

An aerial photograph of a small, forested island in a body of water. The island features a small, light-colored building with a dark roof, a circular clearing, and a small structure. The surrounding water is a deep blue-green, and the forest is dense with various shades of green. The text is overlaid on the top left of the image.

Integrating Climate Change into Watershed Plans

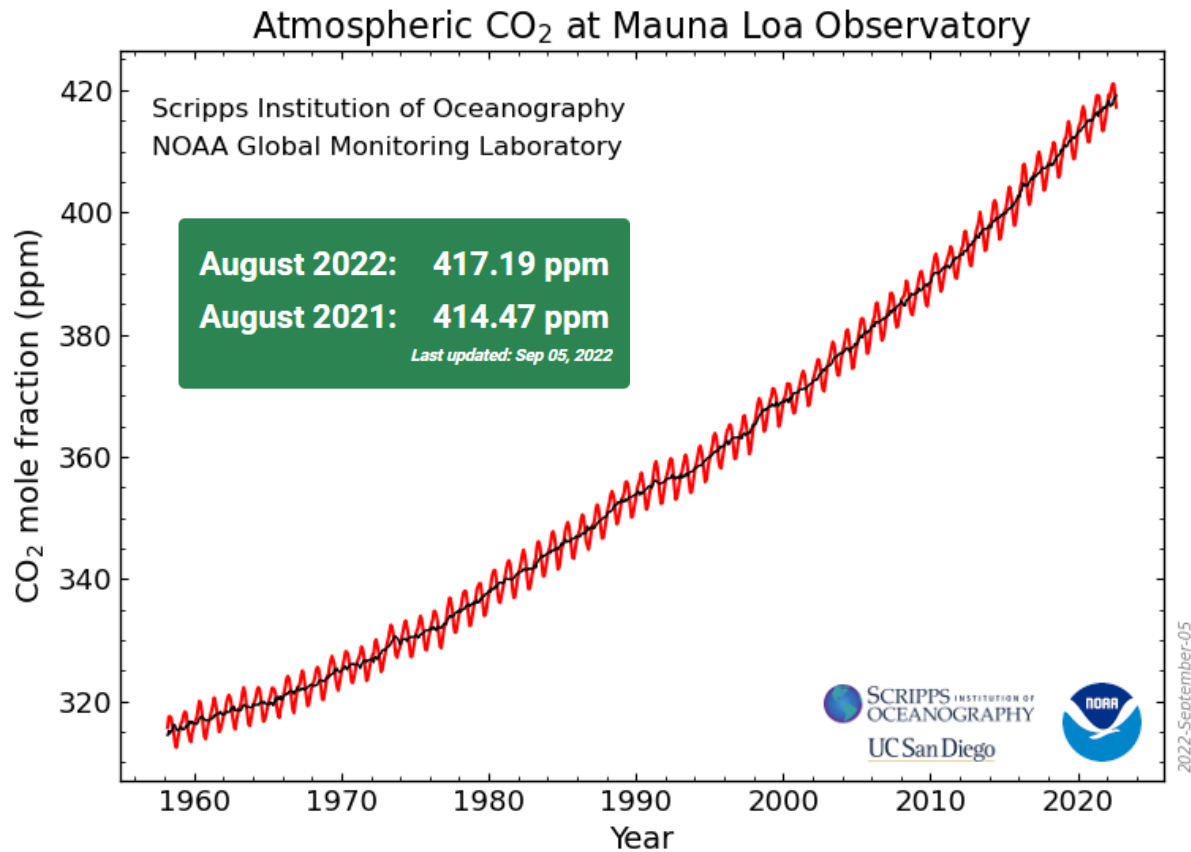
2022 Latornell: Re-imagining Conservation

Presented by: Sharon Lam and Yuestas David

October 18, 2022

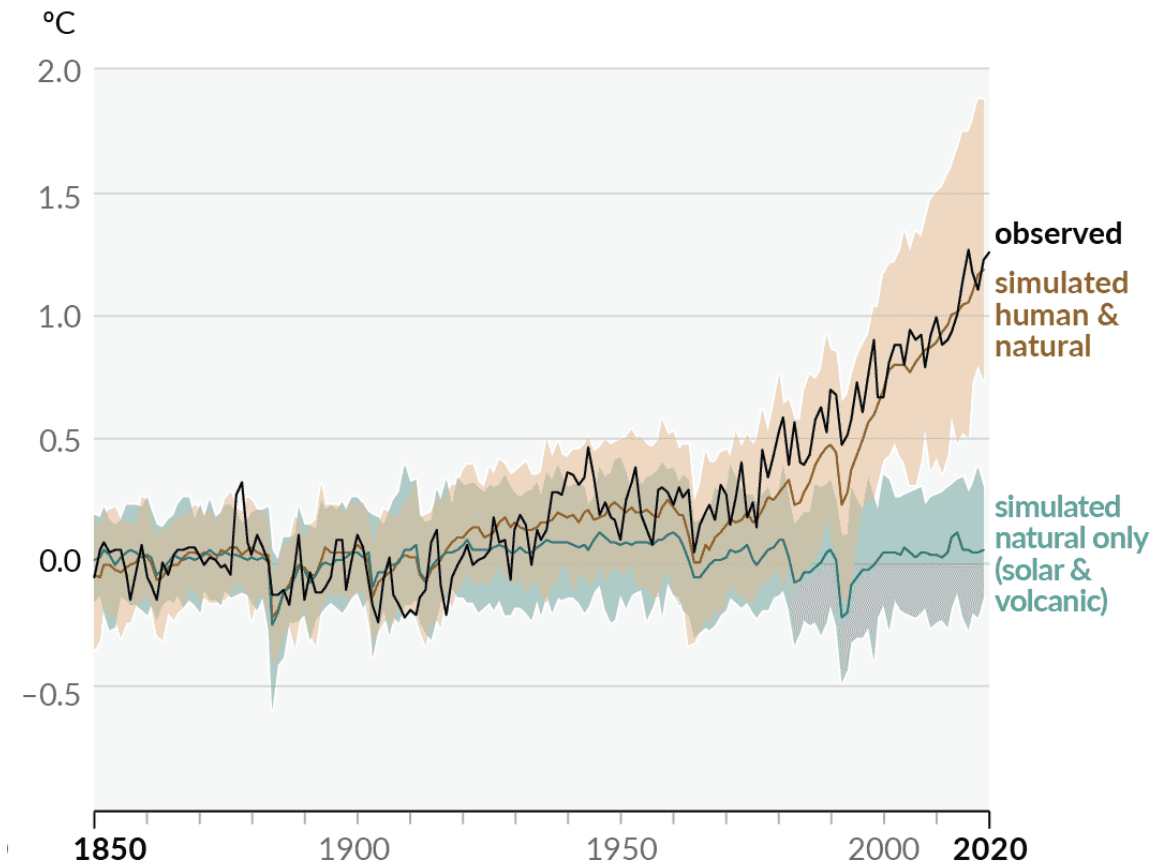
Why?

Climate change is real and we are the cause



Source: [National Oceanic & Atmospheric Administration \(NOAA\): Trends in Atmospheric Carbon Dioxide](#)

(b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850–2020)



Source: [IPCC Sixth Assessment Report, Working Group I](#)

Climate change is happening now



Source: [NASA:
Global Temperature
Anomalies](#)

It is affecting all regions in the world



GLOBAL AVERAGE TEMPERATURE

The January-December 2021 average global surface temperature was the sixth highest since global records began in 1880.

ARCTIC SEA ICE EXTENT

During its growth season, the Arctic had its seventh-smallest annual maximum extent (tied with 2007) on record. During its melt season, the Arctic had its 12th-smallest annual minimum extent on record.

NORTHWESTERN U.S. AND WESTERN CANADA

An extreme heat wave affected much of the northwestern U.S. and western Canada during the last week of June. Canada set a new national maximum temperature.

EUROPE

Europe's 2021 temperature was the ninth-highest on record.

SOUTHERN EUROPE

An intense heat wave impacted parts of southern Europe. Sicily had a daily maximum temperature that if verified, would be Europe's highest maximum temperature on record.

ASIA

Asia had its seventh-warmest year on record.

TYPHOON SURIGAE

Surigae was an extreme cyclone, with the strongest maximum wind speed ever recorded for a storm during the months of January-April anywhere in the world.

WESTERN NORTH PACIFIC TYPHOON SEASON

Below-average activity: 23 storms, including 10 typhoons.

TYPHOON RAI

Rai was a strong and destructive typhoon. It made landfall in the southern Philippines on December 16, wreaking havoc across the region.

OCEANIA

Although Oceania had an above-average temperature, it was its coldest year since 2012.

SOUTHWEST PACIFIC CYCLONE SEASON

Near-average activity: 9 storms, including 4 cyclones

TROPICAL CYCLONE TAUUKTAE

Tauktae was one of the strongest cyclones on record to make landfall on India's west coast.

NORTH INDIAN OCEAN CYCLONE SEASON

Near-average activity: 5 storms, including 3 cyclones.

SOUTH INDIAN OCEAN CYCLONE SEASON

Near-average activity: 12 storms, including 5 cyclones

CYCLONE SEROJA

Cyclone Seroja brought strong winds and record rainfall to parts of Western Australia. Seroja also affected Indonesia, causing historic floods and landslides.

ATLANTIC HURRICANE SEASON

Above-average activity: 21 storms, including 7 hurricanes. This was the third highest number of named storms on record.

HURRICANE GRACE

Grace was one of the strongest hurricanes to make landfall in eastern Mexico.

EASTERN NORTH PACIFIC HURRICANE SEASON

Above-average activity: 19 storms, including 8 hurricanes.

SOUTH AMERICA

The year 2021 was South America's sixth-warmest year on record.

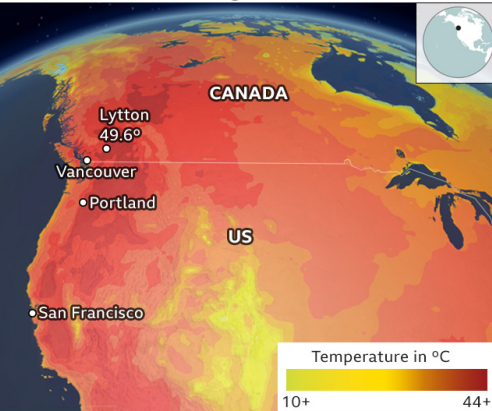
NORTH AMERICA

North America had its seventh-warmest year on record.

HURRICANE IDA

Ida was a dangerous Category 4 hurricane when it made landfall in the U.S. state of Louisiana on August 29 – the same day that Hurricane Katrina did 16 years earlier. Ida caused significant damage to parts of Cuba and the southern and northeastern U.S.

Temperatures in Canada and north-west US reached record highs on 29 June

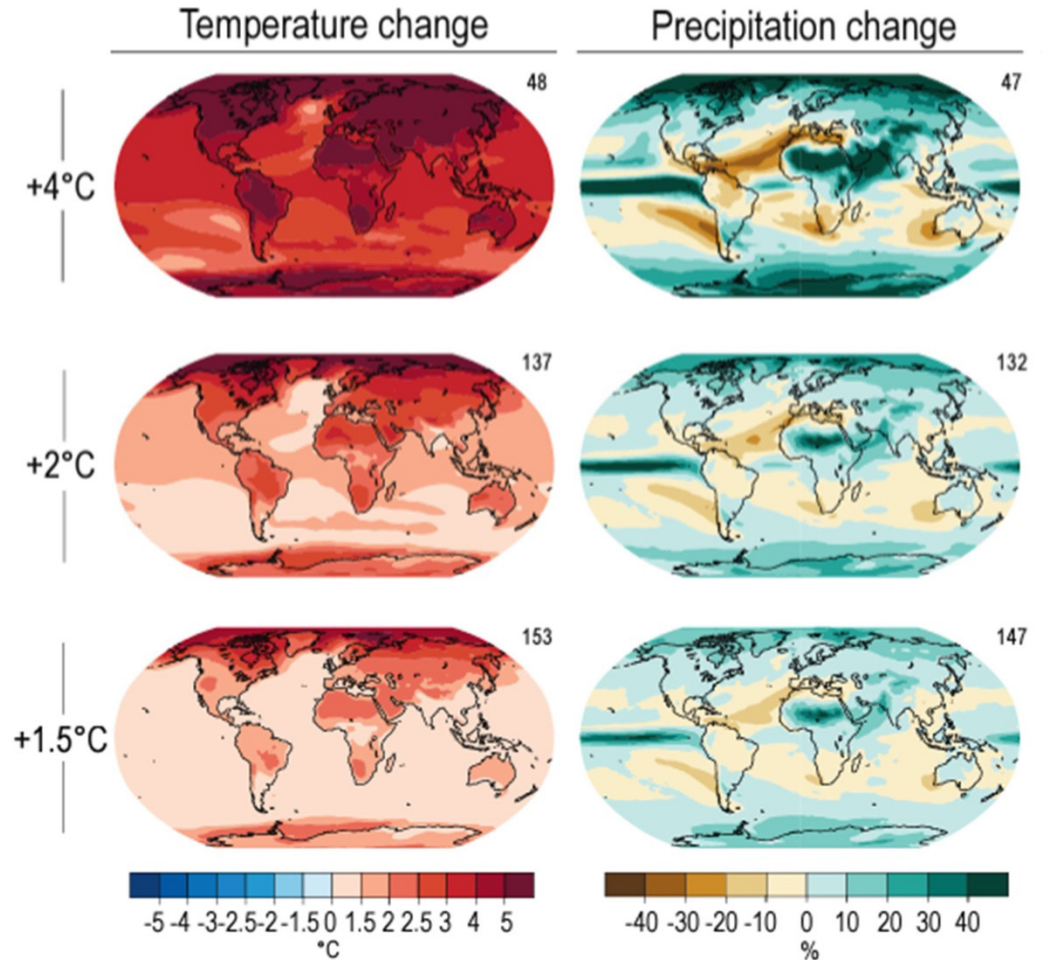
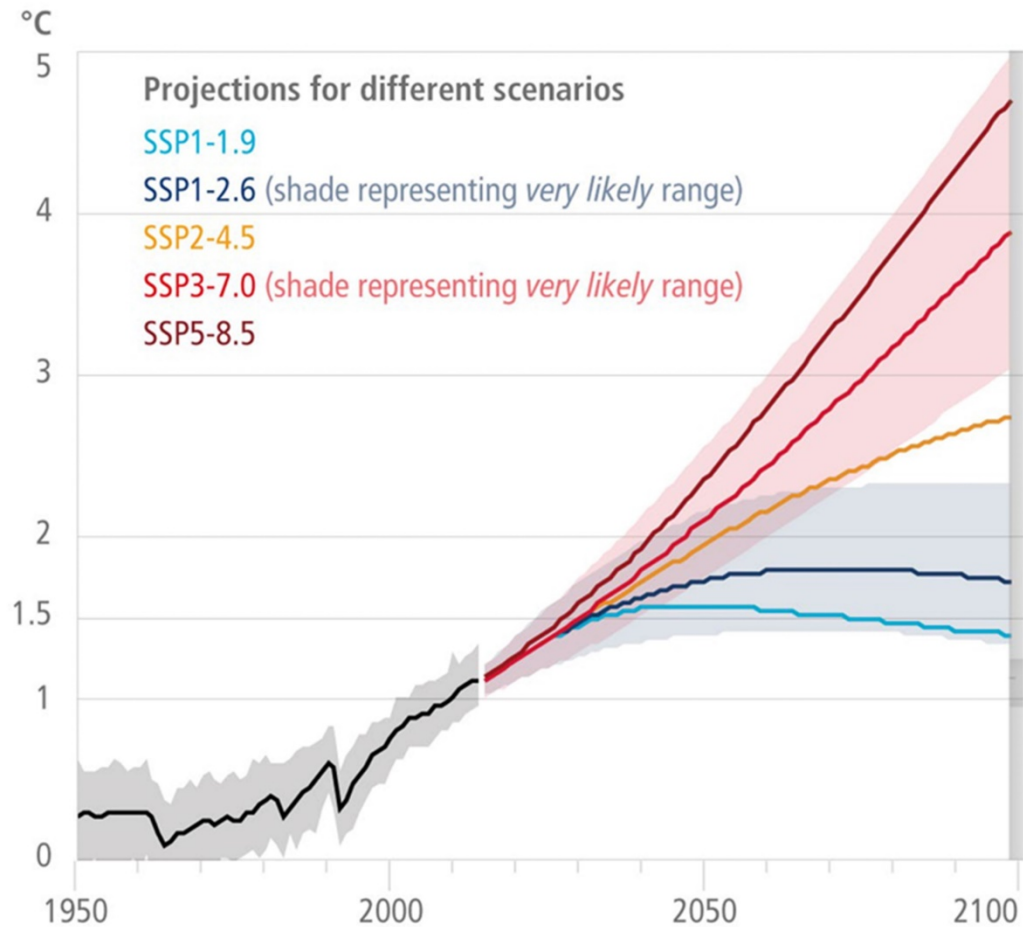


Source: NOAA: Selected Significant Climate Anomalies and Events in 2021

ANTARCTIC SEA ICE EXTENT

During its growth season, the Antarctic reached a maximum extent that was near-average. During its melt season, the Antarctic had its 12th smallest minimum extent on record.

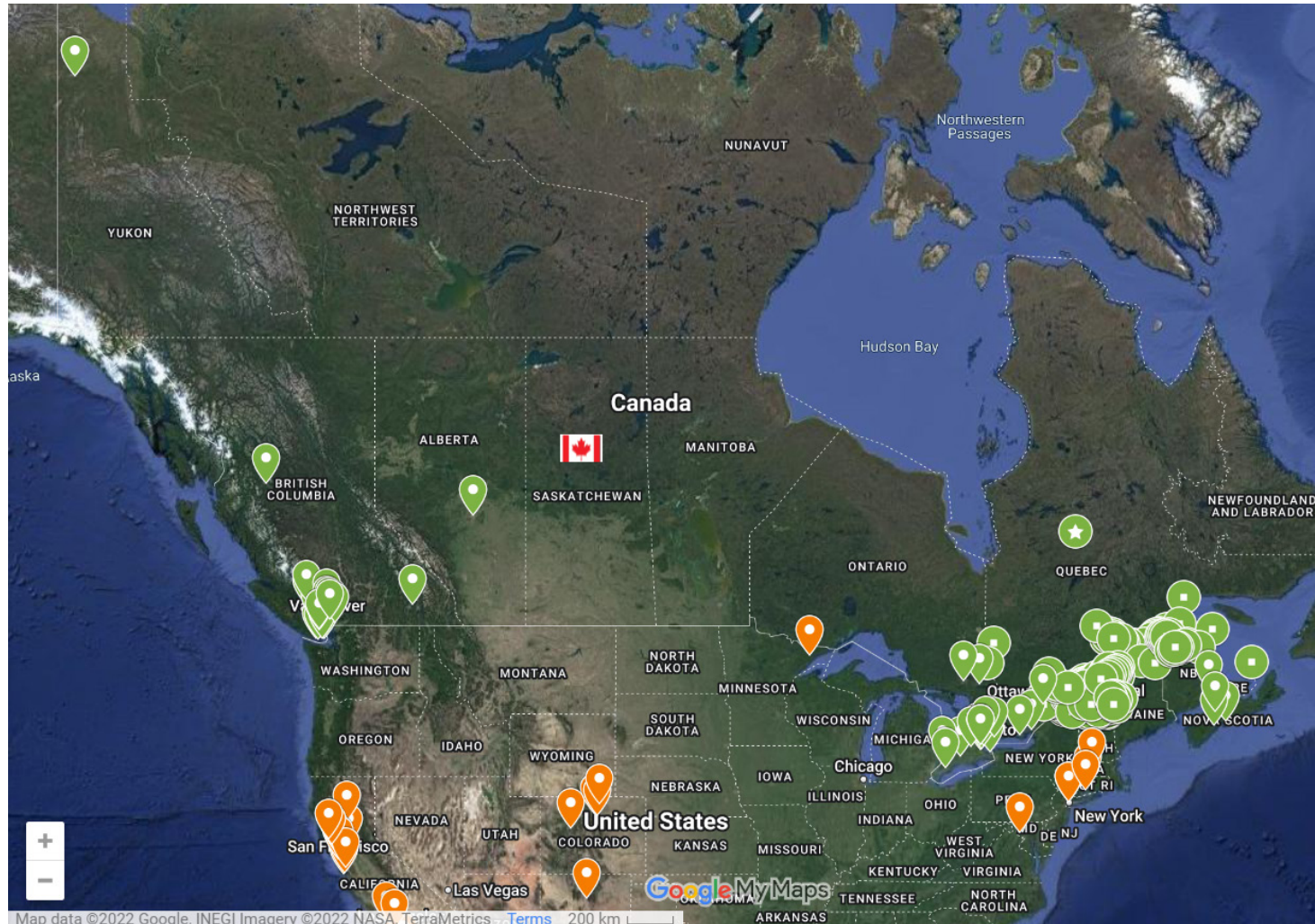
It will continue without rapid and sustained social and economic transformation



Source: IPCC Sixth Assessment Report, Working Group II

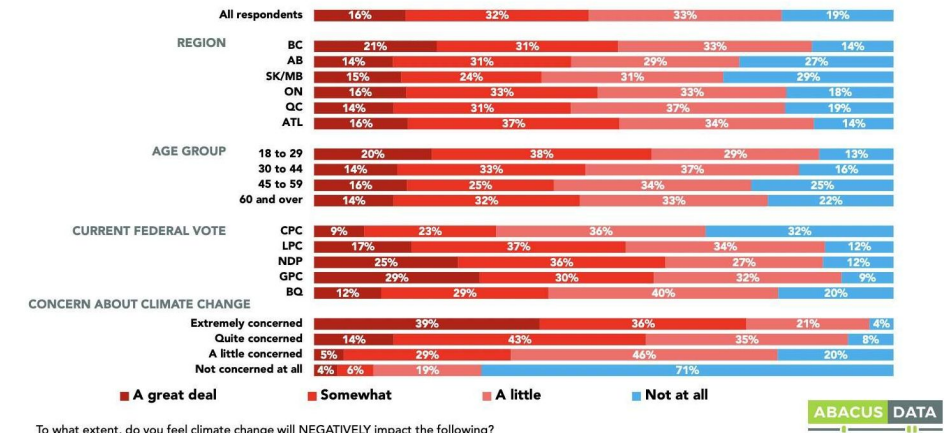
Some good news

Climate emergency declarations



Source: [Climate Emergency Declaration and Mobilisation in Action \(cedamia\)](#)

CLIMATE CHANGE'S NEGATIVE IMPACT ON... YOUR HEALTH

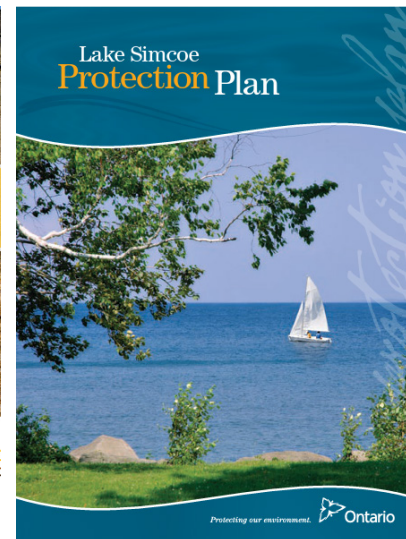
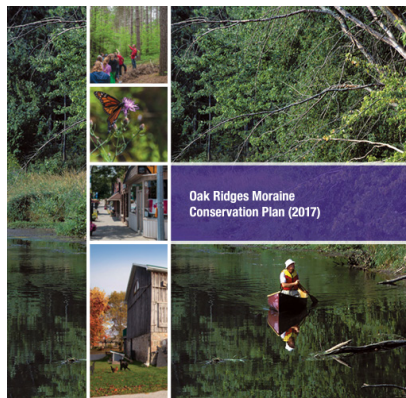
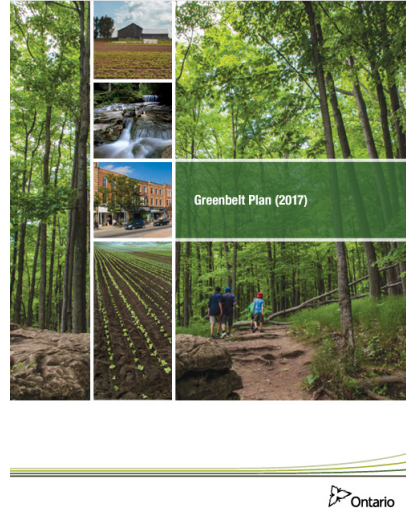
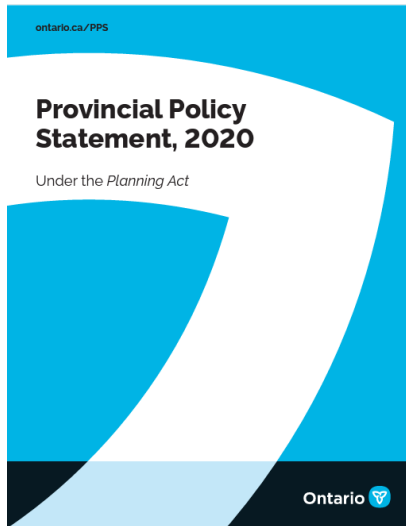


Source: [Canadian Climate Institute \(Twitter\)](#)

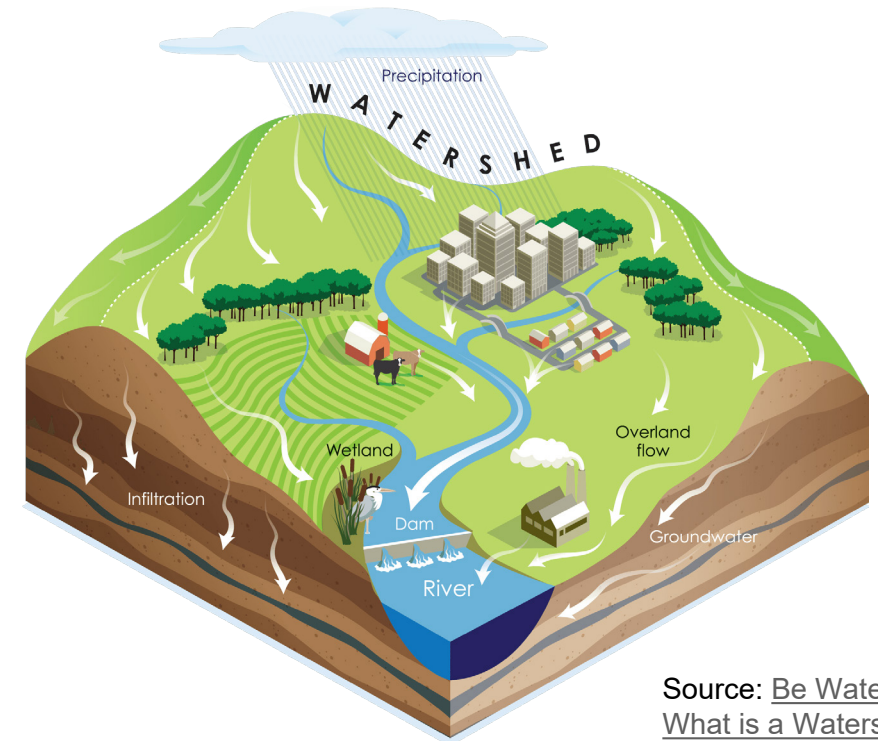


Credit: [S. Goldberg](#)

Considering climate change impacts at the watershed scale



“Planning authorities shall protect, improve or restore the quality and quantity of water by... c) evaluating and preparing for the *impacts of a changing climate* to water resource systems at the watershed level” (PPS, 2020, 2.2.1)



Source: Be Water Friendly: What is a Watershed?

Watershed plans

Helps inform municipal decision-making about:

- Where growth can occur
- How water and wastewater servicing should be planned
- The design of new or expanded infrastructure
- The amount and design of stormwater management that is needed
- How to identify and protect water resources
- Where protection, restoration, and enhancement of the natural environment should occur



How?

How?

(TRCA's perspective)

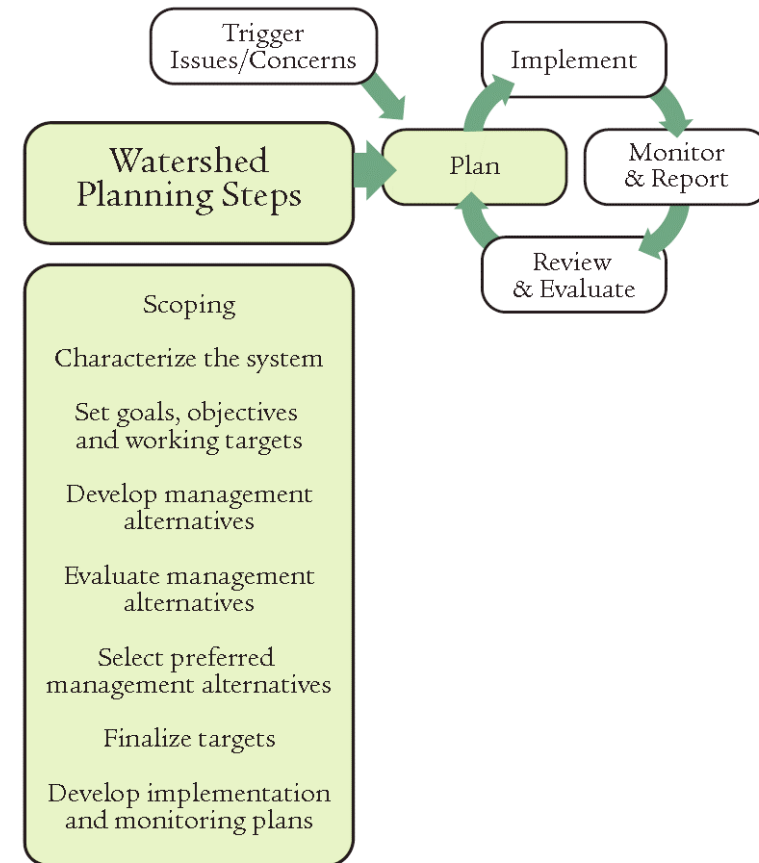
Cycles of adaptive management

Climate adaptation planning process



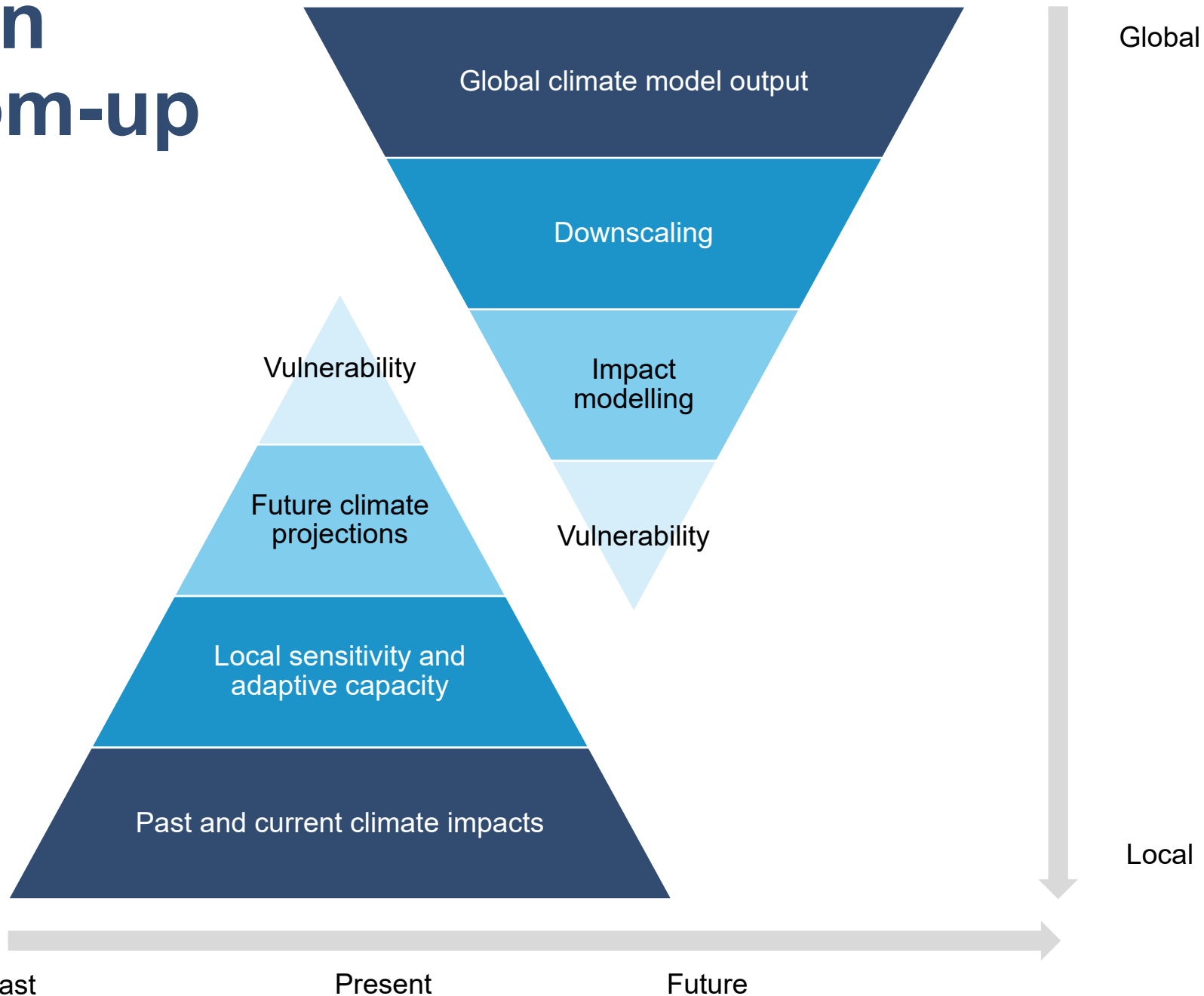
Source: [Government of Canada: Canada in a Changing Climate: National Issues Report](#)

Watershed planning process



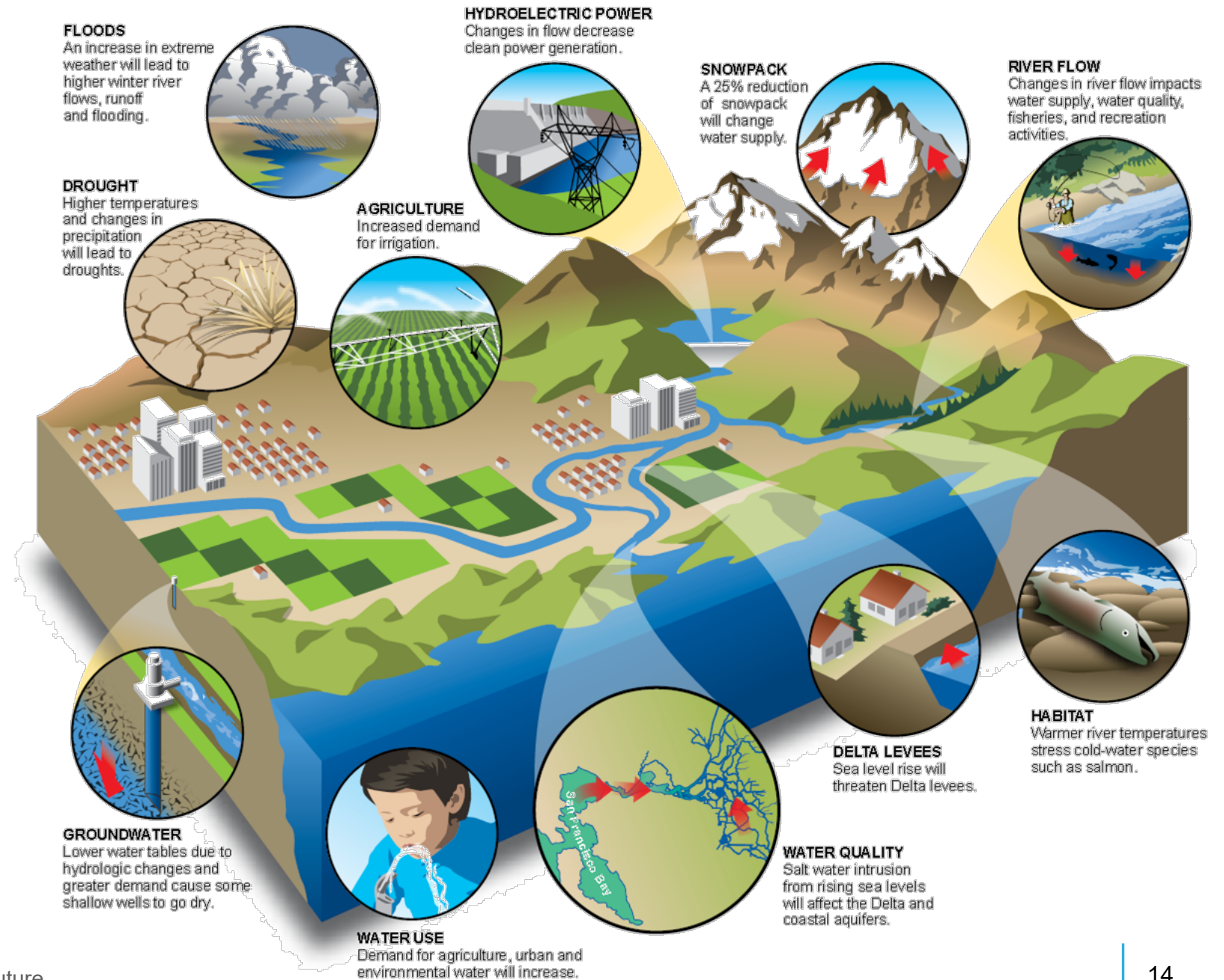
Source: [Conservation Ontario: Overview of Integrated Watershed Management in Ontario](#)

Top-down vs. bottom-up

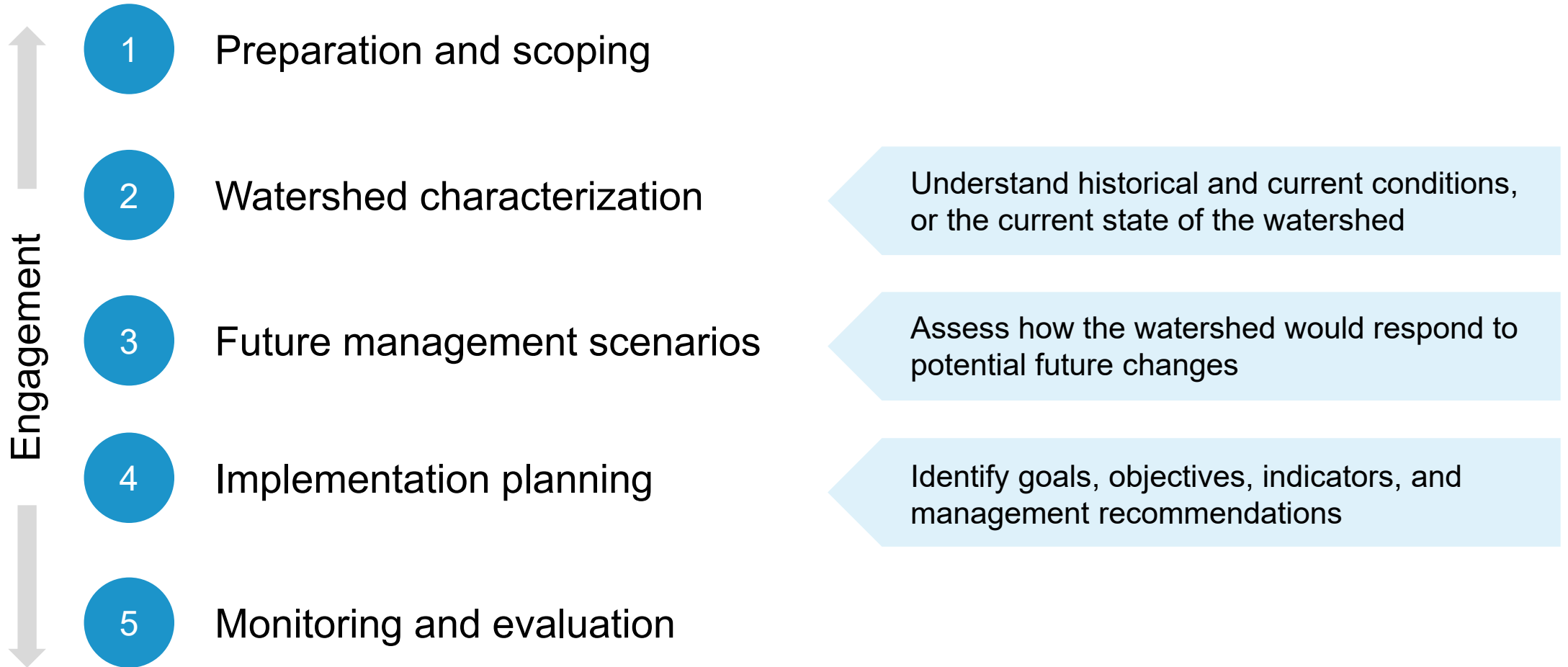


Adapted from various sources including: [Canadian Council of Ministers of the Environment: Implementation Framework for Climate Change Adaptation Planning at a Watershed Scale](#)

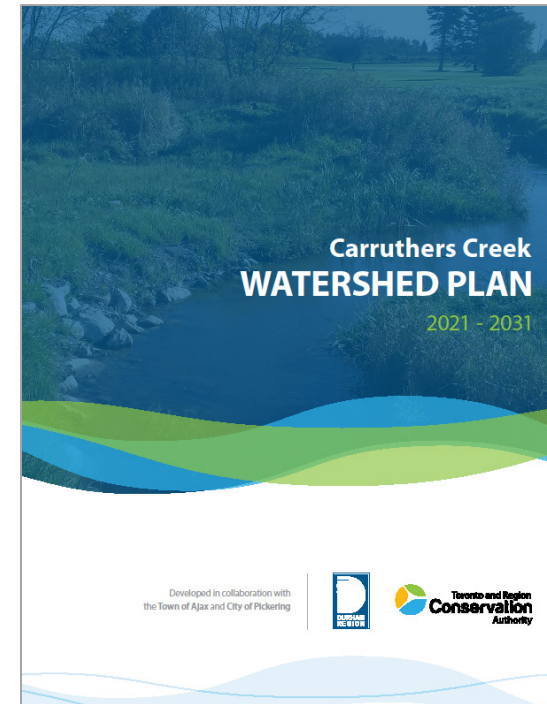
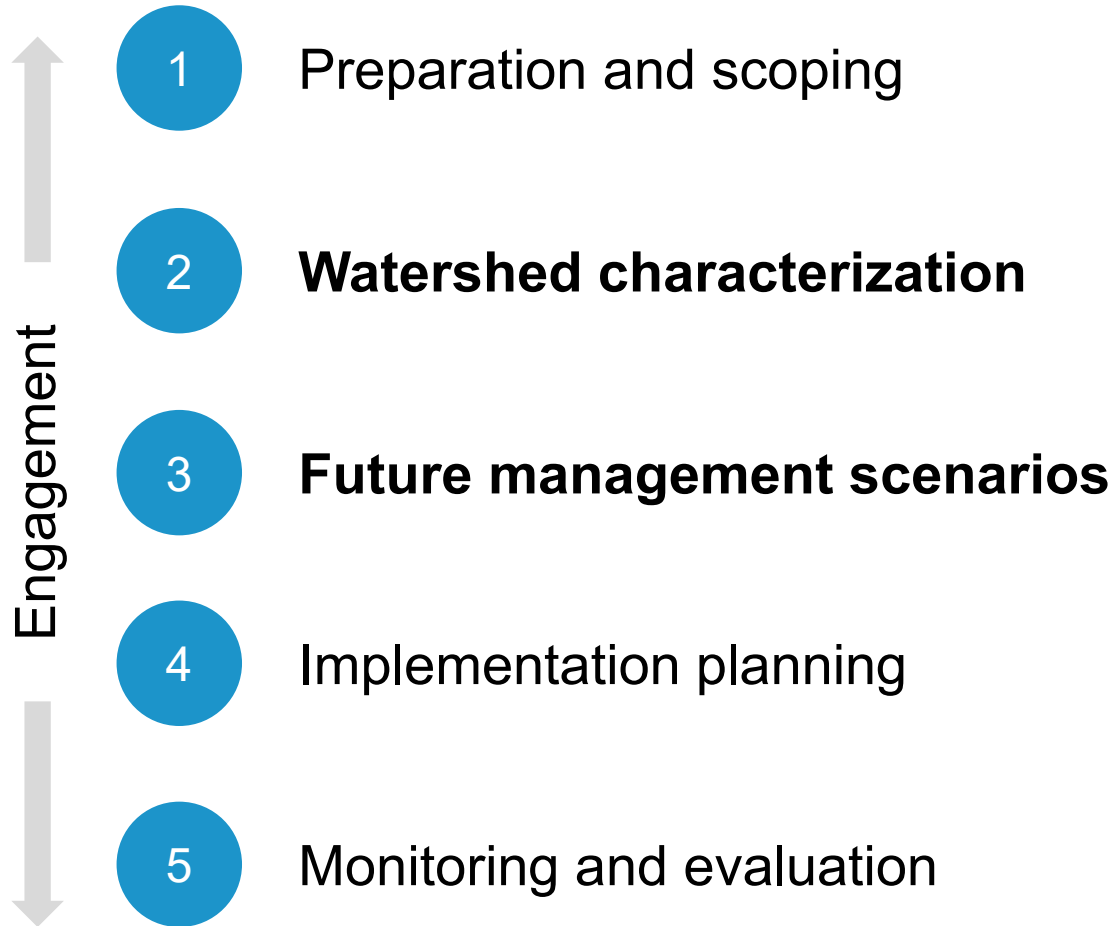
How climate change impacts a watershed



TRCA watershed planning process



TRCA watershed planning process



Etobicoke Creek
Watershed Plan
(2020-2023)

Humber River
Watershed Plan
(2022-2025)

Watershed Characterization

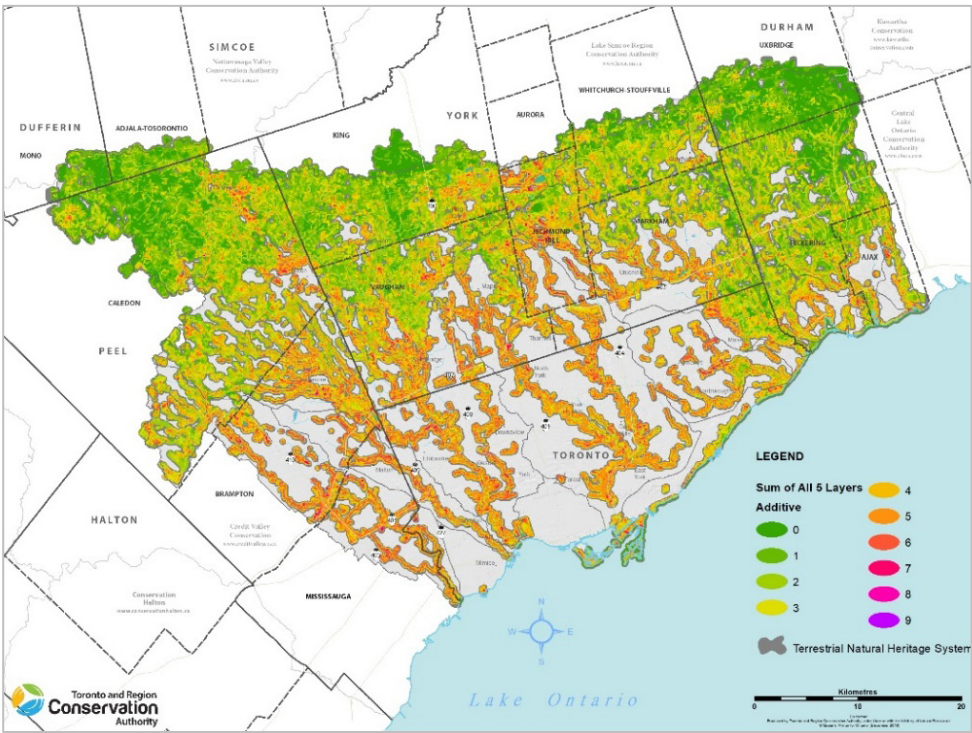
From Carruthers Creek to Humber River

Carruthers Creek	Etobicoke Creek
Aquatic Barriers	Water Resource System
Aquatic Ecology	
Surface Water Quantity	
Headwaters Drainage Features	
Terrestrial Natural Heritage	Natural Heritage System and Urban Forest
Hydrogeology	Natural Hazards
Fluvial Geomorphology Matrix	
Surface Water Quality	Water Quality
	Stormwater Management
	Restoration Planning

New in the Humber River WP: **+ Climate Change**

Etobicoke: Natural Heritage System

- Climate change vulnerability indicators and areas
- Based on TRCA's Terrestrial Ecosystem Climate Change Vulnerability Assessment (2020)



Vulnerability Indicator	Highly Vulnerable Areas (ha)	Percent of natural cover (%)
Habitat patch quality	1,063	41%
Wetland vulnerability	70	2.7%
Climate-sensitive vegetation communities	2	0.1%
Soil drainage	15,586	70%
Ground surface temperature	14,026	63%

Humber: Research questions

Data Analysis

Public
Engagement
+
Literature Scan

Policy Scan

1. How has the climate changed over the Humber River watershed between 1961-1990 to 1981-2010?
 - a. Are changes occurring uniformly across the watershed?
 - b. How do the changes compare with the rest of the jurisdiction?
2. What climate-related impacts have already been felt across the Humber River watershed, including impacts on natural and human systems?
3. What actions have been undertaken to address climate change (both mitigation and adaptation) at the municipal or watershed-scale?
 - a. What targets are municipalities working towards?

Humber: Climate parameters

- Mean temperature
 - Maximum temperature
 - Minimum temperature
 - Extreme heat
 - Extreme cold
 - Total precipitation
 - Extreme precipitation
 - Dry days
 - Agricultural variables
 - Ice potential
- Also exploring:
 - Drought/moisture deficit
 - Length of extreme heat and cold
 - Snow



Local climate data

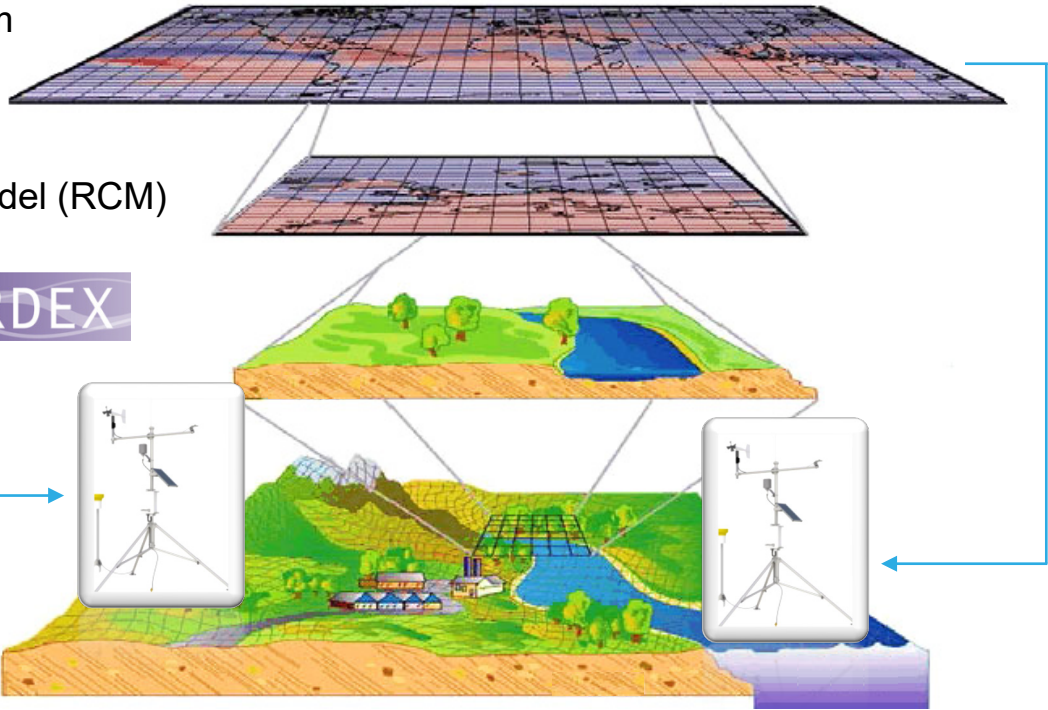
Dynamical Downscaling

Global climate model (GCM)
~100-300 km

Regional climate model (RCM)
~50-10 km

WCRP CORDEX
NA-CORDEX

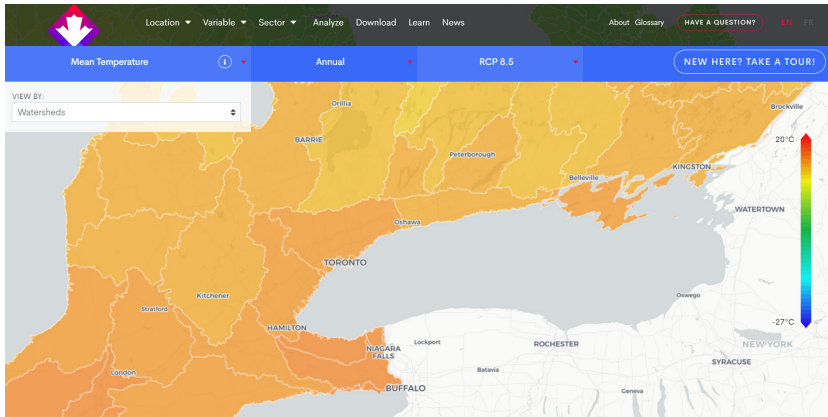
Bias adjustment



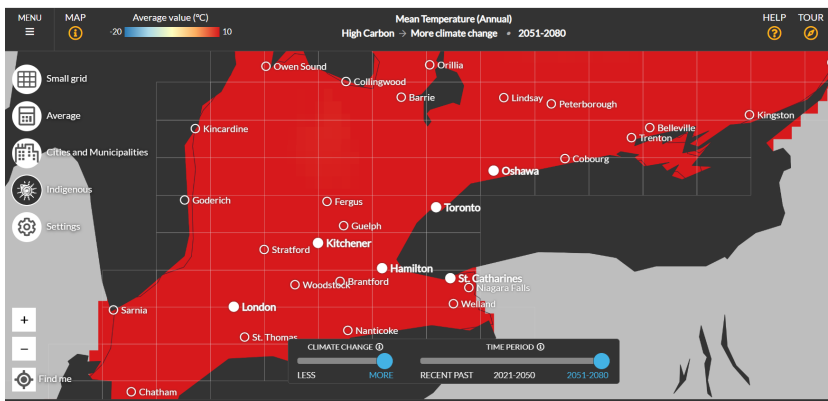
Statistical Downscaling

Examples of existing climate data portals:

[ClimateData.ca](#)



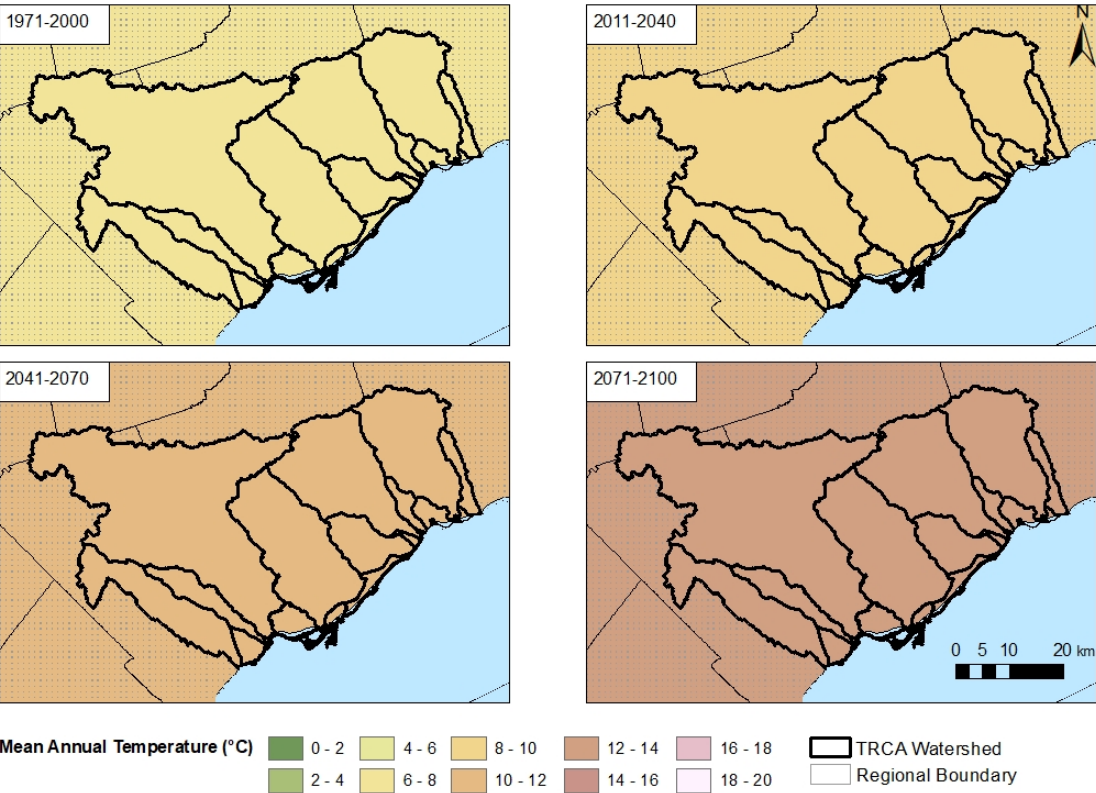
[Climate Atlas of Canada](#)



Source: [Indiana University Bloomington](#)

Humber: Climate data and impacts

Bias-adjusted, regional climate model ensemble output



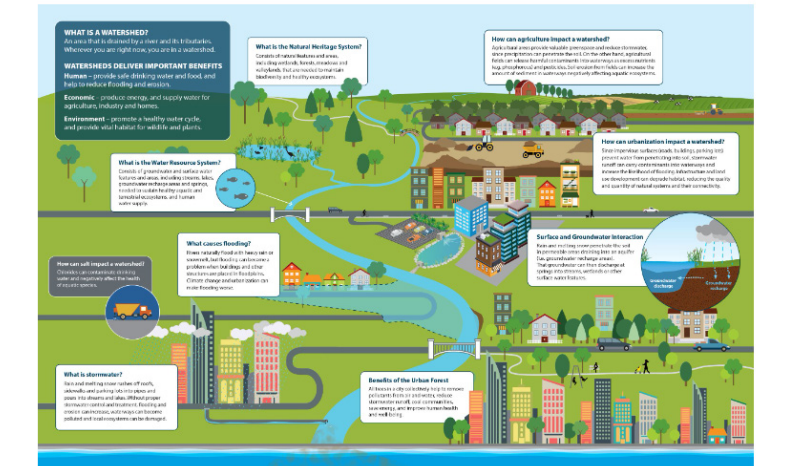
Climate/weather-related stories

HRWP Engagement Survey

The following introduction sets the context for the survey questions, which begin on the next page.

What is a Watershed?

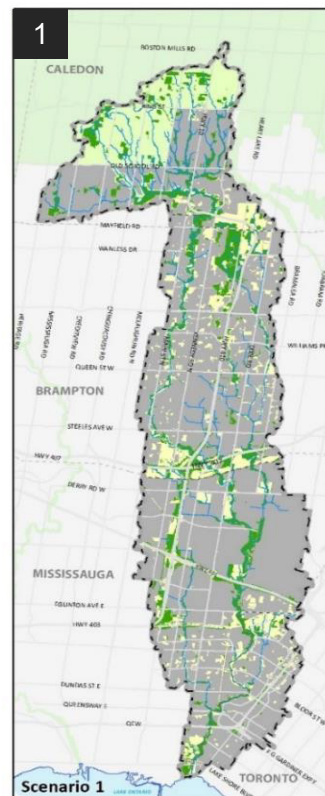
The [video](#) and graphic below help explain what a watershed is and the impacts of certain land uses.



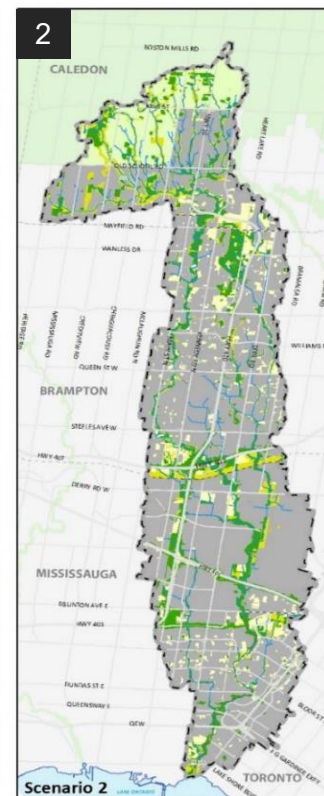
Future Management Scenarios

Future management scenarios

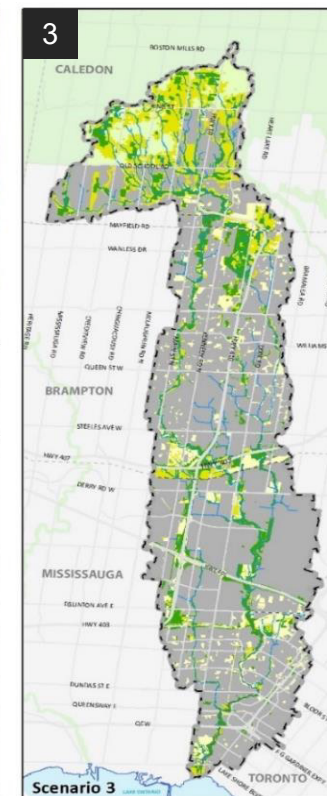
	Urban Expansion	NHS Cover	Canopy Cover	Runoff Control
Current	No	12.3%	14.7%	Existing
1	Yes	12.4%	14.7%	5 mm
2	Yes + Highway 413	18.5%	18.8%	12.5 mm
3	Yes	22.8%	26.5%	25 mm
4	No	22.8%	26.7%	25 mm



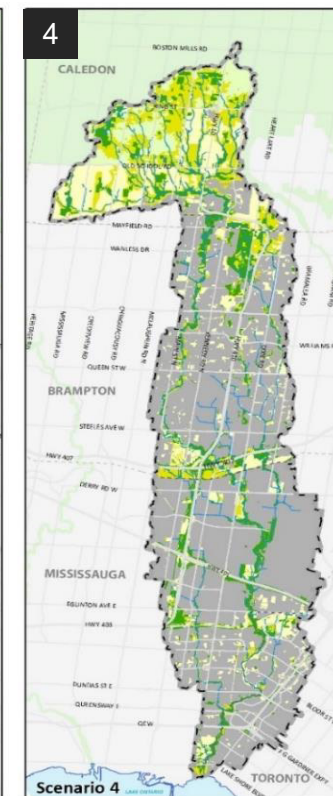
Urban expansion with minimal enhancements



Urban expansion with moderate enhancements
+
GTA West Hwy



Urban expansion with optimal enhancements



Existing urban boundary with optimal enhancements

Qualitative approach

- What if scenarios → climate impact statements

If (climate stressor)	Then (outcome)	So (consequence)
Increase in air temperatures	Warmer water temperatures	Loss of cold/cool fish habitat
Increase in air temperatures	Warmer water temperatures	Increase in algal blooms, especially in lakes, ponds and slow-moving rivers
Increase in the intensity and frequency of precipitation events	Increased runoff from roads and/or agricultural land	Decrease in stream water quality
Increase in the frequency/intensity of extreme weather events	Damage to trees and natural features in riparian corridors	Loss of ecosystem goods and services
Increase in the frequency/intensity of extreme weather events	Damages to urban trees (and reduced urban tree canopy cover)	Loss of ecosystem goods and services
Increase in average temperature and hot days over 30 °C	Higher tree mortality	Decreased shade from loss of urban tree canopy
Increase in average temperatures and changes in precipitation patterns	Shifting eco-regions for flora and fauna	Increased survival and spread of invasive species such as Emerald Ash Borer

Quantitative Approach

Downscaling method	Daily	Subdaily	Needs correction?
Statistically	Climate portals: climatedata.ca ; climateatlas.ca	University of Wisconsin-Madison: Daily data disaggregated into hourly	No
Dynamically	NA-CORDEX	NA-CORDEX direct request; bias correction method and daily data needed	Yes, with observed dataset

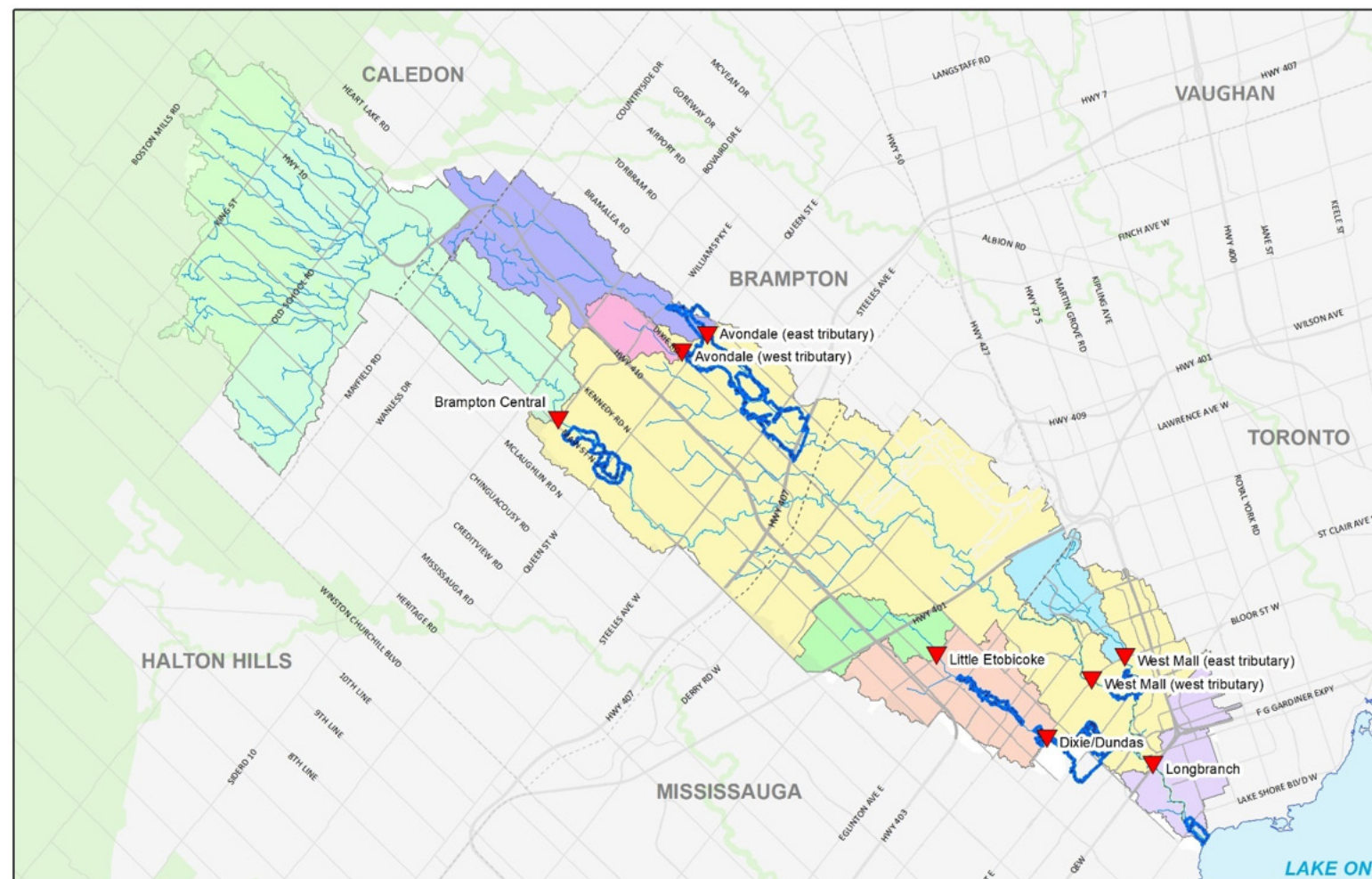
Challenges

Scenario 1: Urban Expansion with Minimal Enhancements	Scenario 2: Urban Expansion with Mid-range Enhancements	Scenario 3: Urban Expansion with Optimal Enhancements	Scenario 4: Existing Urban Boundary with Optimal Enhancements
Current Climate	Current Climate	Current Climate	Current Climate
Future Climate	Future Climate	Future Climate	Future Climate

To include and differentiate climate impacts on future management scenarios, you would need to double the number of scenarios.

Etobicoke: Flood Risk

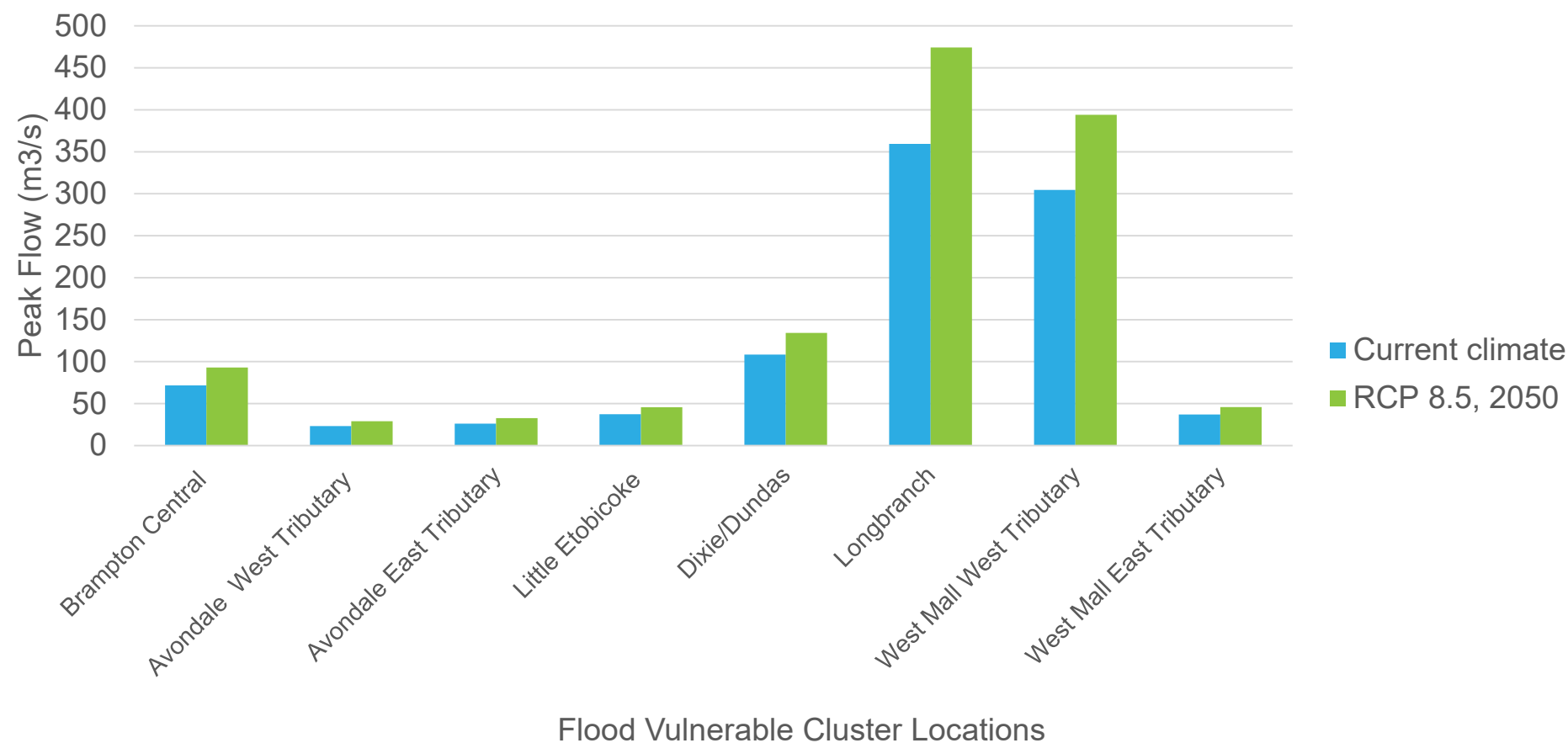
- Objective: Identify flood vulnerable clusters and compare peak flows between scenarios
- Integrating CC - Update **event** design storms (2-100 yr return period) used in hydrology model based on projected climate (IDF-CC Tool)
- With **continuous** modeling, can comment on frequency and duration of flooding



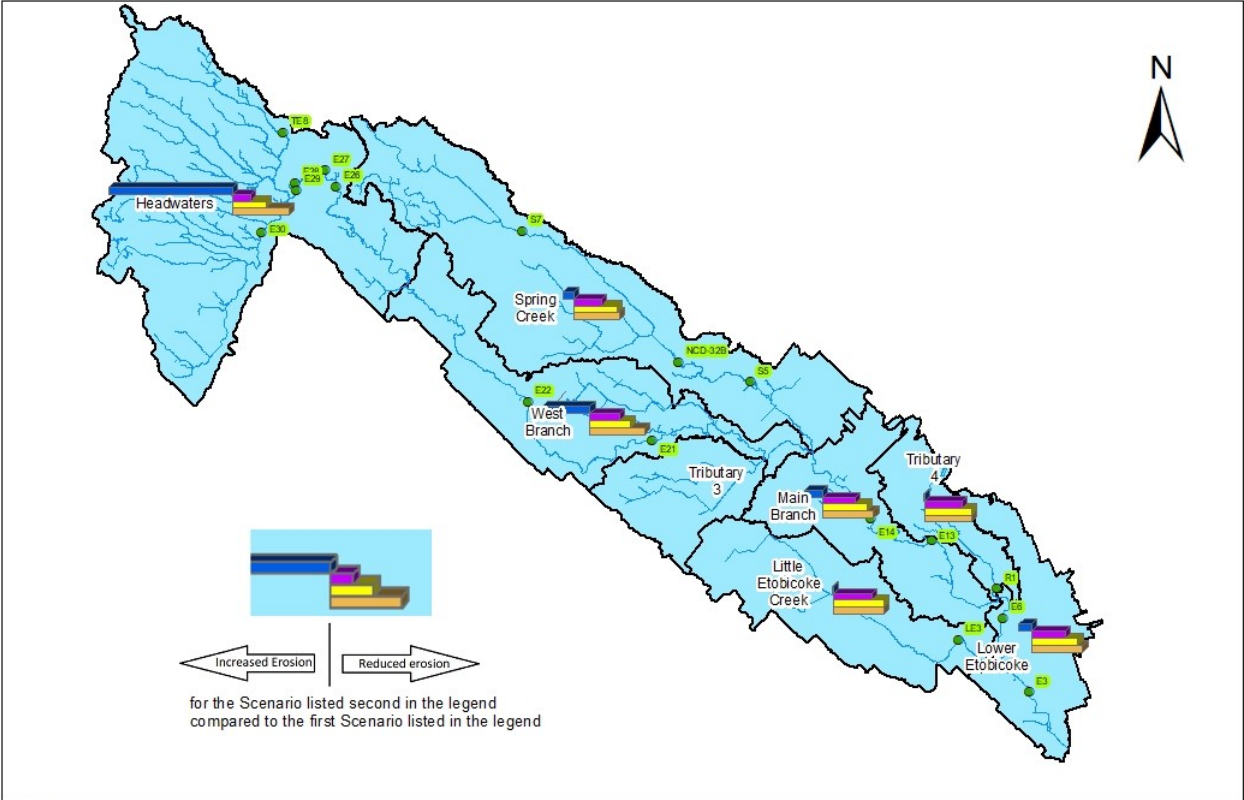
Flood vulnerable clusters in the Etobicoke Creek Watershed

Etobicoke: Flood Risk

Comparison of peak flows at FVC locations under current and future climate for the 100-year return period storm in Scenario 1



Etobicoke: Erosion Potential



Toronto and Region Conservation Authority

Created by: TRCA Engineering Services
Date: Monday, February 28, 2022
Disclaimer:
The data used to create this map was compiled from a variety of sources & dates. The TRCA takes no responsibility for errors or omissions in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data on this map, please contact the TRCA Engineering Services: (416) 661-6600.

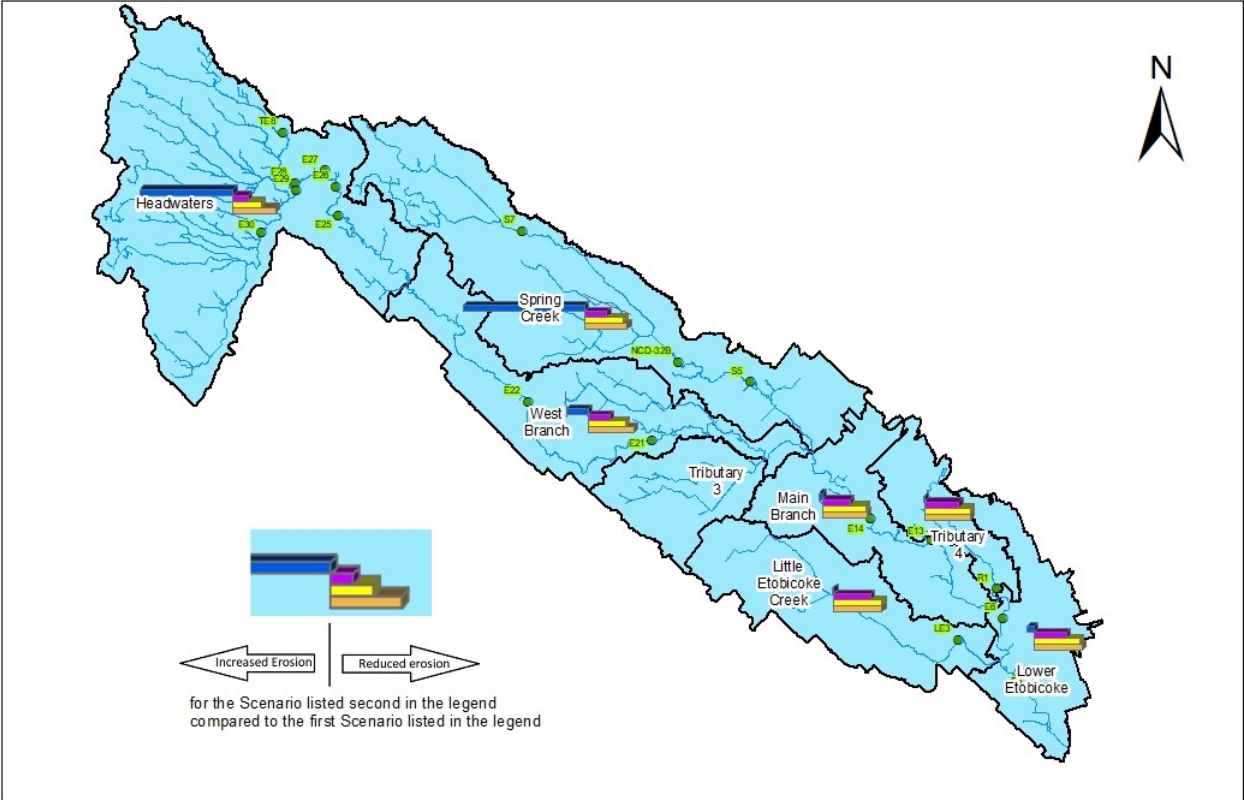
Etobicoke Creek Watershed Plan:

Average Change in Cumulative Effective Work (CEW) between Scenarios in each Subwatershed

0 2.5 5 10 Kilometers

- Sites_CEW
- CEW_Ex_S1
- CEW_S1_S2
- CEW_S1_S3
- CEW_S1_S4

Existing vs Scenario 1
Scenario 1 vs Scenario 2
Scenario 1 vs Scenario 3
Scenario 1 vs Scenario 4



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Etobicoke Creek Watershed Plan:

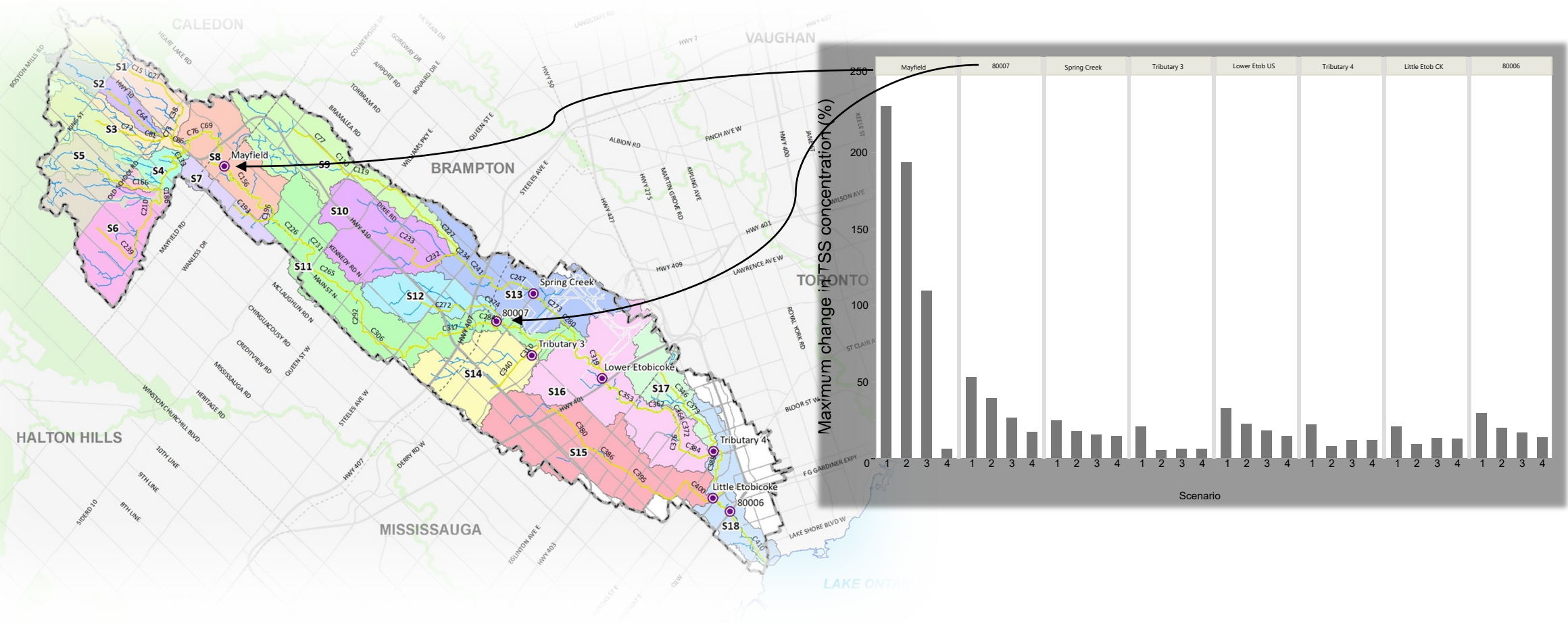
Average Change in Time of Exceedance (TOE) between Scenarios in each Subwatershed

0 2.5 5 10 Kilometers

- Sites_TOE
- TOE_EX_S1
- TOE_S1_S2
- TOE_S1_S3
- TOE_S1_S4

Existing vs Scenario 1
Scenario 1 vs Scenario 2
Scenario 1 vs Scenario 3
Scenario 1 vs Scenario 4

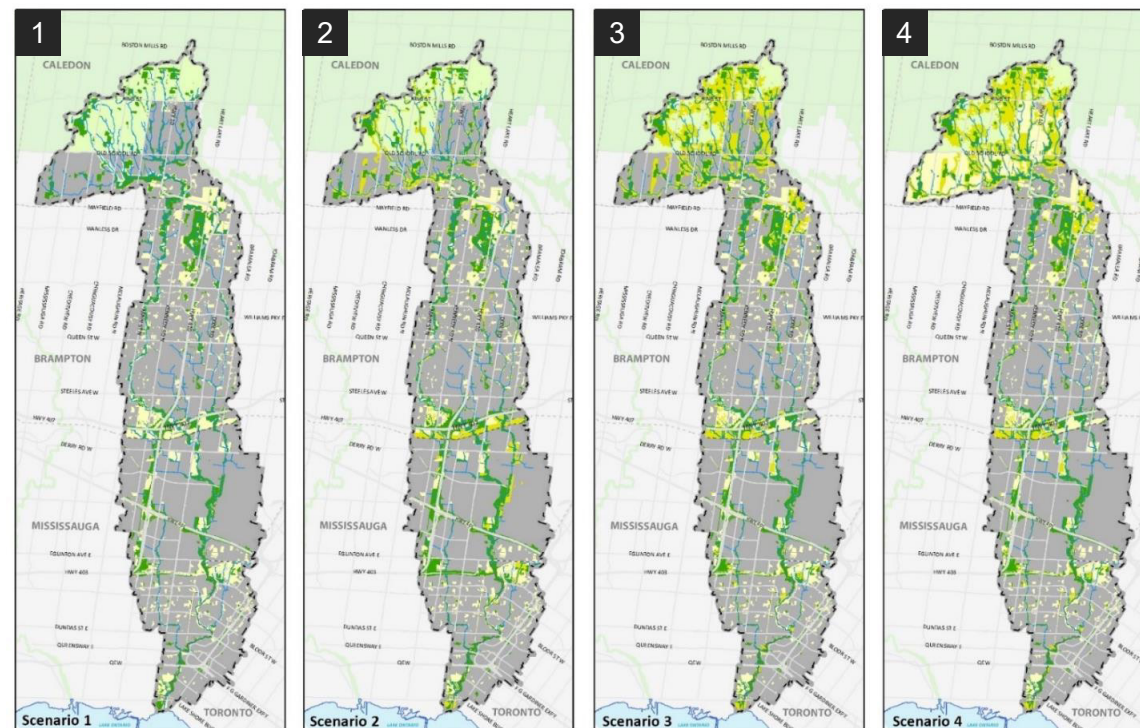
Etobicoke: Water Quality



Etobicoke: Urban forest

- Objective: Identify tree planting opportunities under each future management scenario
- Integrating CC – a qualitative approach was taken (if-then-so)
- With species distribution data, a more quantitative spatial analysis of vulnerability could be undertaken (e.g. heat and drought tolerance)
- CC can also be considered in the prioritization phase to identify suitable/strategic areas to prioritize planting

Etobicoke Creek Scenarios



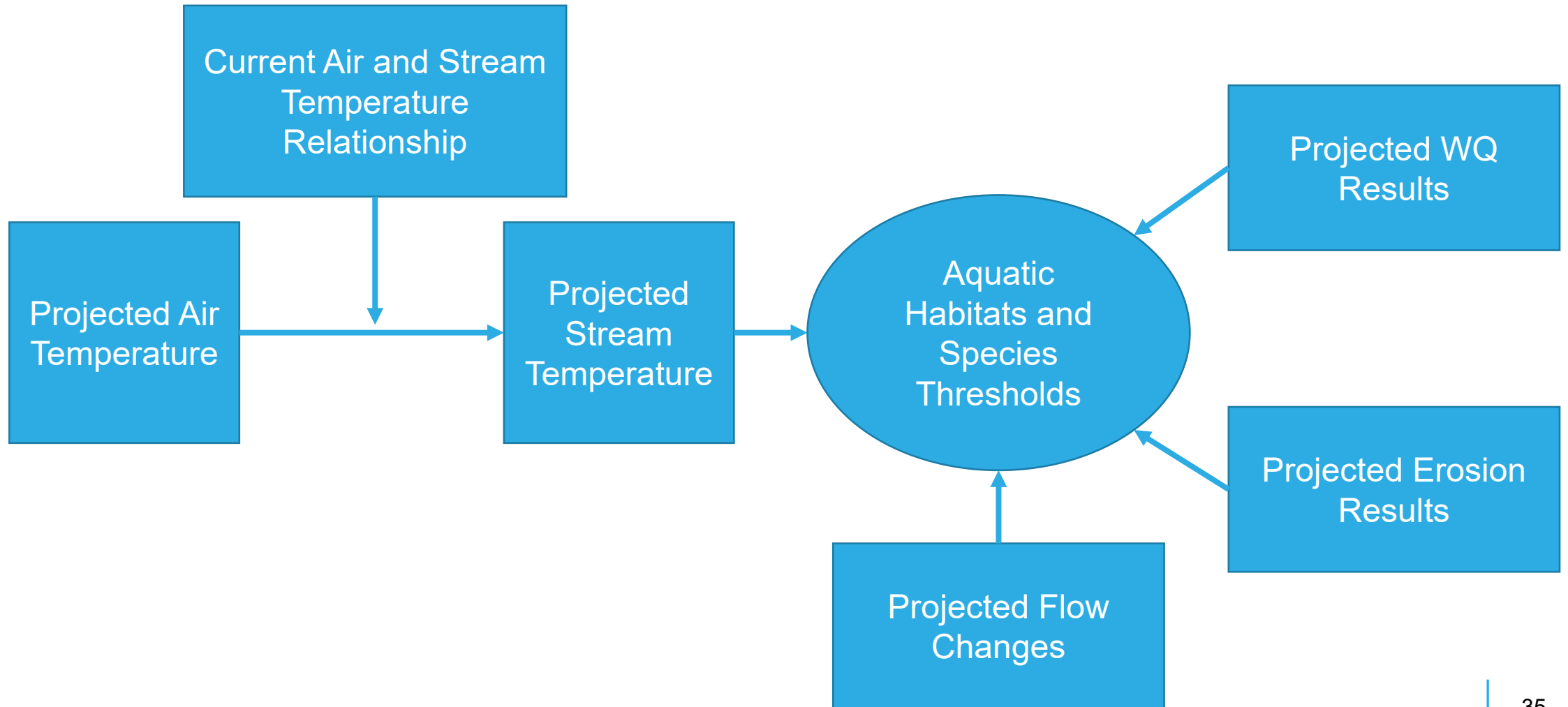
Urban expansion
with minimal
enhancements

Urban expansion
with moderate
enhancements
+
GTA West Hwy

Urban expansion
with optimal
enhancements

Existing urban
boundary with
optimal
enhancements

Etobicoke: WRS-Aquatic Species/Habitat



From Carruthers Creek to Humber River

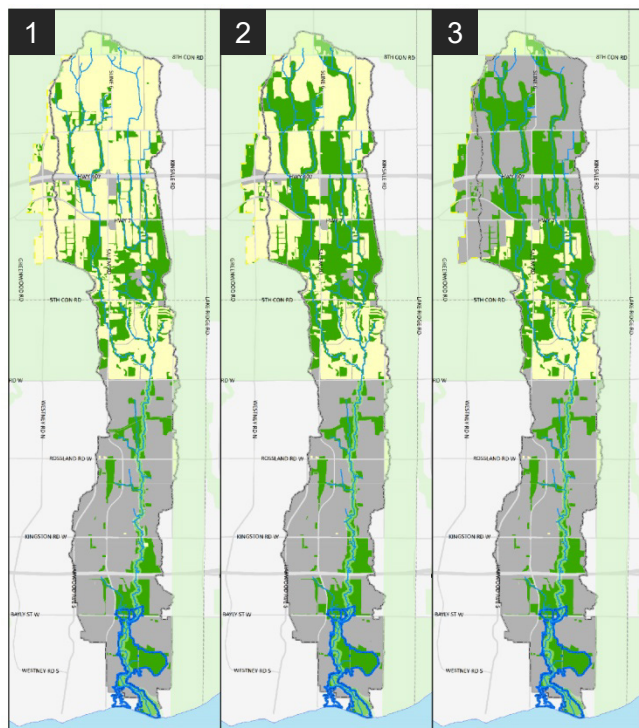
Carruthers Creek



Etobicoke Creek



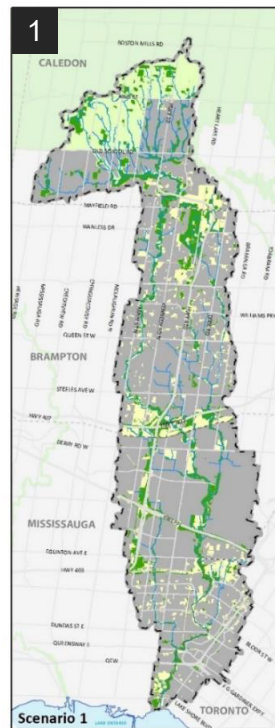
Humber River



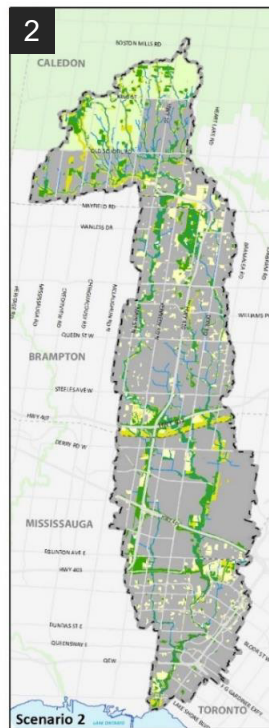
Official Plan
(2031)

Official Plan
(2031)
+
Enhanced
NHS

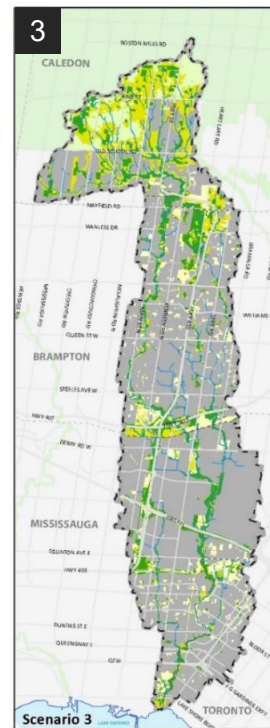
Post-2031
development
in the
headwaters
outside the
enhanced NHS



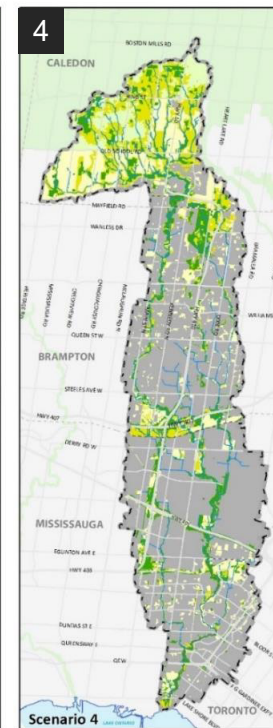
Urban expansion
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Urban expansion
with moderate
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+
GTA West Hwy



Urban expansion
with optimal
enhancements



Existing urban
boundary with
optimal
enhancements

+ Climate change
(RCP 8.5, possibly 4.5)

Work with Tech Leads
to develop a tailored
approach to integrating
CC into all technical
components

Align climate
projections with land
use scenario timelines

Future directions for integrating climate change

- Ecosystem response modelling
- IPCC Sixth Assessment Report (AR6) scenarios
- Cumulative effects assessment (including development applications)
- Ecosystem services (valuation and impacts)
- Monitoring and evaluation (including key performance indicators)
- TRCA Climate Change Action Plan



Credit: Jason Raposo

Workshop

Activities:

1. Mapping approaches for integrating climate change into watershed planning (*12 min*)
2. Identifying existing knowledge and implementation gaps (*15 min*)

Activity 1: Mapping approaches for integrating climate change into watershed planning

How have you integrated climate change into watershed planning, or what plans or ideas do you have?

Think:

- Characterization
- Scenario planning
- Management framework

Top-down	Expert survey/ workshop 1-1 interviews Focus groups	Incorporate future precipitation time series into hydrology modelling Impact modelling
	Case studies Seek community input on local climate impacts, stories	Community asset mapping Community risk ranking
Bottom-up	Qualitative	Quantitative

Activity 2: Identifying existing knowledge and implementation gaps

What knowledge/implementation gaps have you encountered, and how have you overcome them?

Think:

- Governance
- Policy, planning, and program
- Engagement
- Research and evidence
- Implementation
- Monitoring and evaluation

Examples from the 2018 Watershed Forum:

Barriers	Actions
<ul style="list-style-type: none">• Lack of a clear definition of roles and responsibilities involved in watershed planning• Lack of a comprehensive and holistic guidance from the Province related to climate change and watershed planning• Misunderstanding of the costs and benefits of climate impacts on water resources• Funding limitations	<ul style="list-style-type: none">• Provide a clear definition of roles and responsibilities• Build partnerships and collaborations among experts who can inform the integration of climate data into watershed plans• Formalize provincial guidance• Bring implementers to the table during the watershed planning process• Express climate change actions in terms of cost-benefit

Workshop

Activities:

1. Mapping approaches for integrating climate change into watershed planning (*12 min*)
2. Identifying existing knowledge and implementation gaps (*15 min*)

Break-out Group Facilitators:

1. Yuestas David & Andrew Chin
2. Sharon Lam
3. Jonathan Ruppert & Rebecca Dolson
4. Lyndsay Cartwright & Caitlin Fortune
5. Meredith Carter & Karen Halley

Thank you

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Climate Science
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Watershed plan components affected by climate

WRS	NHS/Urban Forest	Water Quality	Natural Hazards
Aquatic (fish and benthic) biodiversity	Terrestrial biodiversity	Pollutant wash-off	Flood risk (FVC)
Aquatic habitat quality	Habitat patch vulnerability		Erosion risk
Streamflow	Urban forest biodiversity		

Groundwater