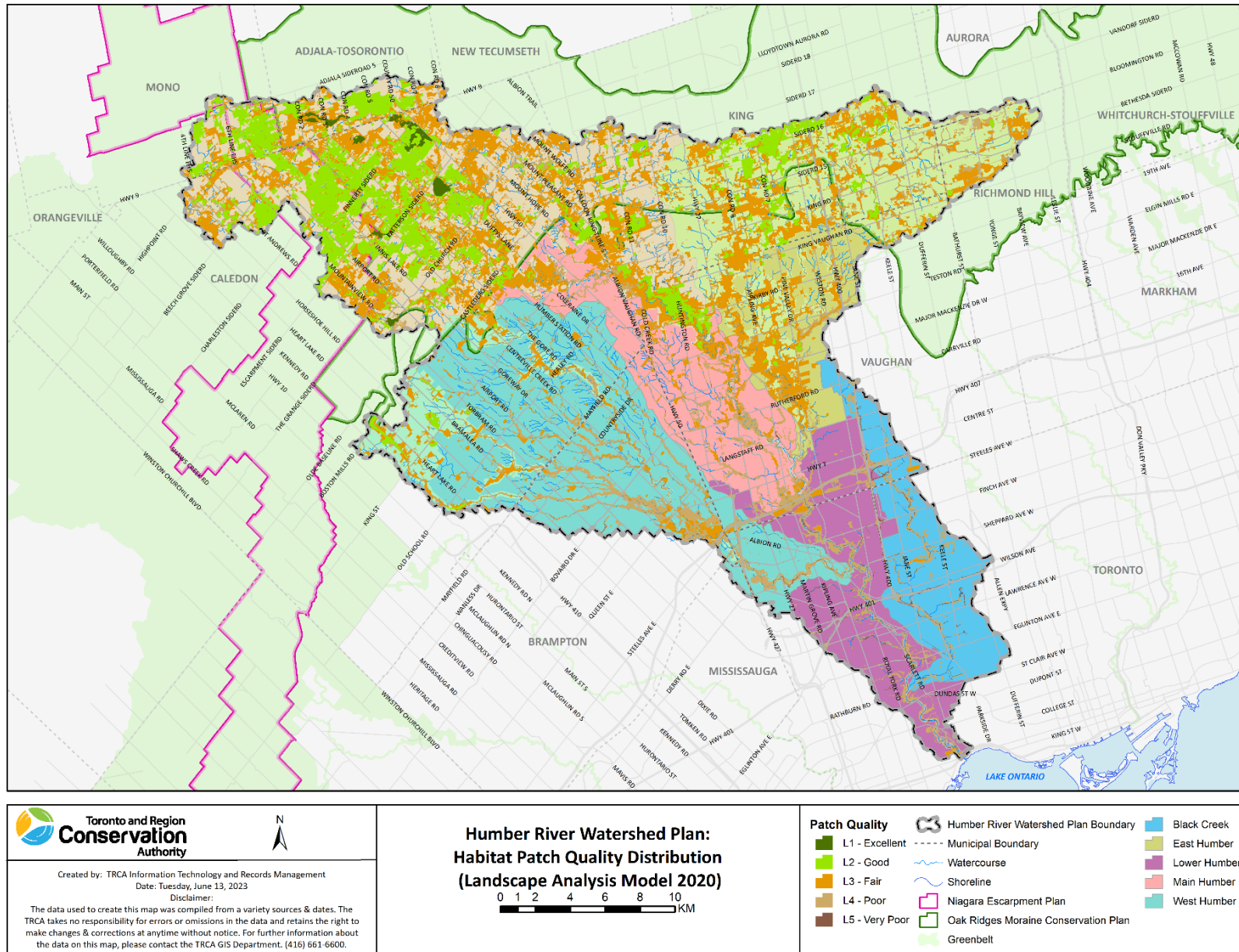
Map 16 - Terrestrial Ecosystem Summary

Humber River Watershed Characterization Report



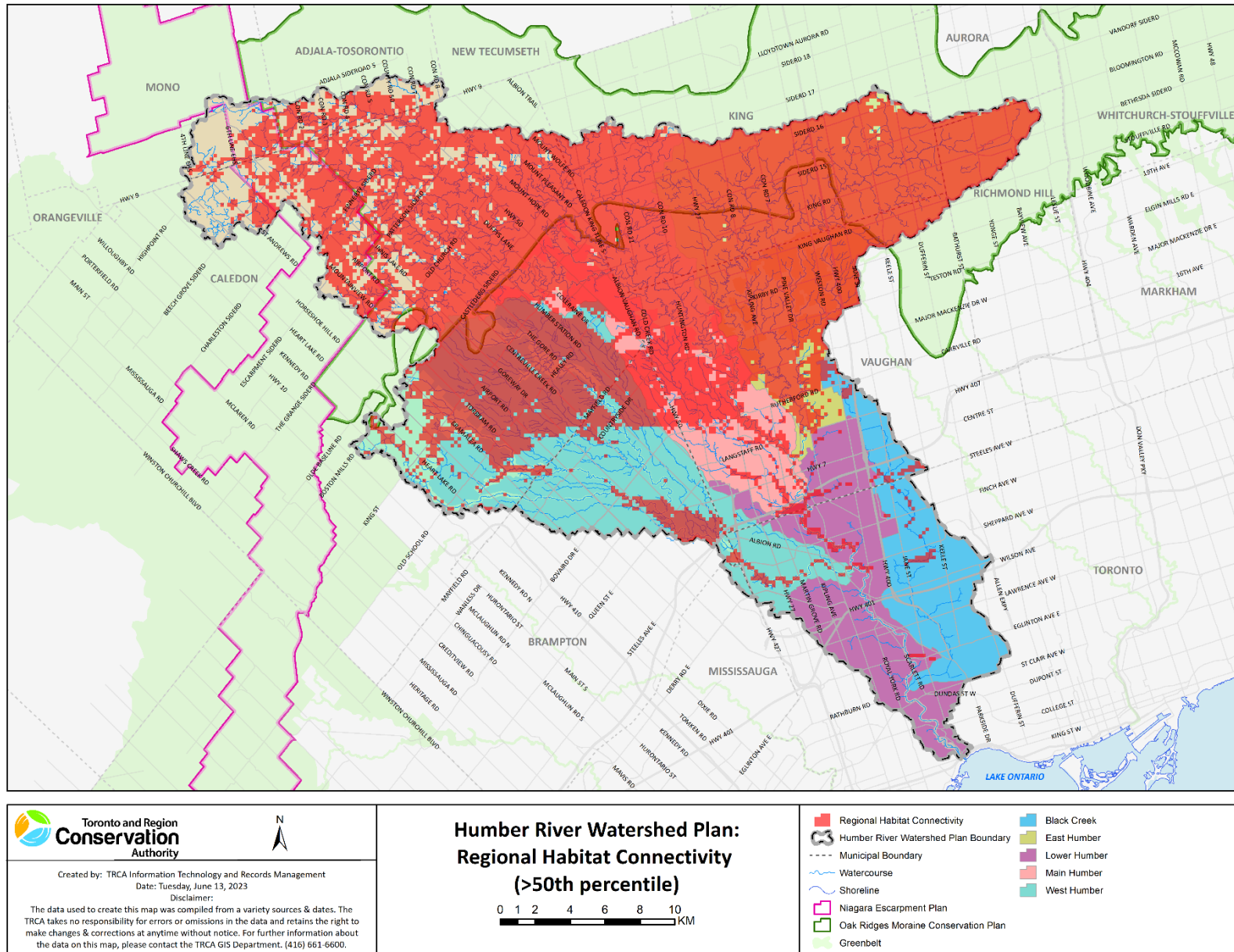
Map 17 - Natural Cover Distribution

Humber River Watershed Characterization Report



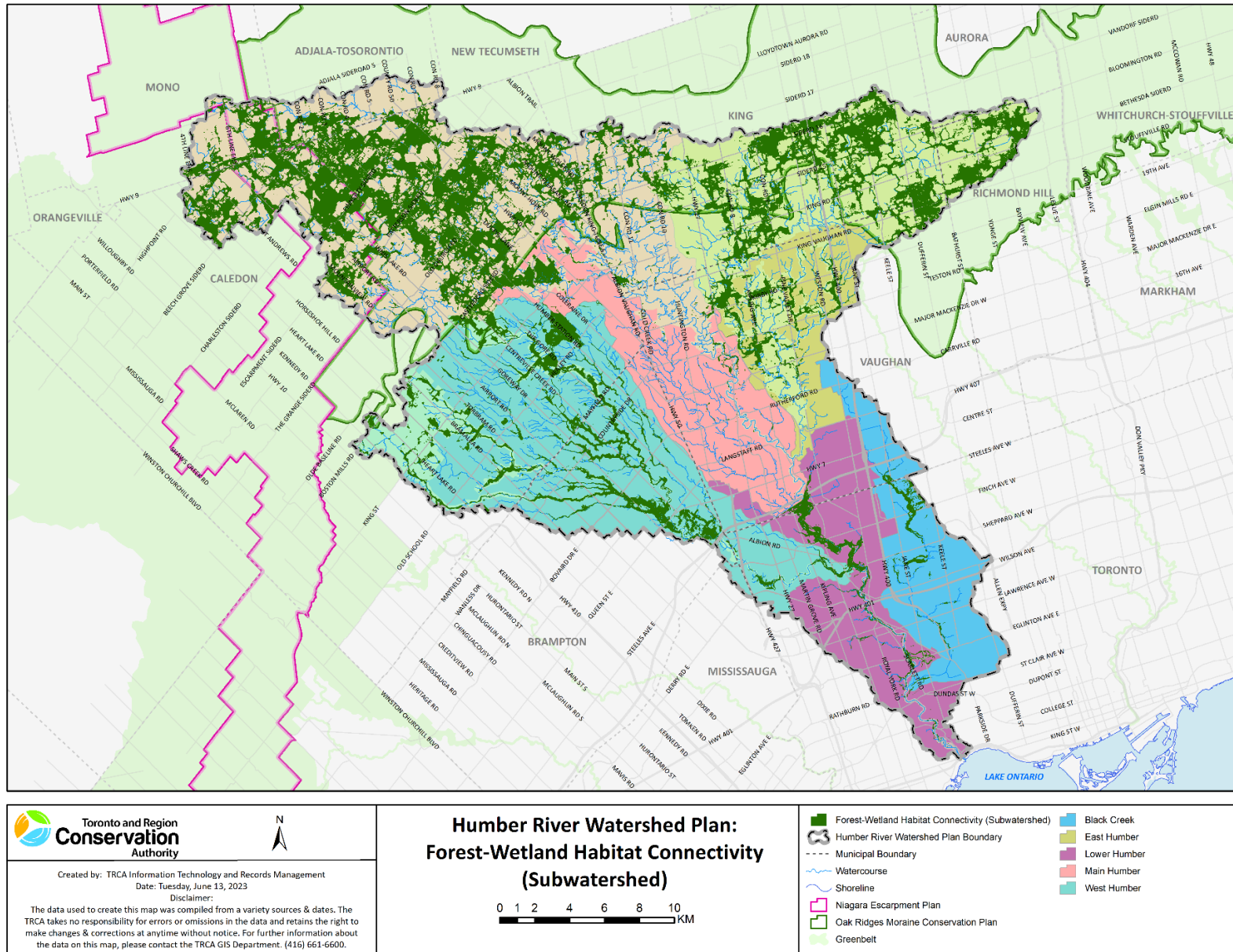
Map 18 - Habitat Patch Quality Distribution

Humber River Watershed Characterization Report



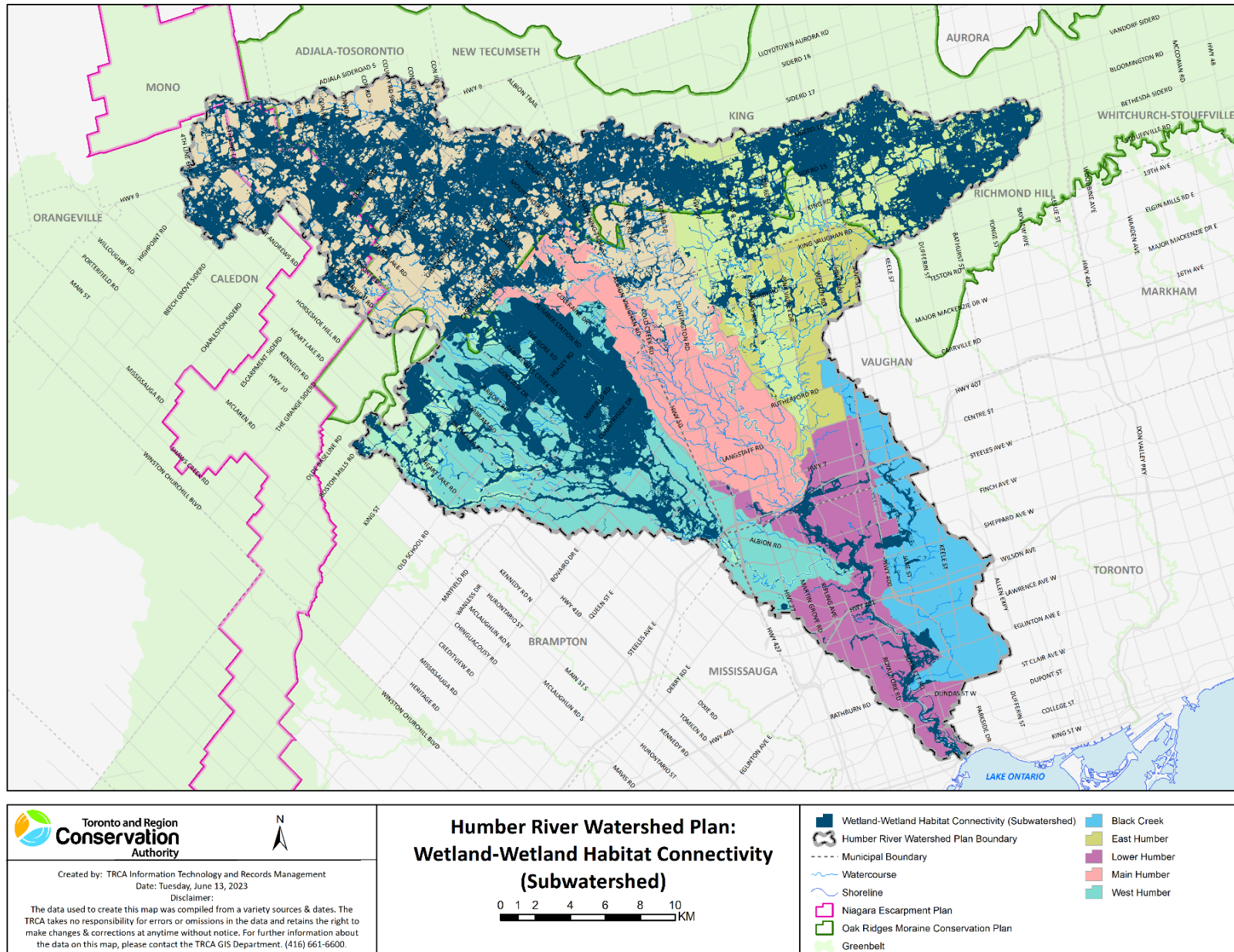
Map 19 - Areas Identified as Important for Regional Habitat Connectivity

Humber River Watershed Characterization Report



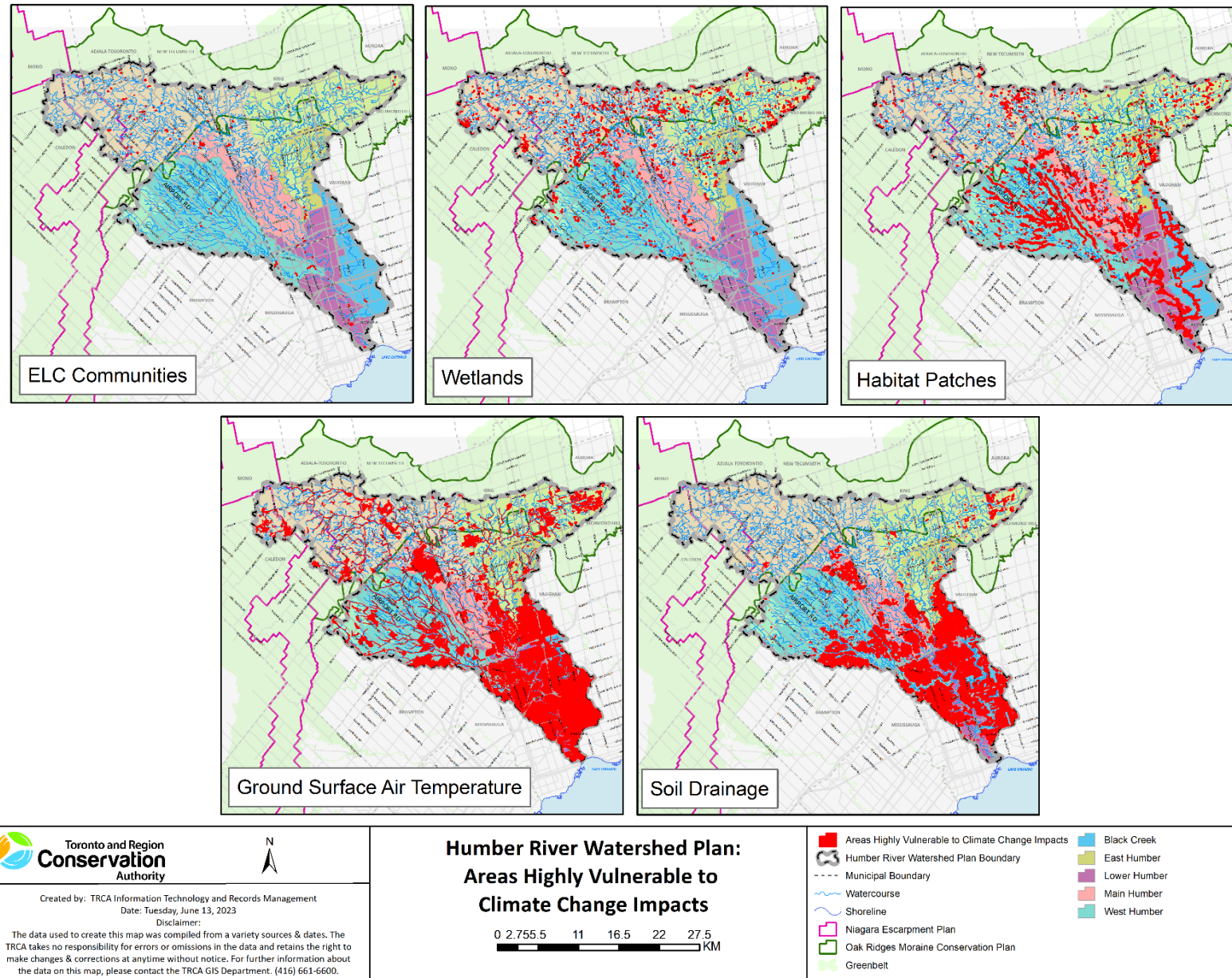
Map 20 - Areas Identified as Important for Local (Forest-Wetland) Habitat Connectivity at Subwatershed Scale

Humber River Watershed Characterization Report



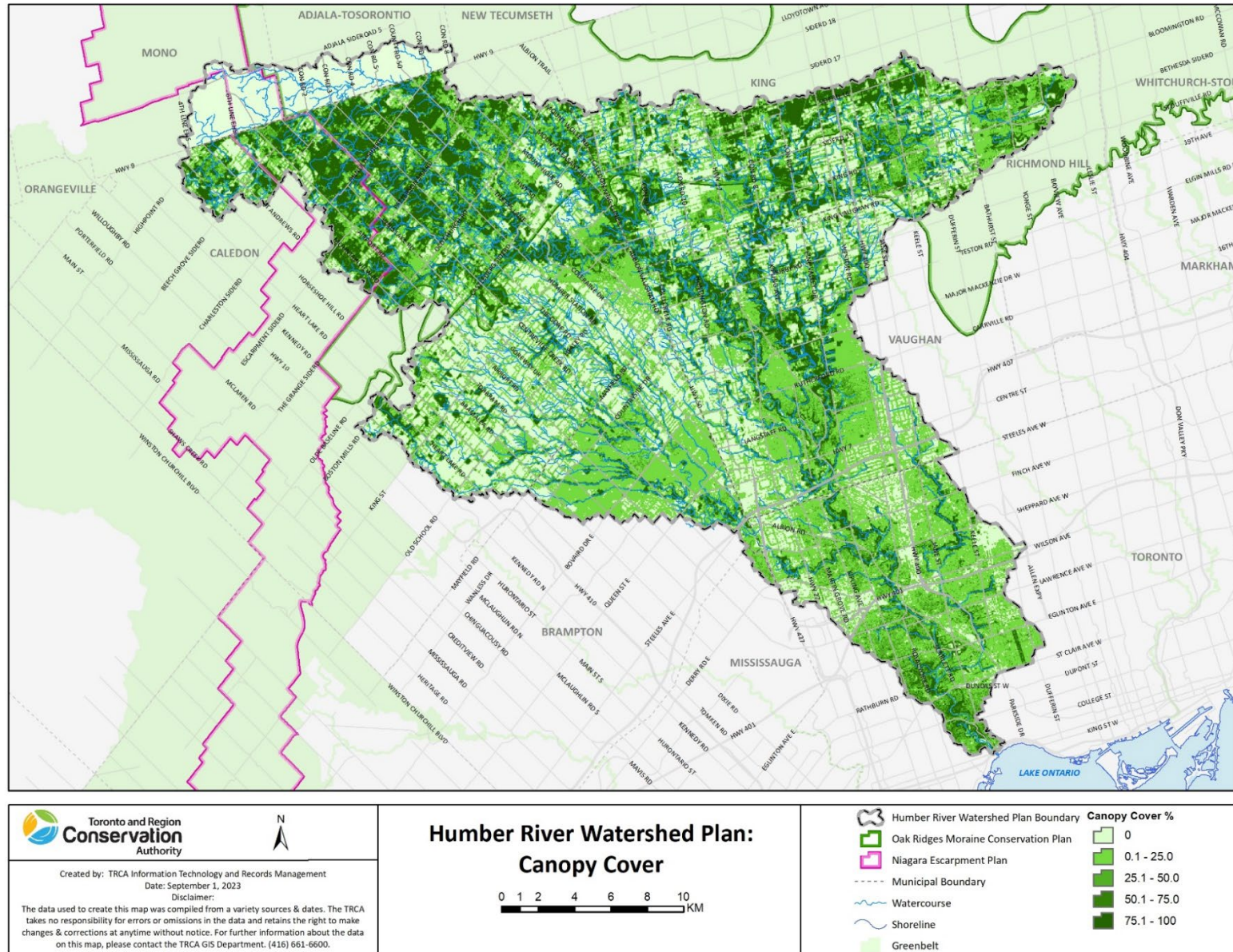
Map 21 - Areas Identified as Important for Local (Wetland-Wetland) Habitat Connectivity at Subwatershed Scale

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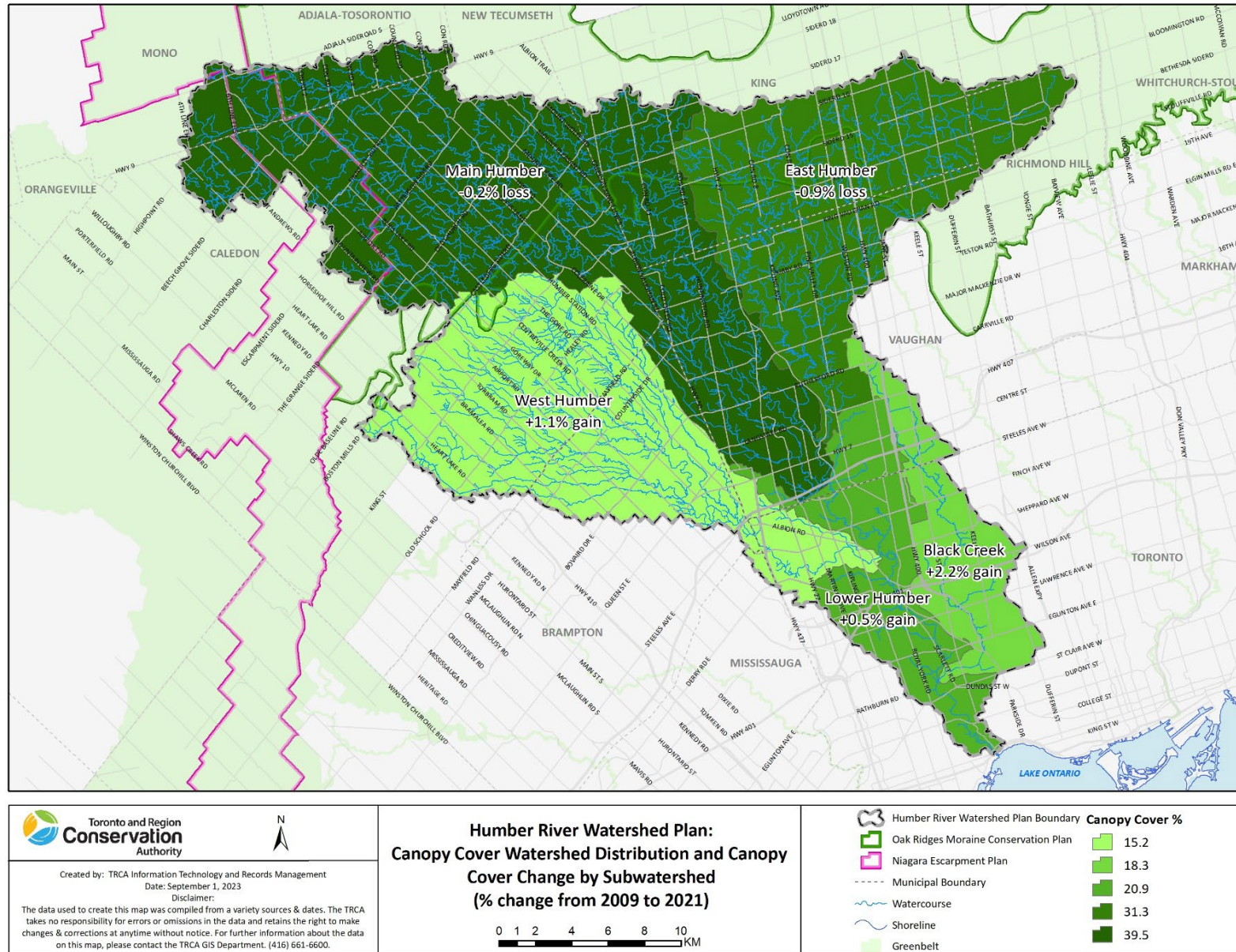
Map 22 - Areas Identified as Highly Vulnerable to Climate Change Impacts

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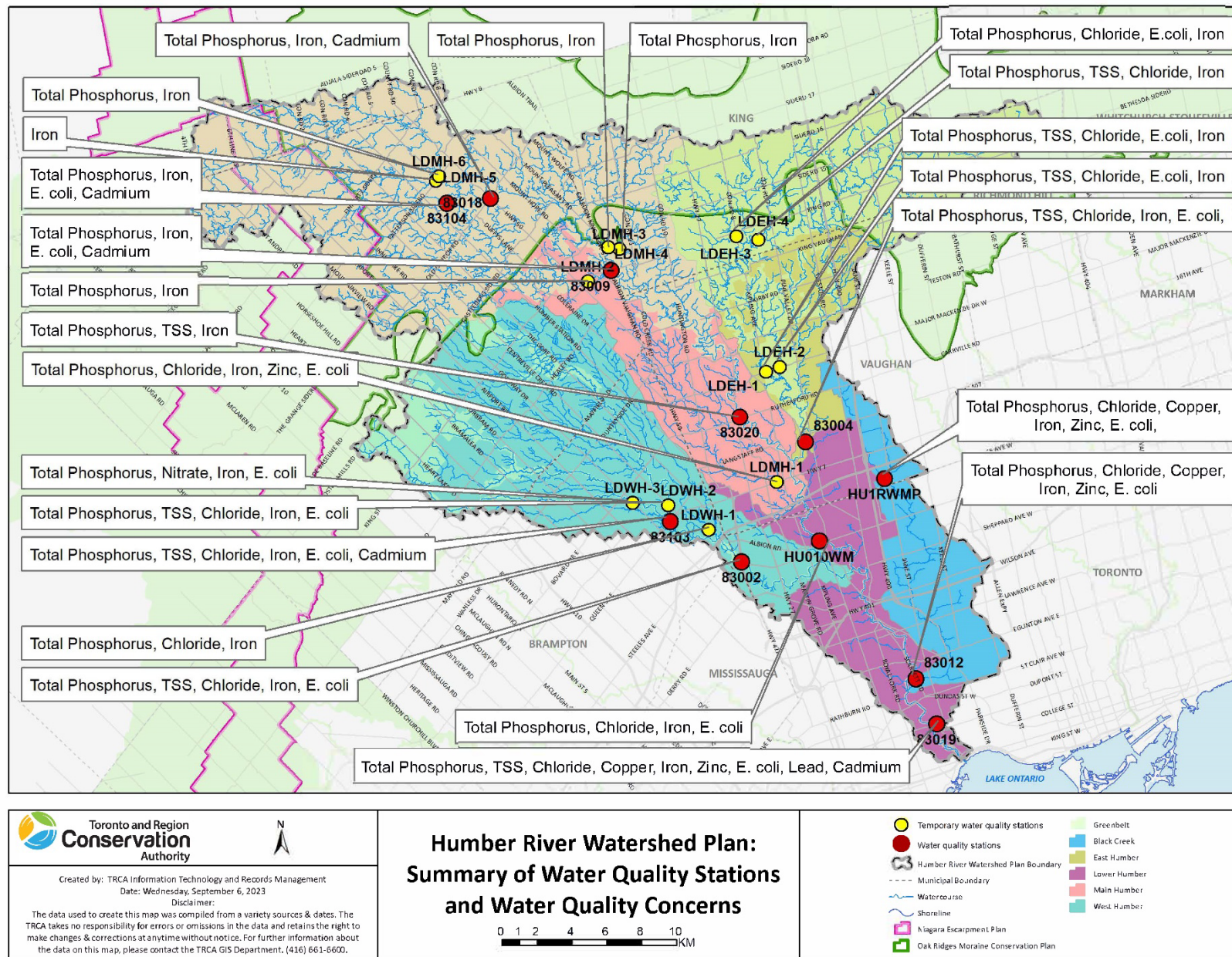
Map 23 - Current (2018/2019/2022) Canopy Cover Distribution Across the Humber River Watershed

Humber River Watershed Characterization Report



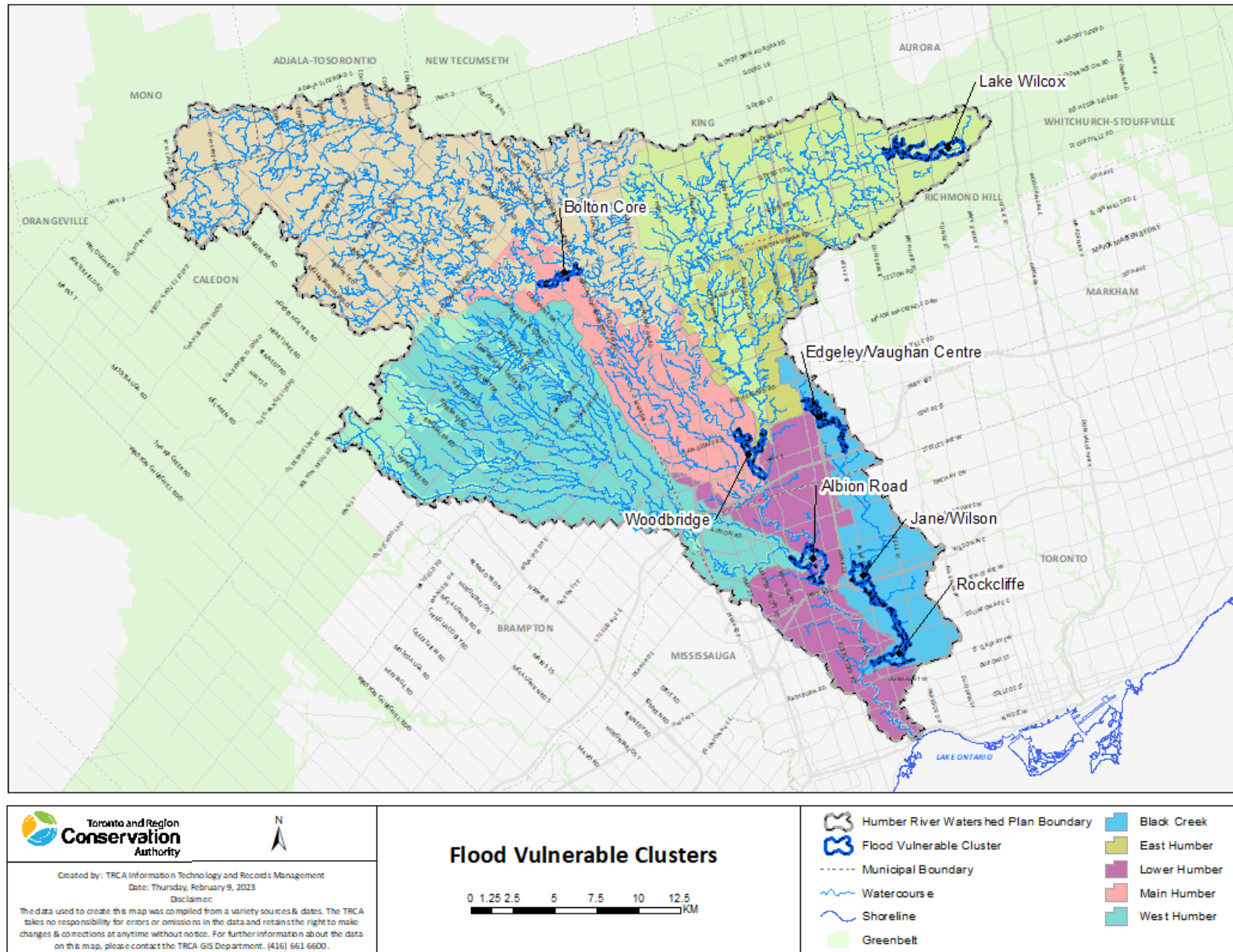
Map 24 - Canopy Cover Watershed Distribution and Canopy Cover Change by Subwatershed (% change from 2009 to 2021)

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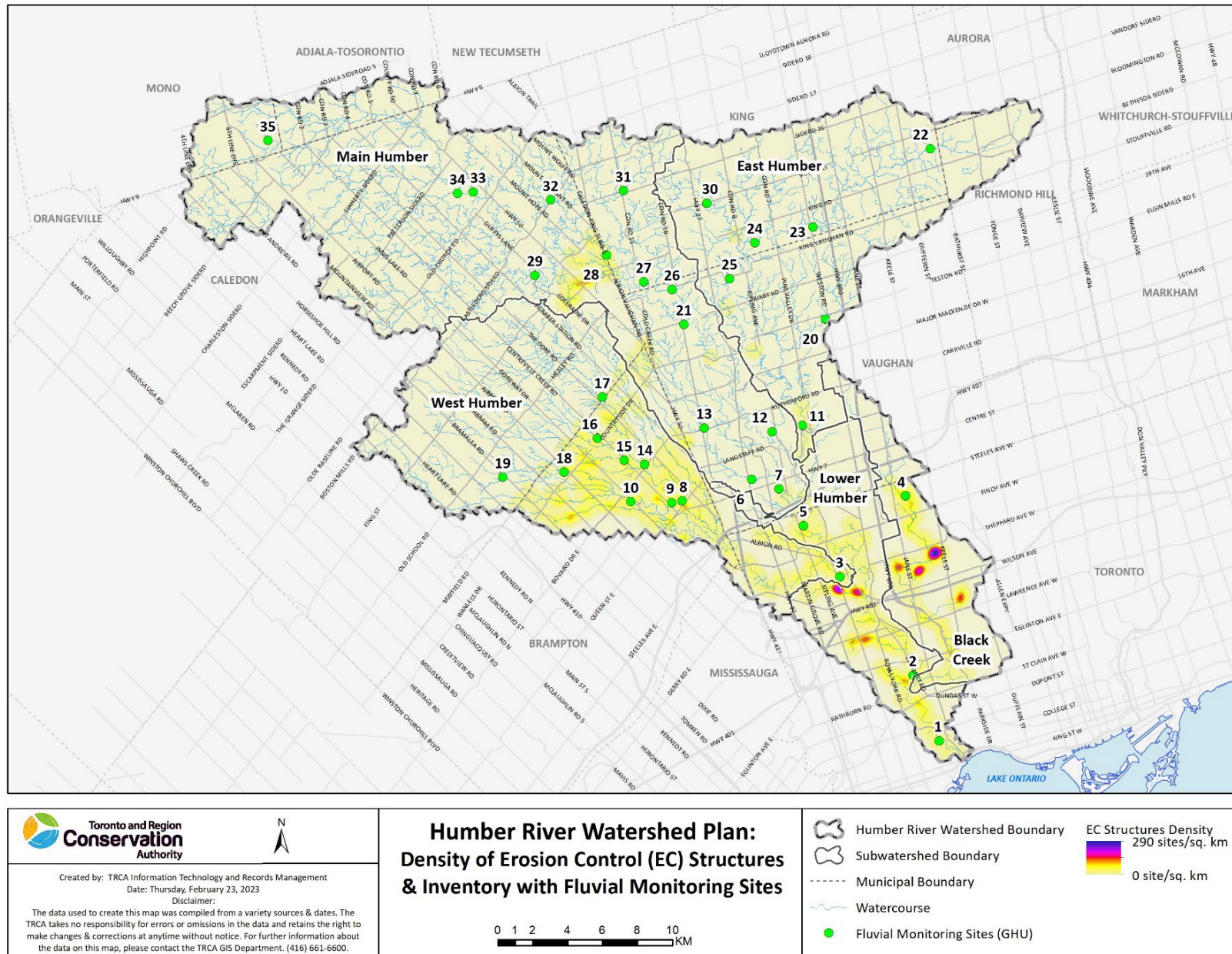
Map 25 - Summary of Water Quality Stations and Water Quality Concerns

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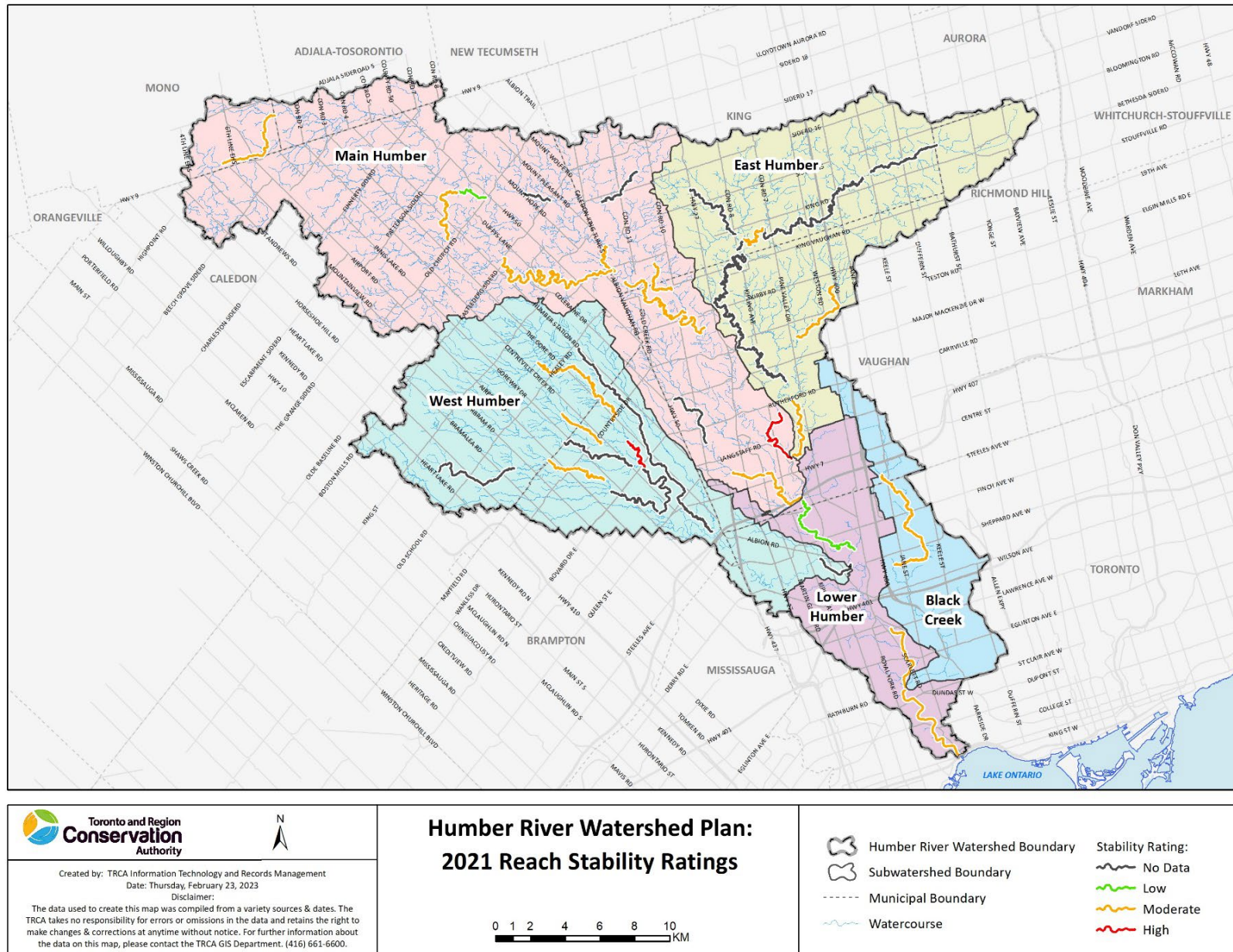
Map 26 - Flood Vulnerable Clusters

Humber River Watershed Characterization Report



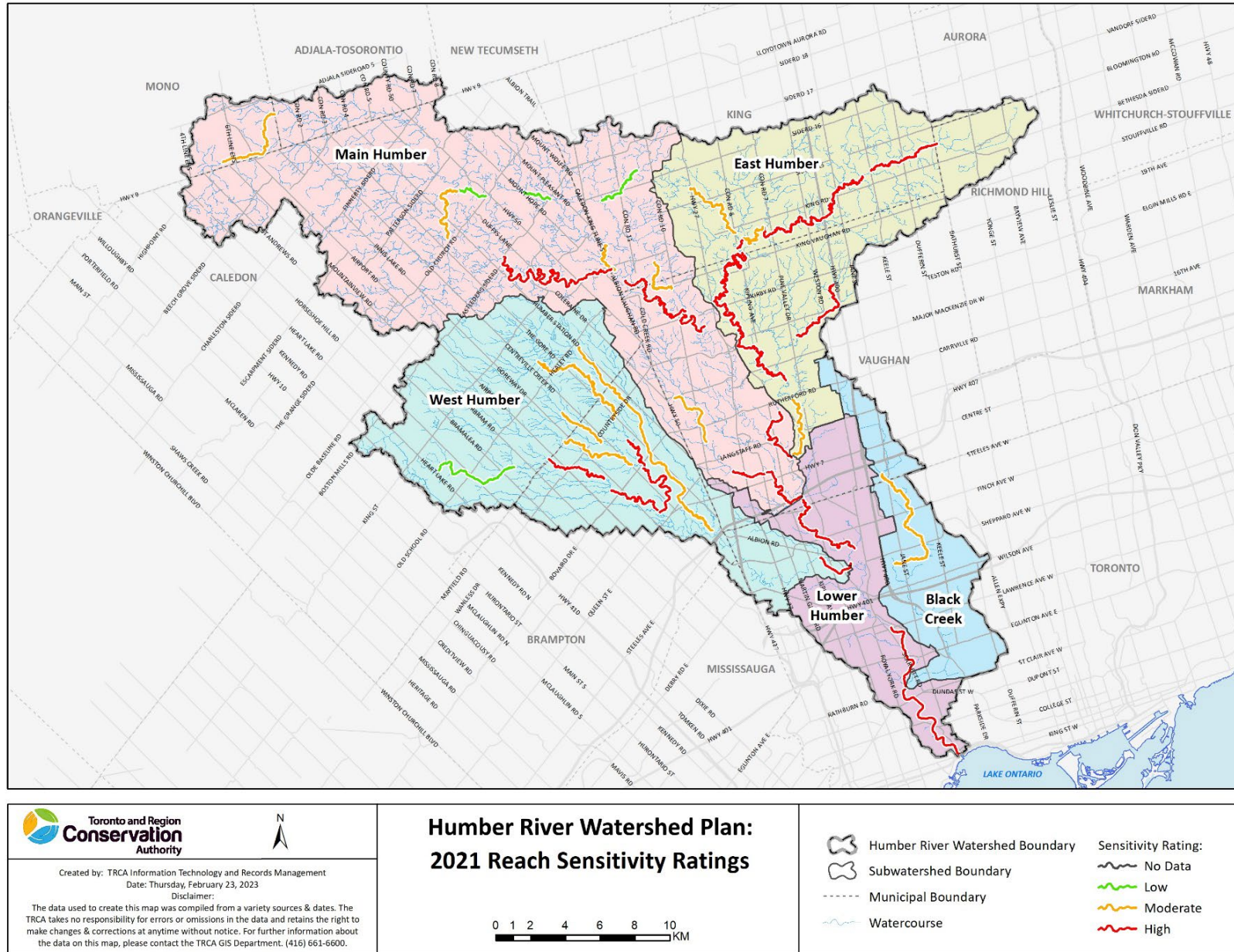
Map 27 - Density of Erosion Control Structures and Location of Fluvial Geomorphic Monitoring Sites and Reaches

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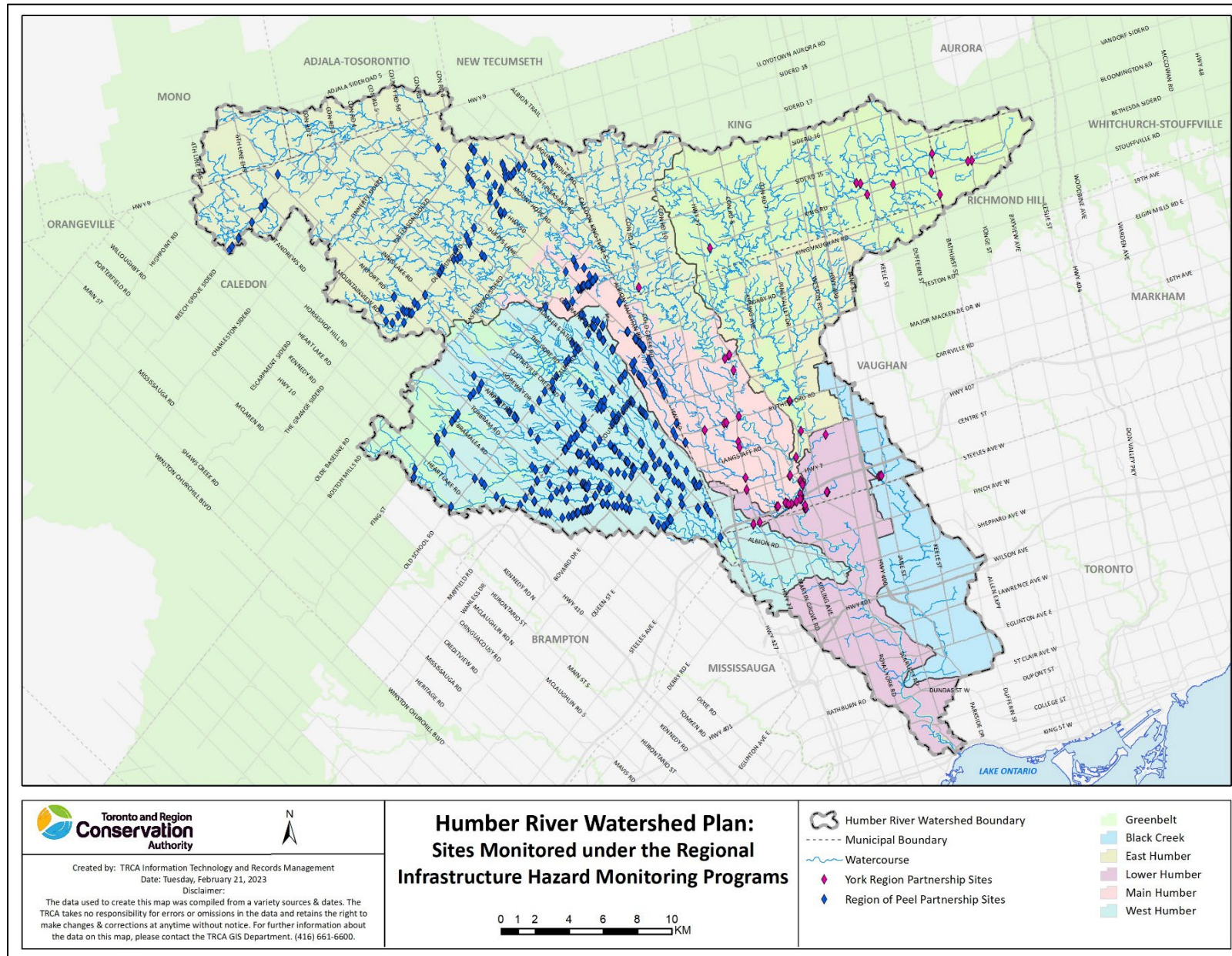
Map 28 - Reach Stability Ratings for the Reaches Surveyed in 2021

Humber River Watershed Characterization Report



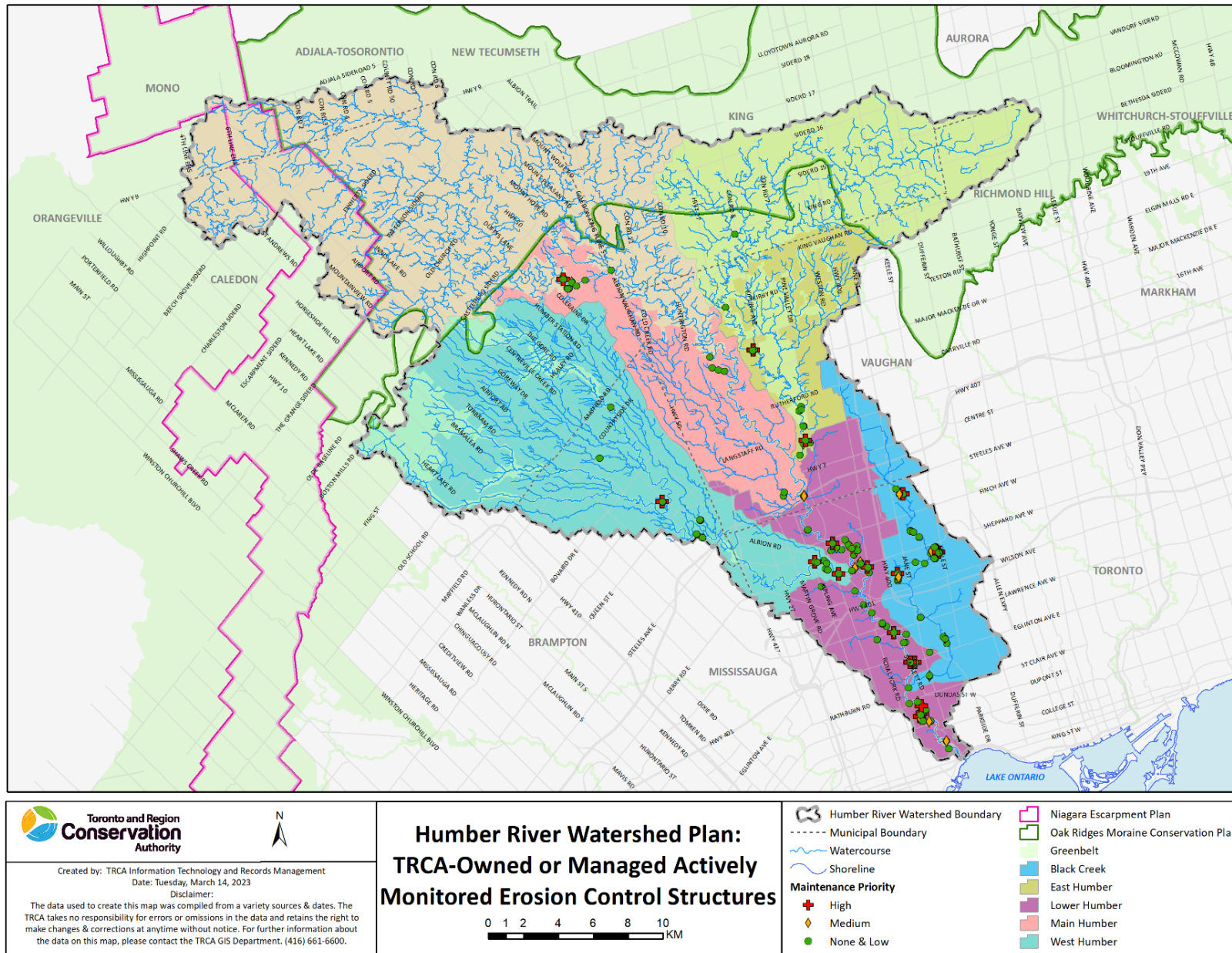
Map 29 - Reach Sensitivity Ratings for the Reaches Surveyed in 2021

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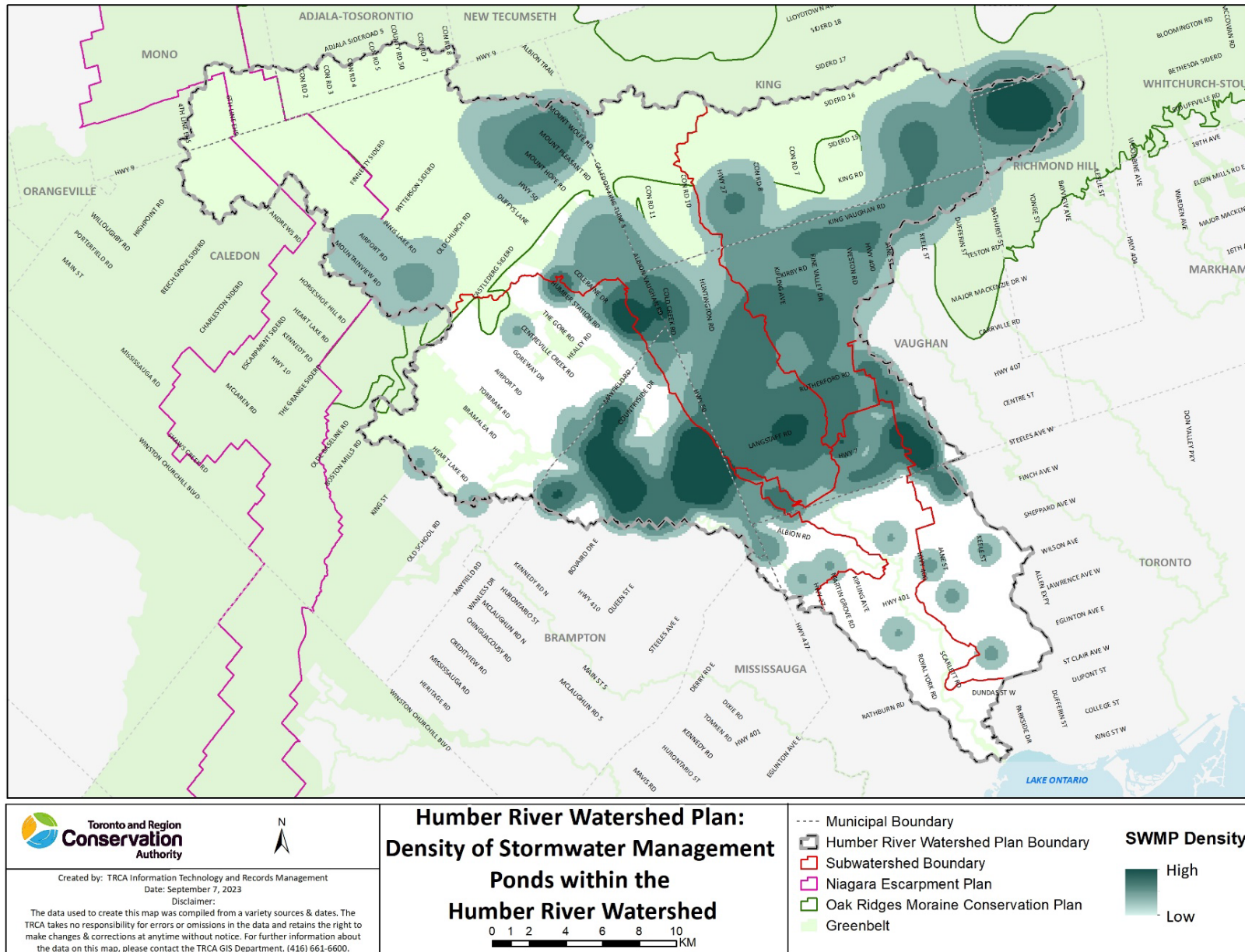
Map 30 - Sites Monitored under the Regional Infrastructure Hazard Monitoring Programs

Humber River Watershed Characterization Report



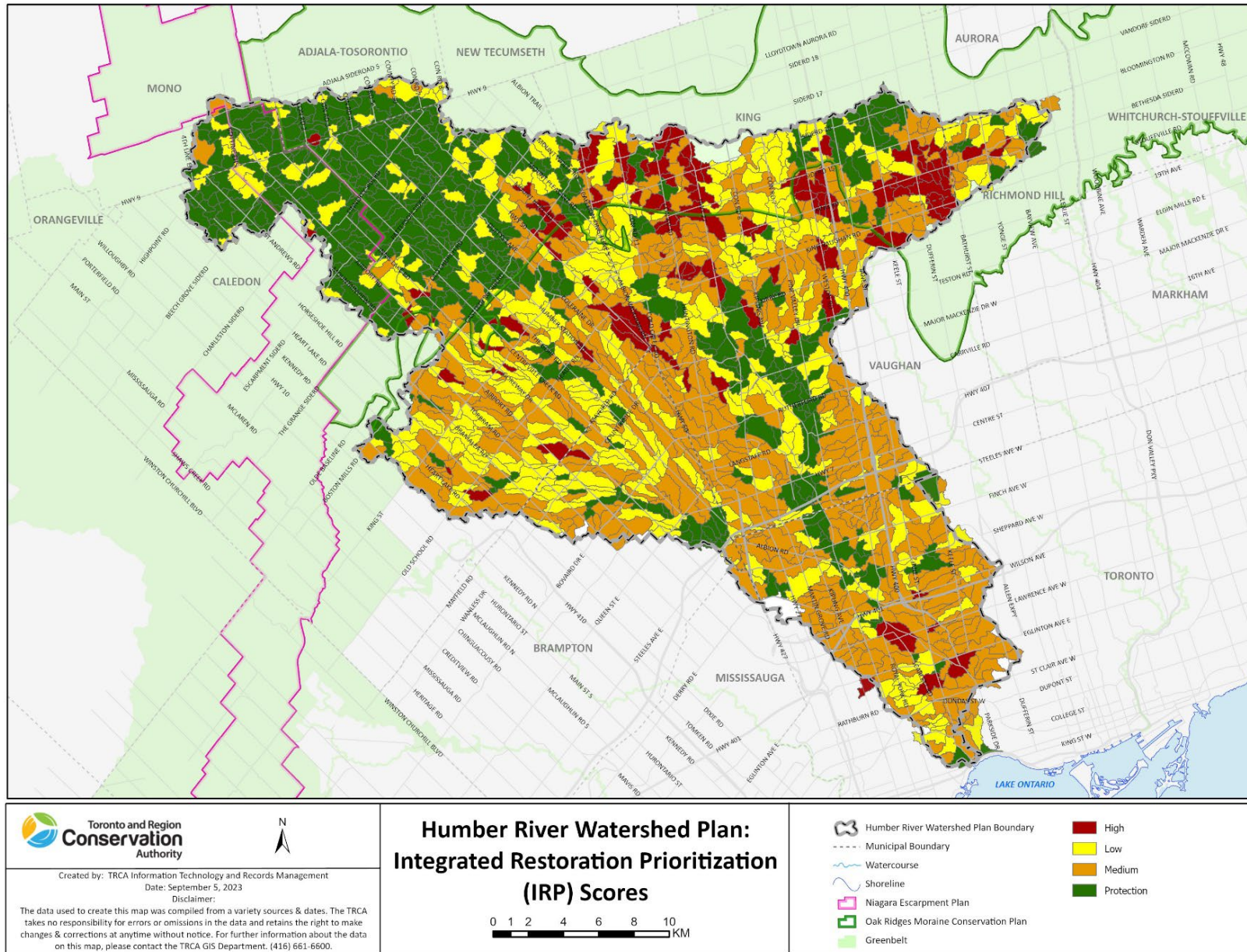
Map 31 - TRCA-Owned or Managed Actively Monitored Erosion Control Structures

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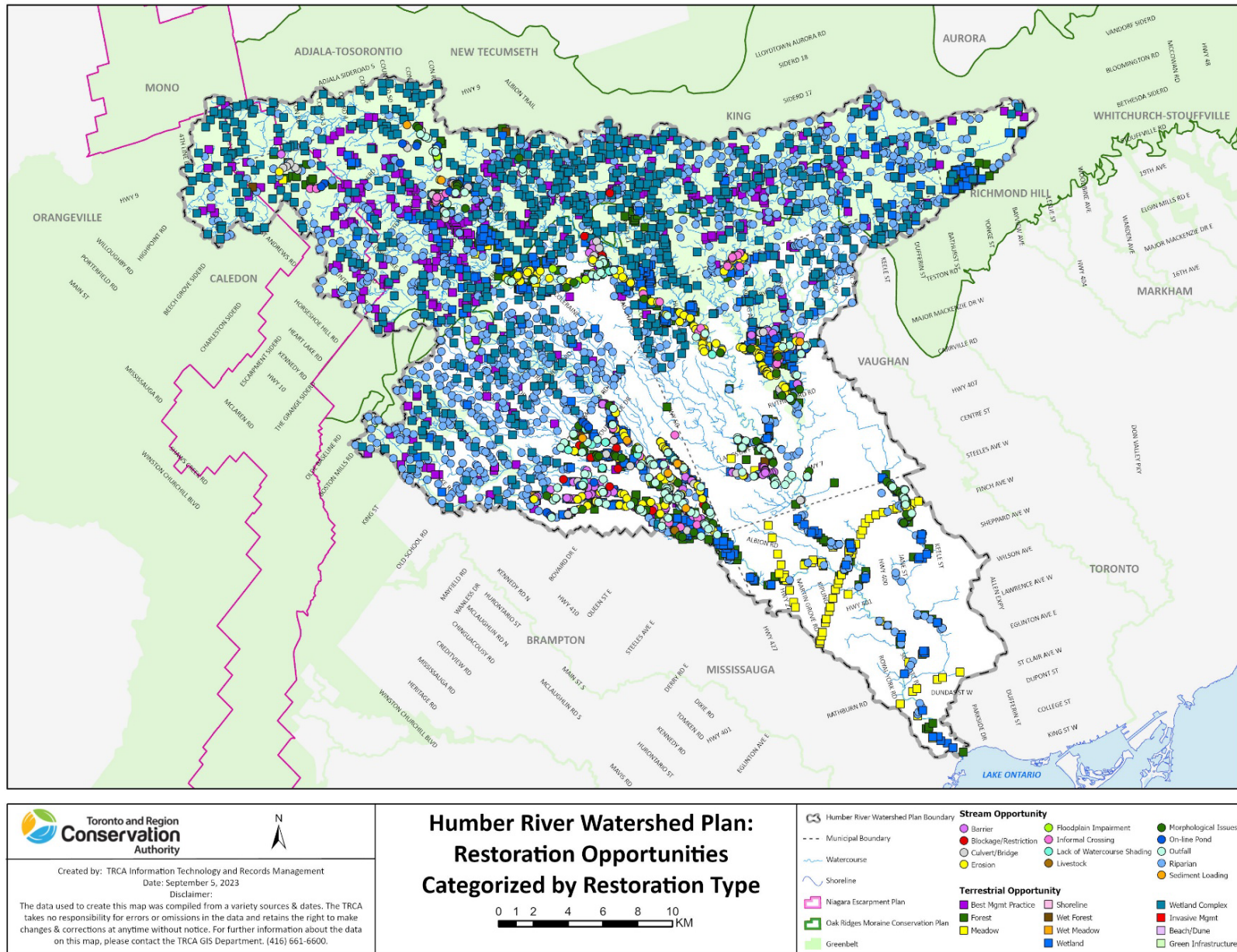
Map 32 - Density of Stormwater Management Ponds within the Humber River Watershed

Humber River Watershed Characterization Report



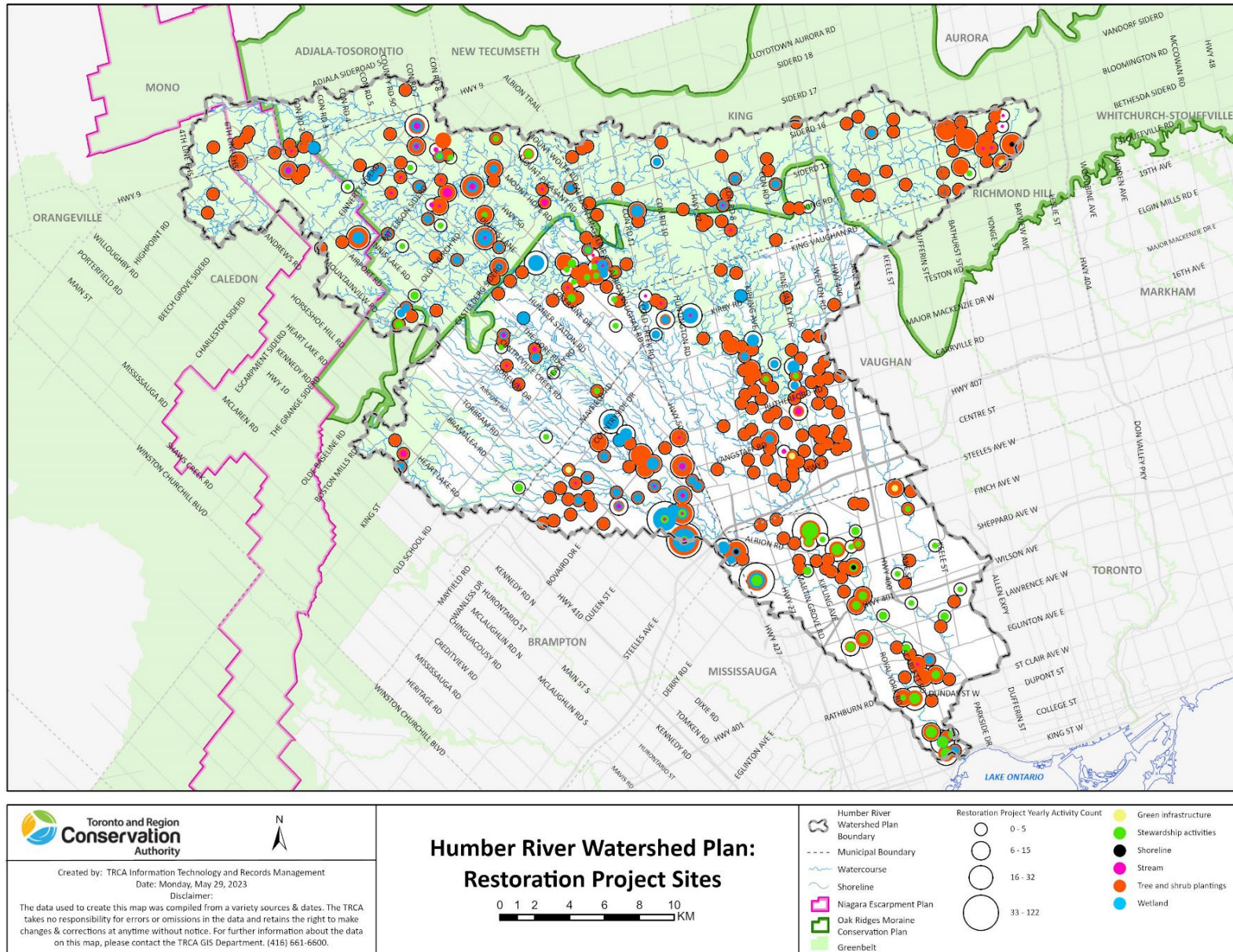
Map 33 - Integrated Restoration Prioritization Scores

Humber River Watershed Characterization Report



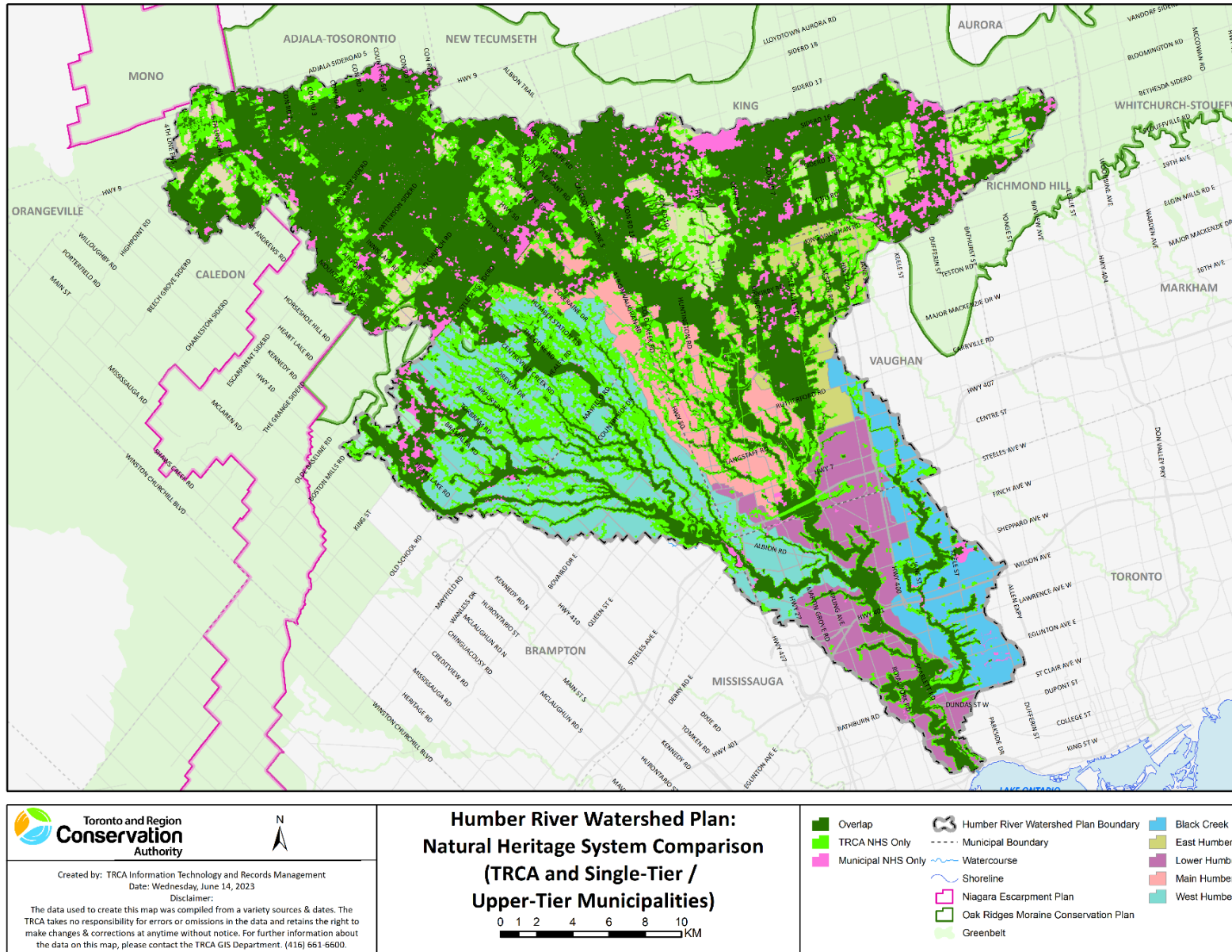
Map 34 - Restoration Opportunities Categorized by Restoration Type

Humber River Watershed Characterization Report

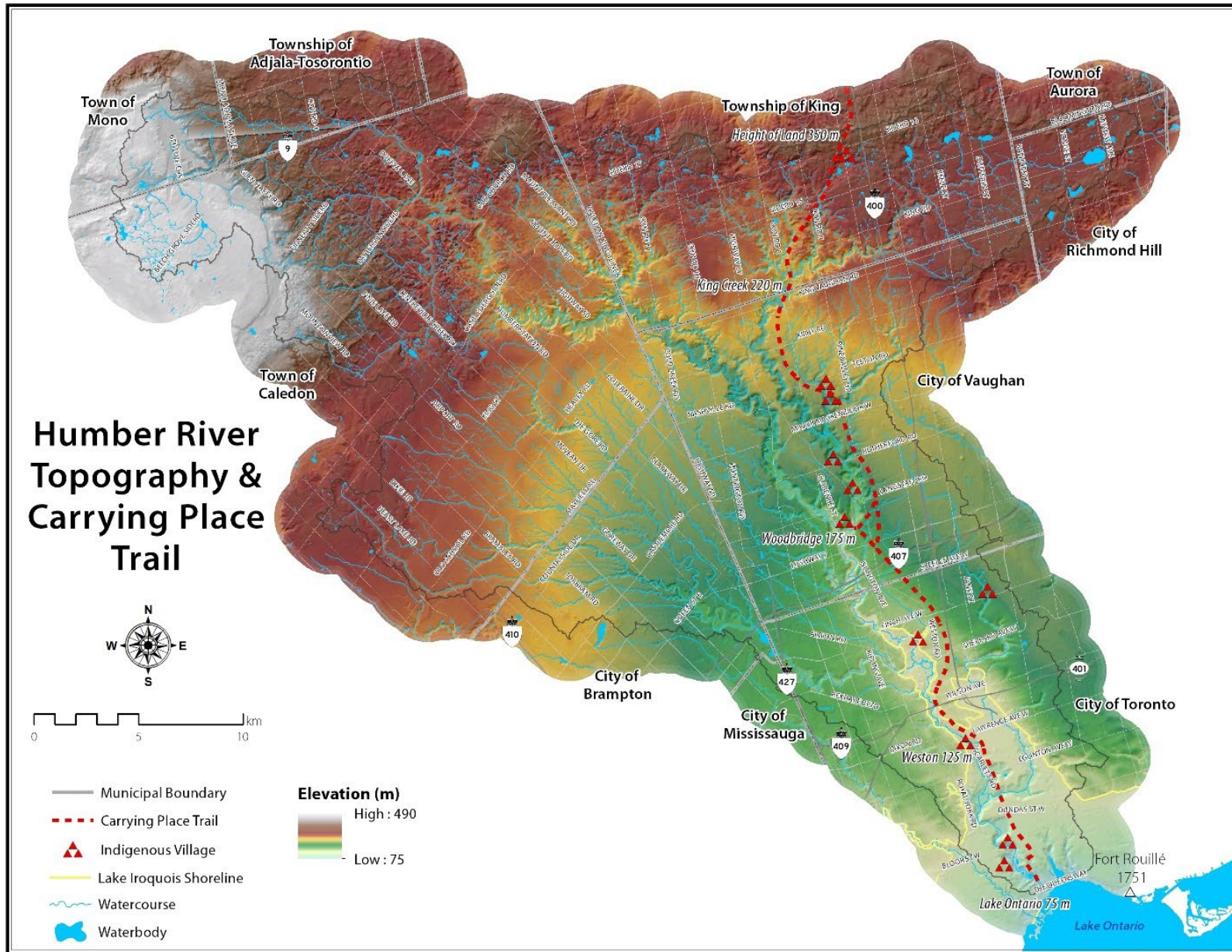


Map 35 - Completed Restoration Project Sites (2002-2021)

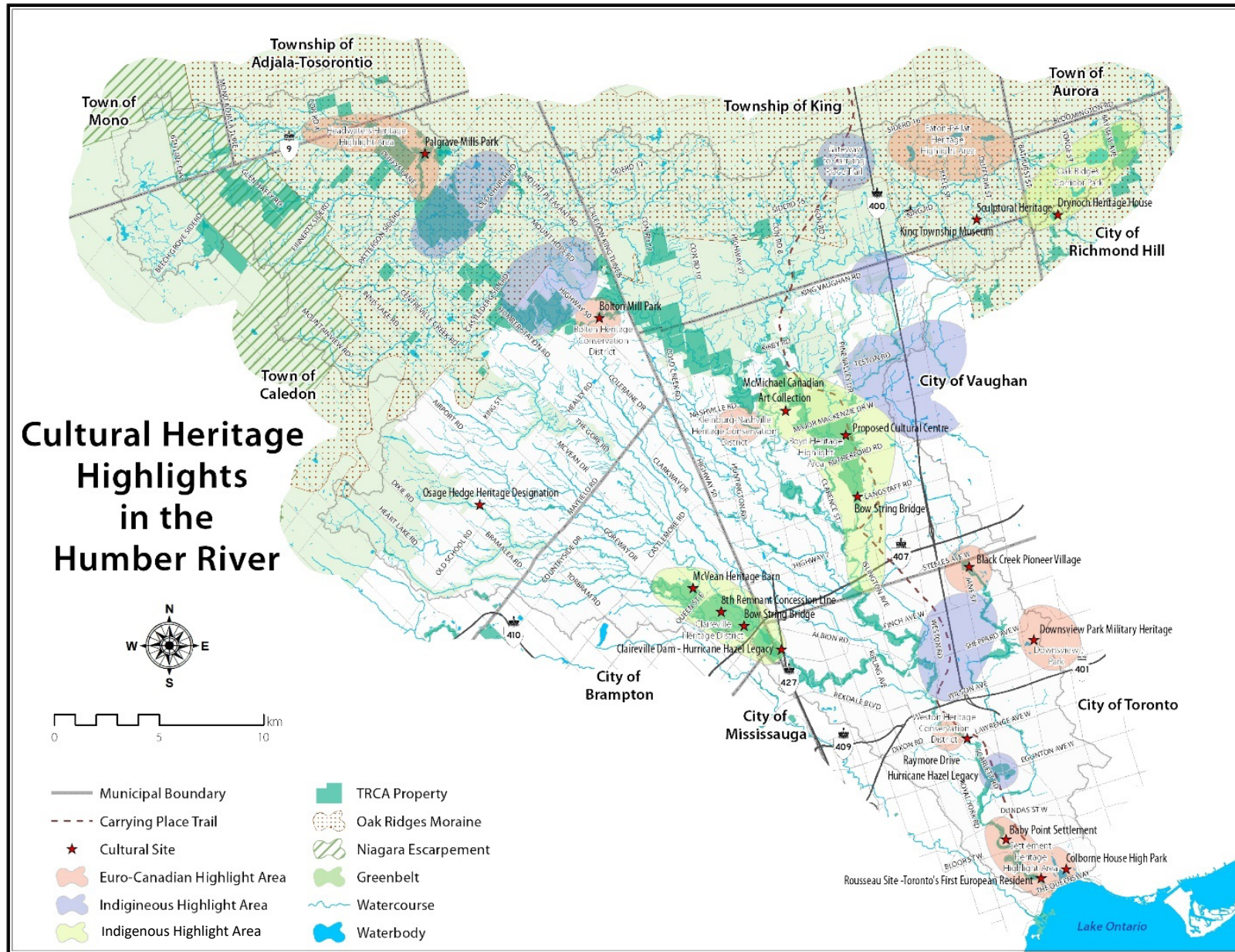
Humber River Watershed Characterization Report



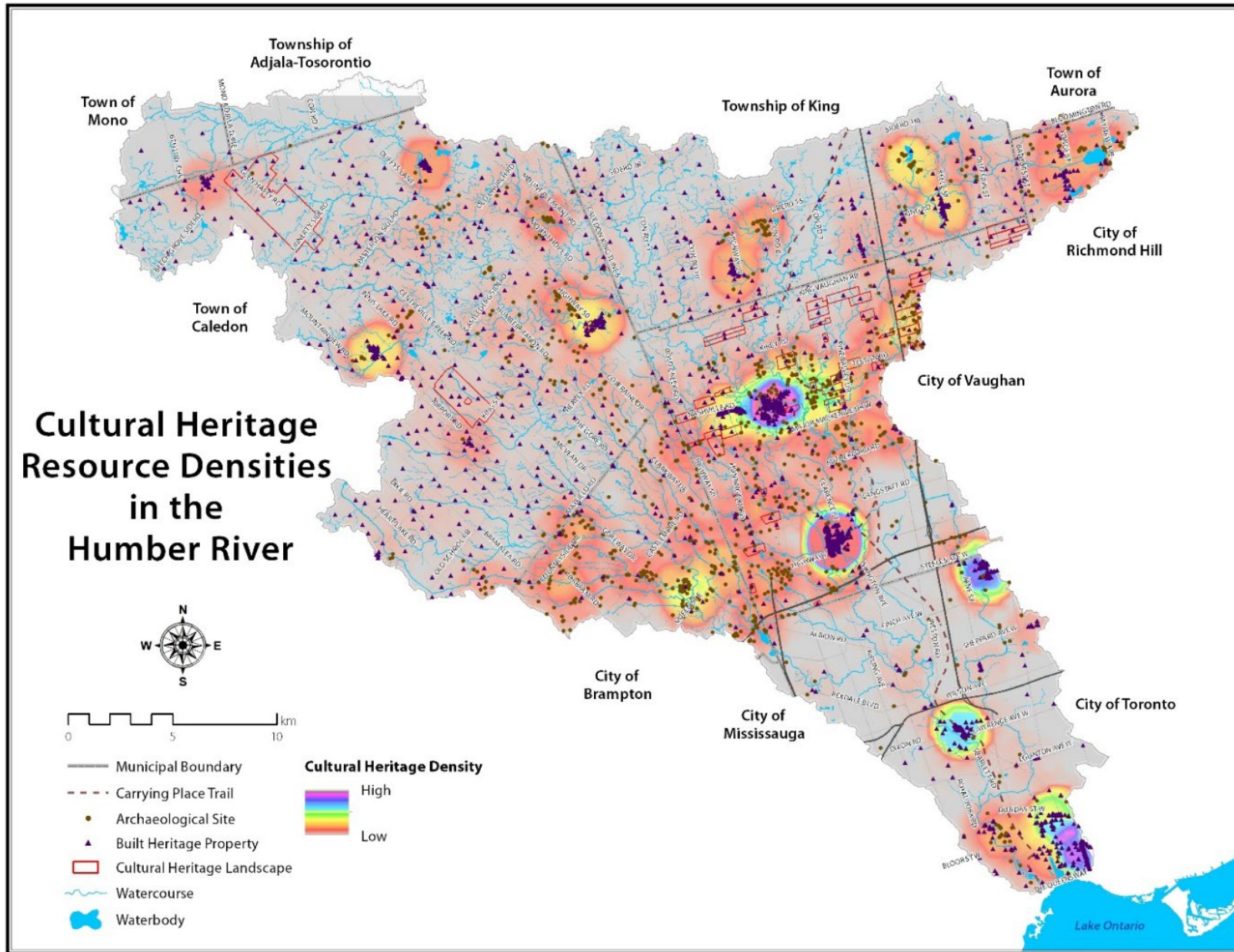
Map 36 - Natural Heritage System Comparison (TRCA and Single-Tier / Upper Tier Municipalities)



Map 37 - Humber River Watershed Topography and Toronto Carrying Place Trail (adapted from Cultural Heritage Rivers System and TRCA 2020)



Map 38 - Cultural Heritage Highlights in the Humber River Watershed (adapted from Cultural Heritage Rivers System and TRCA 2020)



Map 39 - Cultural Heritage Resource Densities in the Humber River Watershed (adapted from Cultural Heritage Rivers System and TRCA 2020)

8.0 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.

Ecologically Significant Groundwater Recharge Areas

Areas where recharge is important to maintaining ecosystem functions of streams and wetlands.

Headwater Drainage Features

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

Highly Vulnerable Aquifers

Aquifers store water underground, supply drinking water in some areas, and provide a clean and constant source of water to streams and some wetlands. Aquifers that are vulnerable to land use threats, such as pesticides and other pollutants, are called **Highly Vulnerable Aquifers (HVAs)**.

Hydrologic Functions

Hydrologic functions are the natural processes that provide the water needed to sustain healthy aquatic and terrestrial ecosystems and drinking water for humans. The functions of the hydrologic cycle 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.

- **Important Hydrologic Functions:** Water is permanent, present throughout the year, either flowing or standing water due to year-round groundwater discharge (e.g., seeps, springs, wetlands, refuge pools, upwelling).
- **Valued Hydrologic Functions:** Water is intermittent, present in the spring due to seasonally high groundwater discharge or contributions from wetlands or other areas that support intermittent flow or water storage. These features are typically still flowing in late spring but are dry or surface-damp by July.
- **Contributing Hydrologic Functions:** Features that provide ephemeral flow or water storage functions for a short time during and after spring freshet and following large rain events only. These features are typically dry or surface-damp by mid-May.
- **Recharge/Limited Hydrologic Functions:** Features that are dry or have standing water. No surface flow occurs; however, a key function may include groundwater recharge.

Intermittent Streams/Watercourses

Small streams that may dry up at certain times of year, such as during the summer.

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.

Permanent Stream/Watercourses

Permanent streams, or perennial streams, flow year-round because of groundwater flow.

Riparian Corridors/Zones

The transition zone between terrestrial and aquatic ecosystems found along riverbanks.

Seepage Areas and Springs

Areas where cold, clean groundwater is bubbling up to the surface, as groundwater discharge. This water is usually high quality and important for certain fish communities.

Significant Groundwater Recharge Areas

Water that seeps into the ground can provide an important source of water (groundwater discharge) to aquifers, streams, and wetlands, and is known as groundwater recharge. Where rates of recharge are relatively high and are connected to drinking water sources, these areas are called **Significant Groundwater Recharge Areas (SGRAs)**.

Significant Surface Water Contribution Area

Areas that contribute to the water volume found instream and are considered to be significant to the overall surface water flow volumes within a watershed.

Urban Forest

The trees and woody shrubs located on all private and public property within a watershed, including urbanized spaces (i.e., along roads) and in forests.

Water Resource System

A system consisting of ground water features and areas and surface water features (including shoreline areas), and their hydrologic functions. Hydrologic functions are the natural processes that provide the water needed to sustain healthy aquatic and terrestrial ecosystems and drinking water for humans. Both water quantity and water quality are important to the WRS. The WRS is comprised of key hydrologic features (lakes, wetlands, permanent/intermittent streams, and seepage areas and springs) and key hydrologic areas (Significant Groundwater Recharge Areas, Ecologically Significant Groundwater Recharge Areas, Highly Vulnerable Aquifers, and Significant Surface Water Contribution Areas).

Wetlands

Areas that are covered by shallow water seasonally or permanently. The four major types of wetlands in Ontario include marshes, swamps, bogs, and fens. By retaining water and releasing it slowly, wetlands provide many benefits to people and nature, such as helping to improve water quality and reducing flooding. Given their transient characteristics between land and water, wetlands are considered components of both the NHS and WRS.

Whitebelt

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

9.0 REFERENCES

The references provided below are separated into the various technical components outlined throughout this report, and include all references used in the preparation of the technical reports (listed in [Section 6.0 Methodology](#)).

Geographic Context

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Water Resource System

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APPENDIX A – LAND USE CLASSIFICATIONS

Below is a full list of land use classifications summarized by urban, rural, and natural general land classifications. Each of these specific land use classifications are assigned an impervious value that is used as part of hydrology modelling/flood risk assessment and other technical disciplines. The impervious values vary by land use classification and are either designated as total imperviousness (TIMP values) or the portion of imperviousness connected to a sewer system (XIMP values) depending on the analysis being undertaken. The summary below only includes the TIMP impervious values for each specific land use classification.

Specific Land Use Classification	TIMP Value (Total Impervious Cover)	General Land Use (Urban, Rural or Natural)
Aggregate extraction	<i>Case specific (one site present in Caledon)</i>	Rural
Agricultural	0%	Rural
Airport	45%	Urban
Beach/bluff	0%	Natural
Cemetery	35%	Rural
Estate Residential	40%	Rural
Forest	0%	Natural
Golf Course	0%	Rural
High Density Residential	80%	Urban
Industrial	95%	Urban
Institutional	80%	Urban
Lacustrine (water)*	100%	Natural
Landfill	<i>Case specific (if present)</i>	Rural
Low/Medium Density Residential	60%	Urban
Meadow	0%	Natural
Commercial/Mixed Commercial Entertainment	95%	Urban
Railway	60%	Urban
Riverine (water)*	100%	Natural
Roads	90%	Urban
Rural Residential	20%	Rural
Successional Forest	0%	Natural
Vacant Lands	<i>Case specific</i>	Where Vacant Land was present it was reclassified into one of the other land use classes as appropriate
Wetlands	0%	Natural
Recreational/Open Space	10%	Rural

* The impervious cover calculation for the hydrology modelling/flood risk assessment assumes that water is 100% impervious in terms of flood risk. For the ecological analyses, water changes to 0% impervious.

APPENDIX B – STREAMFLOW CHARACTERISTICS ANALYSIS RESULTS

Below is a table presenting the results of the streamflow analysis at all eight Humber River watershed flow gauges. Streamflow characteristics are presented for the 30-year time period (historical and current periods) and the 10-year time period (baseline and current periods) including drainage area of each flow gauge and stream flow benchmarks (i.e., average annual discharge, average annual baseflow, 10th percentile, 90th percentile, and 10/90 ratio).

Gauge	Drainage Area (km ²)	Stream Flow Benchmark	Historical 30 yr (1961-1990)	Current 30 yr (1991-2021)	Baseline (2002-2011)	Current (2012-2021)
Black Creek near Weston - 02HC027	58	Average annual discharge (mm/yr)	429	473.1	478.5	489.4
		Average annual baseflow (mm/yr)	182.2	301.7	300.6	312.6
		10th percentile (m ³ /s)	0.202	0.185	0.192	0.192
		90th percentile (m ³ /s)	1.78	1.85	1.91	1.798
		90th to the 10th ratio	8.8	10	9.9	9.4
Humber River at Weston - 02HC003	802	Average annual discharge (mm/yr)	232.96	280.4	301.6	291.4
		Average annual baseflow (mm/yr)	157.6	139.5	146.4	153.9
		10th percentile (m ³ /s)	1.28	1.6	1.71	2.05
		90th percentile (m ³ /s)	11.9	14.4	16.2	13.8
		90th to the 10th ratio	9.296875	9	9.5	6.7
Humber East near Pine Grove - 02HC009	190.9	Average annual discharge (mm/yr)	193	231	244.5	251.13
		Average annual baseflow (mm/yr)	130.35	131.45	137.8	162.7
		10th percentile (m ³ /s)	0.184	0.28	0.28	0.347
		90th percentile (m ³ /s)	2.4	2.84	2.98	3.013
		90th to the 10th ratio	13.0	10.1	10.6	8.7

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Gauge	Drainage Area (km ²)	Stream Flow Benchmark	Historical 30 yr (1961-1990)	Current 30 yr (1991-2021)	Baseline (2002-2011)	Current (2012-2021)
Humber River at Elder Mills - 02HC025	296.3	Average annual discharge (mm/yr)	263	274.6	275.7	290.6
		Average annual baseflow (mm/yr)	169.8	208.84	166.2	197.4
		10th percentile (m ³ /s)	0.94	0.932	0.86	1.15
		90th percentile (m ³ /s)	4.597	4.82	4.85	4.82
		90th to the 10th ratio	4.9	5.2	5.6	4.2
East Humber at King Creek - 02HC032	94.8	Average annual discharge (mm/yr)	196	222.9	222.9	226.2
		Average annual baseflow (mm/yr)	106.7	123.6	121.6	129.1
		10th percentile (m ³ /s)	0.085	0.107	0.096	0.124
		90th percentile (m ³ /s)	1.32	1.49	1.48	1.49
		90th to the 10th ratio	15.5	13.9	15.4	12.0
Cold Creek near Bolton - 02HC023	62.2	Average annual discharge (mm/yr)	243	273.8	278.9	273.8
		Average annual baseflow (mm/yr)	155.8	176.8	172	187.9
		10th percentile (m ³ /s)	0.2	0.236	0.249	0.239
		90th percentile (m ³ /s)	0.762	0.8836	0.9028	0.8547
		90th to the 10th ratio	3.81	3.7	3.6	3.6
Humber near Palgrave - 02HC047	163.5	Average annual discharge (mm/yr)	299	310.6	320.2	312.5
		Average annual baseflow (mm/yr)	204.7	214	217.9	227.4
		10th percentile (m ³ /s)	0.6784	0.7	0.75	0.739
		90th percentile (m ³ /s)	2.766	2.71	2.79	2.66
		90th to the 10th ratio	4.1	3.9	3.72	3.6

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Gauge	Drainage Area (km ²)	Stream Flow Benchmark	Historical 30 yr (1961-1990)	Current 30 yr (1991-2021)	Baseline (2002-2011)	Current (2012-2021)
West Humber at Highway 7 - 02HC031	142.2	Average annual discharge (mm/yr)	226	266.16	281.69	279.47
		Average annual baseflow (mm/yr)	70	88.5	96.4	102
		10th percentile (m ³ /s)	0.02	0.056	0.073	0.117
		90th percentile (m ³ /s)	2.269	2.51	2.677	2.78
		90th to the 10th ratio	113.45	44.8	36.7	23.8

APPENDIX C – URBAN FOREST QUANTITY AND QUALITY

Urban Forest Quantity by Municipality and Land Use Type

By reporting municipal canopy cover percent by land use type, differences in canopy cover within individual land uses are evident (see table below). In Toronto, Vaughan, Richmond Hill, and King, canopy cover percentages within the forested land use class are predictably high (above 80% canopy cover) and other natural areas (meadows, wetlands, and beach/bluff) range from 22% to 29% canopy cover. Residential areas in King have a canopy cover percentage of 30%, coming close to the municipal target of 36%, thereby contributing substantially to the municipal target. In Mono, residential areas have 62% canopy cover, almost as high as forested land. There are still gaps between the existing canopy cover and municipal targets, therefore opportunities to increase residential canopy cover within the watershed should be further explored in Toronto (26%), Vaughan (13%), Richmond Hill (17%), Adjala-Tosorontio (33% ±13.6%), Brampton (13%), and Caledon (27%).

Canopy Cover Percent by Municipality and Land Use Type*

	Adjala-Tosorontio		Aurora		Caledon		Brampton		King		Mississauga		Mono		Richmond Hill		Toronto		Vaughan	
Municipal Target	n/a		n/a		n/a		n/a		36-41%		15-25%		n/a		30%		40%		20-25%	
	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err	%	Std Err
Overall canopy cover	48.10	3.97	25.00	15.31	34.59	0.95	22.33	2.03	33.70	1.42	20.00	12.65	47.90	4.58	26.71	3.66	22.18	1.27	22.23	1.14
Agriculture & Aggregate Extraction	8.16	3.91	N/A	N/A	4.18	0.62	N/A	N/A	6.02	1.14	N/A	N/A	14.29	6.61	N/A	N/A	N/A	N/A	3.70	1.01
Residential	33.33	13.61	0.00	0.00	26.80	2.80	12.50	2.55	29.58	3.83	22.22	13.86	61.54	13.49	16.67	5.75	26.36	2.30	12.98	2.33
Forest & Successional Forest	90.48	3.70	100.00	0.00	91.23	1.09	94.74	2.96	95.26	1.34	N/A	N/A	77.78	6.20	82.14	7.24	89.86	3.63	89.30	2.11
Industrial & Commercial	0.00	0.00	N/A	N/A	5.97	2.89	2.86	2.82	0.00	0.00	N/A	N/A	N/A	N/A	0.00	0.00	5.00	1.41	5.23	1.70
Meadow, Wetland, Lacustrine, Riverine & Beach/Bluff	36.67	8.80	0.00	0.00	33.62	2.51	22.58	5.31	26.89	3.05	N/A	N/A	32.14	8.83	22.22	6.93	28.85	6.28	22.70	3.08
Railway	N/A	N/A	N/A	N/A	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00
Institutional, Open	0.00	0.00	100.00	0.00	15.63	4.54	4.35	4.25	10.34	5.66	NA	NA	50.00	35.36	5.88	5.71	18.83	3.15	11.50	3.00

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Space & Other																				
Roads	0.00	0.00	0.00	0.00	9.26	3.94	3.95	2.23	6.67	4.55	0.00	0.00	0.00	0.00	0.00	0.00	11.93	2.44	1.18	1.17

*Colours: **Green** - land use type meets the city-wide target; **Orange** - land use type does not meet city-wide target; **Blue** - land use type is within 5% of target; White - no target is set, or it might not be appropriate to aim to meet target within land use type; **Grey** - not applicable for municipality or data is inconclusive due to low sample size and large standard error.

Urban Forest Quality

The table below presents the urban forest quality data for municipalities in the Humber River watershed (sourced from municipal urban forest study technical reports).

Municipality	Percent of Municipality Area Overlapping with Watershed Boundary	Baseline: Size, Species, Condition	Current: Size, Species, Condition
Caledon East and Bolton	46%	<ul style="list-style-type: none"> Approximately 75% and 80% of all trees in Caledon East and Bolton, respectively, were less than 15.3 cm diameter at breast height (DBH) Top 3 species in Caledon East (eastern white cedar, <i>Thuja occidentalis</i>, 19%; sugar maple, <i>Acer saccharum</i>, 12%; Scots pine, <i>Pinus sylvestris</i>, 9%) and Bolton (black walnut, <i>Juglans nigra</i>, 15%; white ash, <i>Fraxinus americana</i>, 15%; Norway maple, <i>Acer platanoides</i>, 7%) made up 40% of the leaf area 70% of trees in Caledon East were in excellent or good condition; in Bolton 82% of trees were in excellent or good condition 	No current data available
Brampton	27%	<ul style="list-style-type: none"> 81% were less than 15.3 cm DBH Top 3 species made up 25% of the leaf area (white spruce, <i>Picea glauca</i> 9%; European 	No current data available

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Municipality	Percent of Municipality Area Overlapping with Watershed Boundary	Baseline: Size, Species, Condition	Current: Size, Species, Condition
		<p>buckthorn, <i>Rhamnus cathartica</i>, 8%; white ash, 8%)</p> <ul style="list-style-type: none"> • Top 3 species made up 48% of the population (European buckthorn, 30%; hawthorn species, <i>Crataegus spp.</i>, 12%; eastern white cedar, 6%) • 47% of trees were in excellent or good condition 	
Mississauga	0.5%	Area of Mississauga that falls in Humber is small, so data was not considered	
Toronto	21%	<ul style="list-style-type: none"> • 68% were less than 15.3 cm DBH • Top 3 species made up 32.0% of the leaf area (Norway maple, 14.9%; sugar maple, 11.6%; Manitoba maple, <i>Acer negundo</i>, 5.5%) • Top 3 species made up 32.3% of the tree population (eastern white cedar, 15.6%; sugar maple, 10.2%; Norway maple 6.5%) • 81.6% of trees were in excellent or good condition 	<p><i>More small trees reported in 2018 compared with 2008:</i></p> <ul style="list-style-type: none"> • 73% are less than 15.3 cm DBH <p><i>Norway maple is still the most abundant species by leaf area</i></p> <ul style="list-style-type: none"> • Top 3 species make up 31.9% of the leaf area (Norway maple, 16.7%; silver maple, <i>Acer saccharinum</i>, 7.7%; sugar maple, 7.5%) <p><i>Top 3 species remained the same as 2008 and remained at relatively same proportion of population</i></p> <ul style="list-style-type: none"> • Top 5 species make up 32.9% of the tree population (eastern white cedar, 19.2%; sugar maple, 7.9%; Norway maple, 5.8%) <p><i>Average tree condition across the urban forest has declined</i></p> <ul style="list-style-type: none"> • 70% of trees are in excellent or good condition
Vaughan	19%	<ul style="list-style-type: none"> • 71% of trees were less than 15.3 cm DBH 	<p><i>Less small trees reported in 2023 compared with 2012 because the minimum threshold for measuring a tree</i></p>

Humber River Watershed Characterization Report

Municipality	Percent of Municipality Area Overlapping with Watershed Boundary	Baseline: Size, Species, Condition	Current: Size, Species, Condition
		<ul style="list-style-type: none"> Top 3 species made up 37% of the leaf area (sugar maple, 20%; eastern hemlock, <i>Tsuga canadensis</i>, 9%; white pine, <i>Pinus strobus</i>, 8%) Top 3 species made up 36% of the population (sugar maple, 20%; eastern white cedar, 10%; white ash, 6%) 87% of trees were in excellent or good condition 	<p><i>in forested plots was increased from 2.5 cm in 2012 to 5 cm in 2023.</i></p> <ul style="list-style-type: none"> 56% of trees are less than 15.3 cm DBH <p><i>Same species have the most leaf area in 2023 as 2012, but comprise a greater proportion of total leaf area than the previous assessment</i></p> <ul style="list-style-type: none"> Top 3 species make up 48% of the leaf area (sugar maple, 30%; white pine, 10%; eastern hemlock, 8%) <p><i>Eastern white cedar has increased in population size compared to 2012, sugar maple is still most abundant species but makes up a smaller proportion of the population</i></p> <ul style="list-style-type: none"> Top 3 species make up 37% of the tree population (sugar maple, 16%; eastern white cedar 14%; eastern white pine, 7%) <p><i>Less trees were in excellent or good condition in 2023 compared to 2012</i></p> <ul style="list-style-type: none"> 81% of trees were in excellent or good condition
Richmond Hill	19%	<ul style="list-style-type: none"> 71% were less than 15.3 cm DBH Top 3 species made up 30% of the leaf area (sugar maple, 13%; European buckthorn, 9%; white ash, 8%) Top 3 species made up 43% of the population (European buckthorn, 18%; eastern white cedar, 13%; white ash, 12%) 	<p><i>Same proportion of small trees reported in 2022 as 2012</i></p> <ul style="list-style-type: none"> 71% were less than 15.3 cm DBH <p><i>Top 3 species comprise smaller proportion of leaf area and population in 2022 compared to 2012</i></p> <p><i>Sugar maple is still the dominant species by leaf area</i></p>

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Municipality	Percent of Municipality Area Overlapping with Watershed Boundary	Baseline: Size, Species, Condition	Current: Size, Species, Condition
		<ul style="list-style-type: none"> 64% of trees are in excellent or good condition 	<ul style="list-style-type: none"> Top 3 species make up 22% of the leaf area (sugar maple, 8.0%; Manitoba maple, <i>Acer negundo</i>, 7.4%; eastern white cedar, 7.2%) <p><i>Eastern white cedar has increased in population size compared to 2012, European buckthorn is still in top 3 but makes up a smaller proportion of the population</i></p> <ul style="list-style-type: none"> Top 3 species make up 39% of the tree population (eastern white cedar, 16.6%; European buckthorn, 14.4%; and eastern white pine, 8.4%) <p><i>More trees are in good/excellent condition in 2022 than 2012</i></p> <ul style="list-style-type: none"> 75% of trees are in excellent or good condition
Aurora	2%	Area of Aurora that falls in Humber is small, so data was not considered	
King	44%	<ul style="list-style-type: none"> 50% were less than 15.3 cm DBH Top 3 species made up 48% of the leaf area (sugar maple, 21%; eastern white cedar, 14%; white spruce, 13%) Top 3 species made up 45% of the population (eastern white cedar, 18%; sugar maple, 14%; green ash, 13%) Condition data only by land use 	<p><i>There are a greater number of small diameter trees in 2023 than 2012</i></p> <ul style="list-style-type: none"> 61% are less than 15.3 cm DBH <p><i>Sugar maple has remained the dominant species for leaf area, and the percent leaf area has increased since 2012</i></p> <ul style="list-style-type: none"> Top 3 species make up 45% of the leaf area (sugar maple, 29%; American basswood, <i>Tilia americana</i>, 8%; white spruce, 8%) <p><i>Most abundant species are similar between 2012 and 2023</i></p>

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Municipality	Percent of Municipality Area Overlapping with Watershed Boundary	Baseline: Size, Species, Condition		Current: Size, Species, Condition	
				<ul style="list-style-type: none">• Top 3 species make up 31% of the tree population (sugar maple, 13%; eastern white cedar, 10%; white ash, 8%)• 60% of trees are in excellent or good condition	
Tecumseth		Area of Tecumseth that falls in Humber is small, so data was not considered			
Adjala-Tosorontio	5%	No data available		No data available	
Mono	6%	No data available		No data available	

APPENDIX D – ADDITIONAL CLIMATE INFORMATION

Historical Climate Trends

The table below presents a summary of all 49 climate variables (including the 10th percentile, mean, and 90th percentile for each period) that were analyzed to characterize historical climate conditions and trends across the watershed for two 30-year periods: 1961-1990 and 1981-2010. The climate data was averaged across data from seven ECCC climate stations located within or near the watershed.

Climate Parameter	Variable Name	1961-1990			1981-2010			Trend
		10 th	Mean	90 th	10 th	Mean	90 th	
Mean Temperature (°C)	Annual	6.3	7.0	7.8	6.7	7.7	8.8	↑
	Winter	-7.5	-5.9	-4.4	-6.3	-4.7	-2.3	↑
	Spring	4.2	5.6	7.2	4.6	6.3	8.2	↑
	Summer	18.1	19.1	20.2	18.1	19.7	20.9	↑
	Fall	7.7	8.9	10.1	8.0	9.3	10.7	↑
Maximum Temperature (°C)	Annual	11.1	11.8	12.6	11.3	12.4	13.6	↑
	Winter	-3.6	-1.9	-0.5	-2.3	-0.9	1.3	↑
	Spring	9.2	10.7	12.5	9.5	11.4	13.4	↑
	Summer	23.8	24.8	26.0	23.5	25.2	26.6	↕
	Fall	11.9	13.4	14.8	12.3	13.7	15.3	↑
Minimum Temperature (°C)	Annual	1.4	2.2	3.0	2.0	3.0	4.2	↑
	Winter	-11.5	-9.8	-8.2	-10.3	-8.5	-5.8	↑
	Spring	-0.9	0.5	2.1	-0.4	1.2	3.1	↑
	Summer	12.3	13.3	14.3	12.6	14.1	15.4	↑
	Fall	3.3	4.4	5.7	3.7	4.8	6.0	↑
Extreme Heat (days/year)	Days Above 35°C	0.0	0.3	0.3	0.0	0.4	0.9	↑
	Days Above 30°C	3.3	9.4	16.6	1.9	11.1	23.7	↕
	Days Above 25°C	42.1	53.3	64.5	39.5	57.0	76.2	↕
	Days Above 20°C (Tropical Nights)	1.0	4.3	8.5	1.5	6.5	12.9	↑
	Heatwave Frequency	0.4	2.6	4.2	0.0	2.5	4.3	↕
Extreme Cold (days/year)	Days Below -20°C	2.8	7.7	12.9	1.1	5.5	11.3	↓
	Days Below -10°C	37.1	48.6	60.6	22.6	40.6	54.0	↓
	Days Below 0°C (freezing days)	136.0	146.8	159.4	121.9	137.4	150.4	↓

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Climate Parameter	Variable Name	1961-1990			1981-2010			Trend
		10 th	Mean	90 th	10 th	Mean	90 th	
Heating and Cooling Degree Days (days/year)	Heating Degree Days	281.1	292.7	304.3	263.1	282.7	300.5	↓
	Cooling Degree Days	59.2	69.7	80.1	59.3	75.5	94.6	↑
Total Precipitation (mm)	Annual	694.9	807.7	937.9	701.2	834.2	986.8	↑
	Winter	123.7	170.6	221.3	121.9	168.7	214.5	↓
	Spring	132.1	191.5	258.9	138.7	199.2	265.3	↑
	Summer	155.6	230.6	315.0	164.7	238.2	328.6	↑
	Fall	134.1	215.2	293.1	156.5	228.1	301.8	↑
Extreme Precipitation	Max Precipitation in 1 day (mm)	30.8	44.5	62.6	30.1	44.7	63.1	↑
	Max Precipitation in 3 days (mm)	41.9	59.0	81.0	42.9	58.6	77.6	↕
	Simple Daily Intensity Index (SDII) (mm/day)	5.4	6.2	7.0	5.2	6.3	7.2	↕
	95 th Percentile Precipitation (mm)	17.4	20.8	24.5	16.8	21.2	25.7	↕
	99 th Percentile Precipitation (mm)	25.2	33.7	42.6	24.9	34.0	44.5	↕
	Max Consecutive Wet Days (days/year)	4.7	6.4	8.2	5.0	6.7	8.3	↑
Dry Days (days/year)	Total Annual	213.1	228.9	245.9	199.2	220.4	239.4	↓
	Max Consecutive Dry Days	11.3	15.2	20.6	10.1	14.5	20.8	↕
Growing Season	Growing Season Start Date (day of year)	Apr. 19	May 04	May 18	Apr. 11	Apr. 29	May 17	↑
	Growing Season End Date (day of year)	Oct. 03	Oct. 20	Nov. 05	Oct. 08	Oct. 22	Nov. 06	↑
	Growing Season Length (days/year)	146.7	169.5	189.3	152.5	175.9	198.6	↑

Climate Parameter	Variable Name	1961-1990			1981-2010			Trend
		10 th	Mean	90 th	10 th	Mean	90 th	
Agricultural Variables	Corn Heat Units	3441.9	3686.0	3945.2	3543.3	3837.0	4219.2	↑
	Growing Degree Days (Base 0°C)	3037.0	3229.6	3426.1	3115.5	3355.7	3658.0	↑
	Canola Growing Degree Days (Base 4°C)	2131.2	2282.8	2444.6	2177.5	2382.0	2658.6	↑
	Forage Crops Growing Degree Days (Base 5°C)	1932.4	2072.0	2226.5	1970.1	2166.0	2431.8	↑
	Corn and Bean Growing Degree Days (Base 10°C)	1059.2	1162.4	1286.4	1072.3	1236.8	1452.9	↑
	Growing Degree Days - Risk of Presence of Pests (Base 15°C)	410.4	495.1	597.3	415.6	550.0	707.2	↑
Freeze-Thaw and Freezing Rain Potential	Freeze-Thaw Cycles (cycles per year)	55.5	69.7	82.6	56.7	68.7	81.3	↕
	Freezing Rain Potential (days per year)	1.4	3.9	7.1	1.5	3.8	6.7	↕

N.B. The following criteria were used to assign an increasing, decreasing, or variable trend between the two historical periods:

- If there is a consistent increase across the 10th, mean, and 90th percentile, then the trend is increasing (↑).
- If there is a consistent decrease across the 10th, mean, and 90th percentile, then the trend is decreasing (↓).
- If there is a mix of increases/decreases across the 10th, mean, and 90th percentile, then the trend is variable (↕).

Climate-Related Impacts in the Humber River Watershed

Through the stories shared by respondents to the HRWP Public Engagement Survey (active from September 19, 2022 to October 31, 2022), more specific environmental, social, and economic consequences were also highlighted and are summarized in the table below. Specific events such as Hurricane Hazel, the July 2013 storm, past ice jams, and drier than normal conditions in 2022 were top of mind for many respondents.

Climate or Weather-Related Impact	Consequences Highlighted by Survey Respondents
Drier conditions	<ul style="list-style-type: none"> • Loss of habitat for waterbirds, aquatic species, difficulty for spawning fish.
Drier conditions, more invasive species	<ul style="list-style-type: none"> • Impacted entire ecosystem as well as human enjoyment of the river. • Environmental degradation and drought, lack of water for animals and birds.
Drier conditions, more invasive species, flooding	<ul style="list-style-type: none"> • Less animal life and more discolouration and garbage in creek.
Drier conditions, wind storms	<ul style="list-style-type: none"> • Drop in water levels, loss of wildlife breeding areas, spring erosion of banks, change in river course.
Flooding	<ul style="list-style-type: none"> • Damage to residential properties. • Ice jams and related flooding north of Old Mill Bridge. Restricting pedestrian and bicycle access. Ice jam damaging physical infrastructure (lighting, benches) and many trees for several months most years. • Minor basement damage. • Repeated flooded basements and failure to be insured to cover damage. • Gentrification as only the affluent could afford repairs. • Environmental impacts. • Loss of a 100-year-old willow tree due to the July 2013 storm. • Buildup of ice over local springs channels water from roads flooding into homes.
Flooding, ice storms	<ul style="list-style-type: none"> • Environmental impacts. • Destruction of the natural landscape, especially the trees and park infrastructure.
Flooding, more invasive species	<ul style="list-style-type: none"> • Because the water was very high Black Creek could not empty into it very well. This backed up the water in Black Creek and contributed to flooding in Smythe Park up to Weston Road. Many trees were lost as well as animals. The stormwater ponds have never been cleaned from these toxic floods and the wildlife population in Smythe has greatly diminished. The frog population is down to about 4 from a few hundred. • Repeated flooding of park lands due to rain storms or snow storms, damage to trees and other flora, deposit of gravel/rocks/concrete slabs in river bed that impede water flow. Also invasive Cormorants have arrived in area. • Urbanization over decades creates greater runoff into the river which creates flooding events. The flooding of July 8, 2013 can be one example due to the large flooding that swamped cars and caused shoreline erosion at the indicated position. However, any rain event will create shoreline erosion at many points as more water is directed into the river

	<p>rather than taken into the ground to slowly filter to the river over a greater timeframe. Shoreline erosion means invasive species of plants such as Phragmites or Japanese Knotweed are eroded from one location and transported down the river to implant into another section of the river. Another story with the above location is the City of Toronto allowing Clearway Construction to set up a work camp on the flood plain. The ice floes of the Winter of 2021-2022 then took much of their construction material into the river. They currently have portable toilets and fuel stored on site waiting for the 2022-2023 ice floes to take them into the river.</p>
More invasive species	<ul style="list-style-type: none"> • Loss in biodiversity and ecosystem integrity.
More precipitation	<ul style="list-style-type: none"> • Power outages, fallen trees, flooding.
More precipitation, flooding	<ul style="list-style-type: none"> • Environmental impacts. • Hurricane Hazel led to the formation of conservation areas throughout Ontario. • Destruction of property due to Hurricane Hazel and the July 2013 storm.
More precipitation, flooding, extreme heat	<ul style="list-style-type: none"> • Socioeconomic impacts. • Some bad, some good. • Following the Hurricane Hazel impacts on the Humber River and watershed the TRCA was set up in Ontario. • Property damage from flooding, loss of habitat – Chimney Crayfish, fish in stream. • Flooding and ice jams, damage of surrounding recreational area, loss of animal habitats. • The neighbourhood that this particular habitat of the Humber River is within is one with a high proportion of marginalized populations. Restoration of this space is a big part of revitalizing access to green spaces, good food, and cultural expression within the community. The advance of European Buckthorn, Dog-Strangling Vine, and wild grapes has seen much of this riparian habitat and surrounding forest get pulled down and have its entire undergrowth outcompeted by these non-native species. The usage of this space has also decreased substantially due to the loss of habitat and flooding events as well. • No ice or water any more in the spring like there used to be.
Warmer temperatures, more invasive species	<ul style="list-style-type: none"> • Environmental impacts.
Various (e.g., warmer temperatures, drier conditions, flooding, extreme heat, more invasive species, wind	<ul style="list-style-type: none"> • Overall drop in biodiversity and less enriching experiences in nature. • We have wrecked the planet and we need to adjust our actions. I have rescued boats/paddle boarders from the river as flood waters capsized them. I have seen yachts washed out of the river with flooding. We pull all kinds of trash from the river and it needs to stop.

storms, ice storms, snow storms)

- Changes in land use, erosion, loss of habitat, invasive species proliferation, but also beneficially the retention of ravines and green space, even though degraded ravines.
- Damaged trees that are very old, flooding, invasion of pests such as caterpillars and beetles, erosion and flooding. This has caused an economic impact as clean-up is costly and exterminators and tree and shrub treatments or removal on our properties are costly and retaining walls on natural slopes put up by municipalities cost the taxpayers millions of dollars. Furthermore, there is an effect environmentally as greenspace is diminished.

Municipal Climate Emergency Declarations, and Actions Plans/Strategies

The table below provides detailed information regarding municipal climate emergency declarations and comprehensive climate change action plans/strategies for the municipalities that lie within the Humber River watershed.

Municipality	Climate Emergency Declaration	Comprehensive Climate Change Action Plans/Strategies	
		Mitigation	Adaptation
City of Toronto	Oct 2, 2019	TransformTO Net Zero Strategy (2021)	Toronto's Resilience Strategy (2019)
Peel Region	Oct 24, 2019	Peel Climate Change Master Plan (2019)	
City of Mississauga	Jun 19, 2019	Mississauga Climate Change Action Plan (2019)	
City of Brampton	Jun 5, 2019	Brampton's Community Energy and Emissions Reduction Plan: Our 2040 Energy Transition (2019)	Brampton's Climate Change Adaptation Plan (<i>underway</i> ¹)
Town of Caledon	Jan 28, 2020	Resilient Caledon: Community Climate Change Action Plan (2021)	
York Region	-	York Region Climate Change Action Plan (2022)	
		York Region Community Energy and Emissions Plan (<i>underway</i> ²)	-
City of Vaughan	Jun 4, 2019	Vaughan Municipal Energy Plan: Plug into a Smart Energy Future (2016)	- ³
City of Richmond Hill	-	Richmond Hill's Climate Change Framework (2020)	
		Richmond Hill's Path to a Low-Carbon Future (or Community Energy and Emissions Plan; 2021)	-
Township of King	Jul 8, 2019	King Climate Action Plan (<i>draft</i>)	
Township of Aurora	Oct 22, 2019	Town of Aurora Community Energy Plan (2021)	Town of Aurora Climate Adaptation Plan (2022)

Municipality	Climate Emergency Declaration	Comprehensive Climate Change Action Plans/Strategies	
		Mitigation	Adaptation
Dufferin County	-	Dufferin Climate Action Plan (2021)	
		Dufferin Corporate Climate Action Plan (<i>underway</i>)	
Town of Mono	-	Mono Community Climate Action Plan (2022)	
Simcoe County	-	-	⁴
Township of Adjala-Tosorontio	-	-	⁵

Note: Municipal corporate energy conservation and demand management plans were excluded as these are mandated under the [Ontario Government's Electricity Act Regulation 507/18](#); Sector-specific plans and strategies were also excluded (e.g. transportation, food/agriculture, health, etc.)

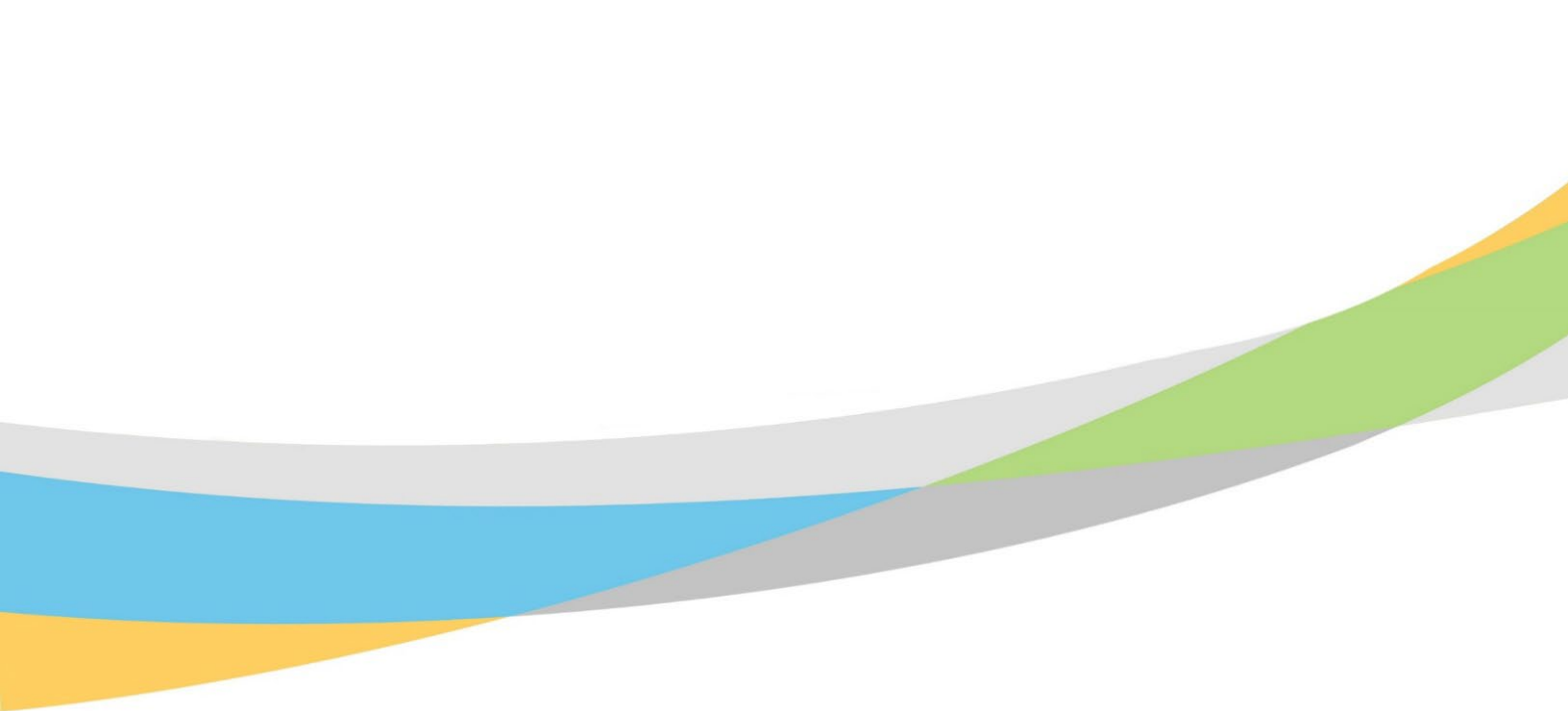
¹ For more information, see [here](#).

² This plan is referenced in York Region's Climate Change Action Plan (2022).

³ A Climate Change Adaptation and Resilience Framework Background Paper (2022) has been developed as part of the City of Vaughan's Municipal Comprehensive Review to provide focused subject matter reviews and high-level policy recommendations.

⁴ A Draft Climate Change Strategy (2021) has been developed as part of Simcoe County's Municipal Comprehensive Review to identify provincial policy requirements for climate-related land use planning policies in Ontario and Simcoe County.

⁵ A Climate Change Policy Paper (2017) has been developed as part of the Town of Adjala-Tosorontio's Municipal Comprehensive Review to outline the provincial and upper-tier policy requirements which must be addressed, as well as optional policy directions and initiatives.



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