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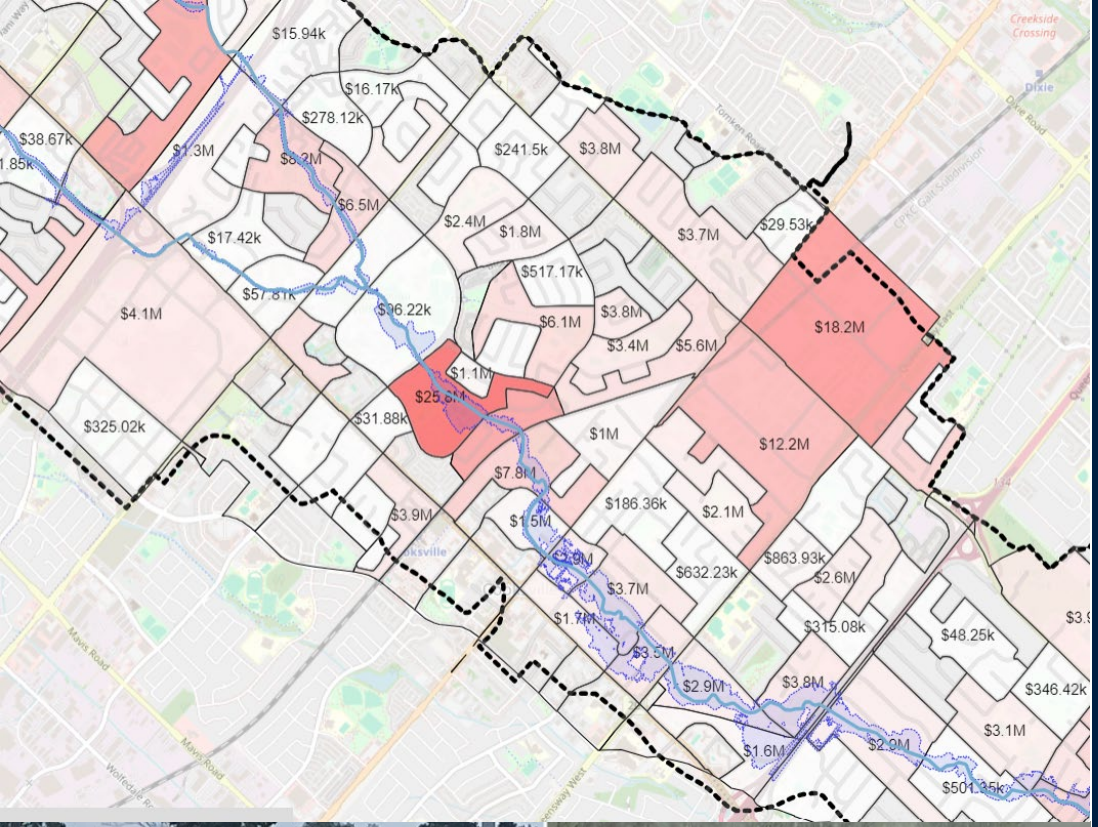
Credit Valley Conservation inspired by nature



Investing in Resilience

Overview of the Risk & Return on Investment Tool (RROIT)

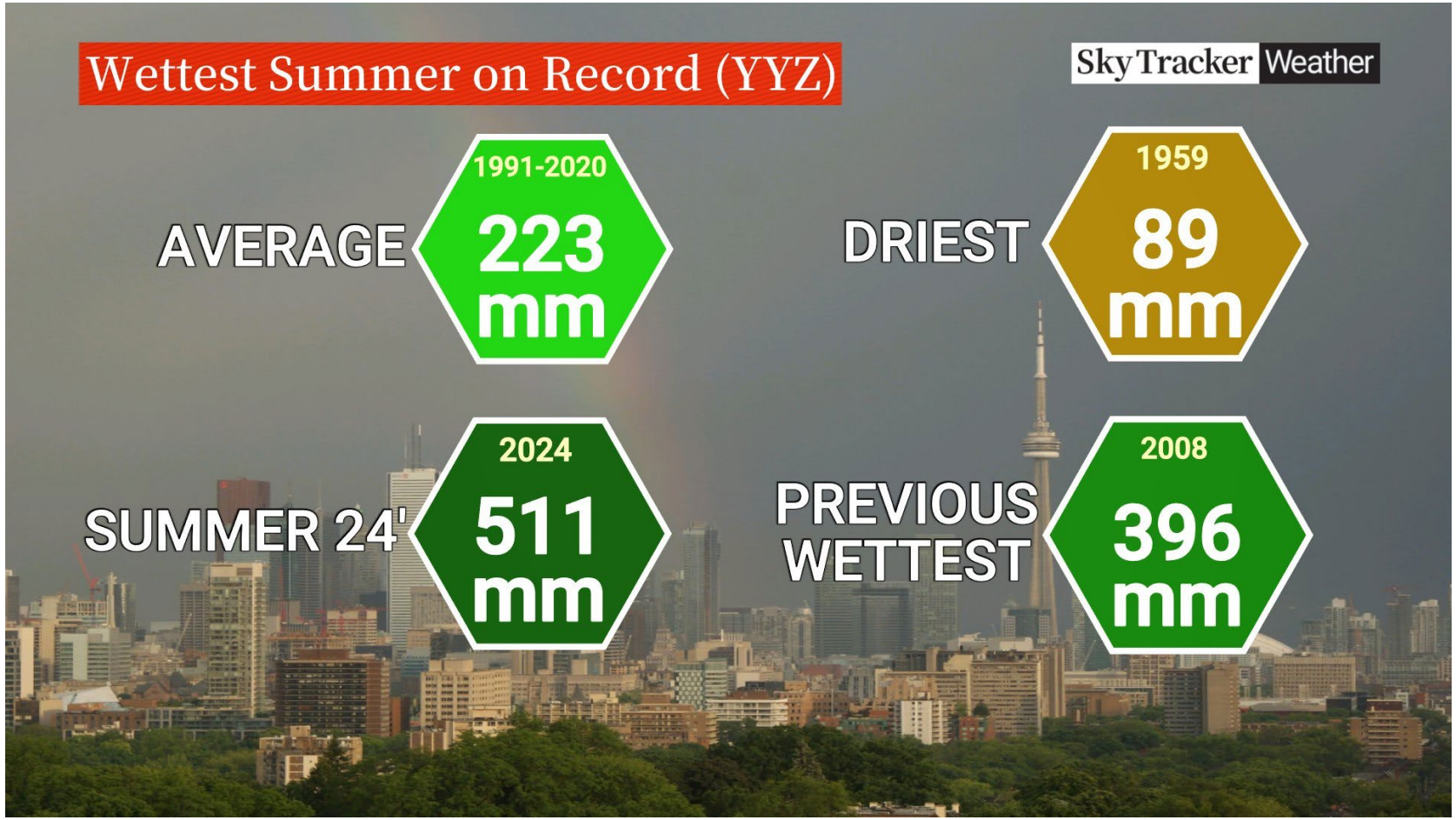
Emma Haug-Kindellan, Engineer, CVC

Kris Robinson, Senior Specialist, CVC

March 27th, 2025

Credit Valley Conservation
inspired by nature

Summer 2024: Record-breaking Rainfall



NEW Rainiest Day, Rainiest Month, Rainiest Summer, Rainiest Year on Record

Breaking the Summer Records by almost +30%

Extreme Rainfall Events & Protecting our Most Vulnerable

- In the past 20 years, the GTA has experienced over 12 (+/-) extreme storm events exceeding infrastructure design standards
- Ranging in total rainfall depth between 60 mm - 250 mm, between 2 hours - 16 hours
- Approx 8 (+/-) "Near Miss" events for CVC's jurisdiction since 2017

GTA

Mississauga parents fear for their children's lives if another flood hits during the school year

"What I saw was almost like a river. How is a teacher with 15, 20 kids, going to safely evacuate them if the building is flooded?" asks a parent after two massive rainfalls in the Applewood Acres neighbourhood flooded St. Edmund Catholic Elementary School.

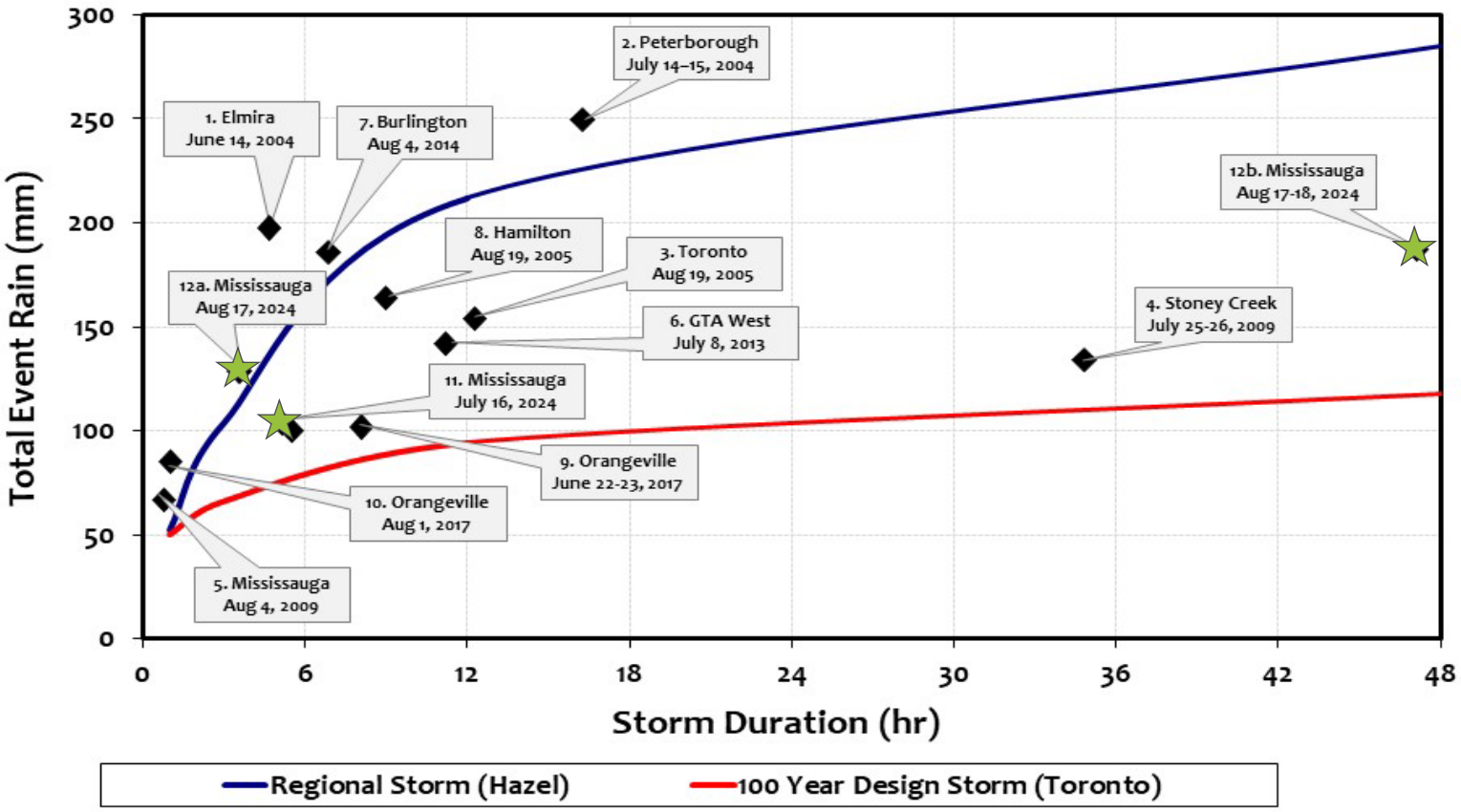
Updated Aug. 29, 2024 at 8:00 a.m. | Aug. 28, 2024 | 2 min read

August 17, 2024

July 16, 2024


July 8, 2013

Extreme Events & Infrastructure Planning



- Infrastructure Design is based on **"Levels of Service":**
  - **Minor System** (i.e., Storm Sewers) → **5-year Storm** (20% / year)
  - **Major System** (i.e., Roadways) → **100-year Storm** (1% / year)
  - **Bridges / Culverts** → **25-year Storm** (4% / year) up to **100-year Storm** (1% / year) or **"Regulatory" Storm**

These **12** (+/-) **extreme storms** have **exceeded the 100-year** design storm (in terms of rainfall)

Of which, ***6 events exceeded the Regional Storm***

Infrastructure Planning – Level of Service and Risk

- Infrastructure design has limitations (designing looking in the rearview mirror instead of what's ahead of us)
- Critical to understand the areas of greatest risk to prioritize protection / enhancement of natural assets, retrofits / upgrades and emergency preparedness
    - *Informed through watershed-scale modelling, field monitoring, master planning and detailed infrastructure assessments*

- **What Level of Risk is a community willing to accept and pay for?**
- **What is an acceptable level of service under future Climate Change?**

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Background for RROIT

National Adaptation Strategy & Municipal Pressures

By 2050, **all infrastructure systems** in Canada are **climate resilient** and undergo continuous adaptation to adjust for future impacts, to deliver reliable, equitable and sustainable services to all of society.

60% of public infrastructure is owned and managed by Local governments. Achieving NAS will require a high-level of participation by municipalities and Indigenous communities.

Increasing **budget pressures and competing priorities** – resiliency investments lower priority → Currently, **no compelling business case** for municipalities to make resiliency investments against competing priorities.

National Infrastructure and Buildings Climate Change Adaptation: State of Play Report

Priority Recommendation to Achieve Short/Medium Term NAS Goals:

- Provide support tools, training, guidance for meeting funding applications with particular focus on addressing technical gaps such as assessing service level, lifecycle, cost-benefit, ecosystem services and social outcomes of nature-based and green infrastructure solutions.

Infrastructure Canada Climate Change Lens requires aspects of grey, green and natural assets, cost-benefit analysis and GHG emissions / Carbon Sequestration

Risk & Return on Investment Tool (RROIT)

Over the past 7 years, CVC and its research partners developed the **Risk & Return on Investment Tool (RROIT)** to address these technical gaps in infrastructure / social planning.

- Outcomes of RROIT directly support funding applications (i.e., INF Canada Climate Lens, etc.)

This has included research contributions / collaborations / partnerships with **over 30+ different institutions** – teamwork makes the dream work!

- RROIT Partners: Risk Science International (RSI) & Climate Risk Institute (CRI)

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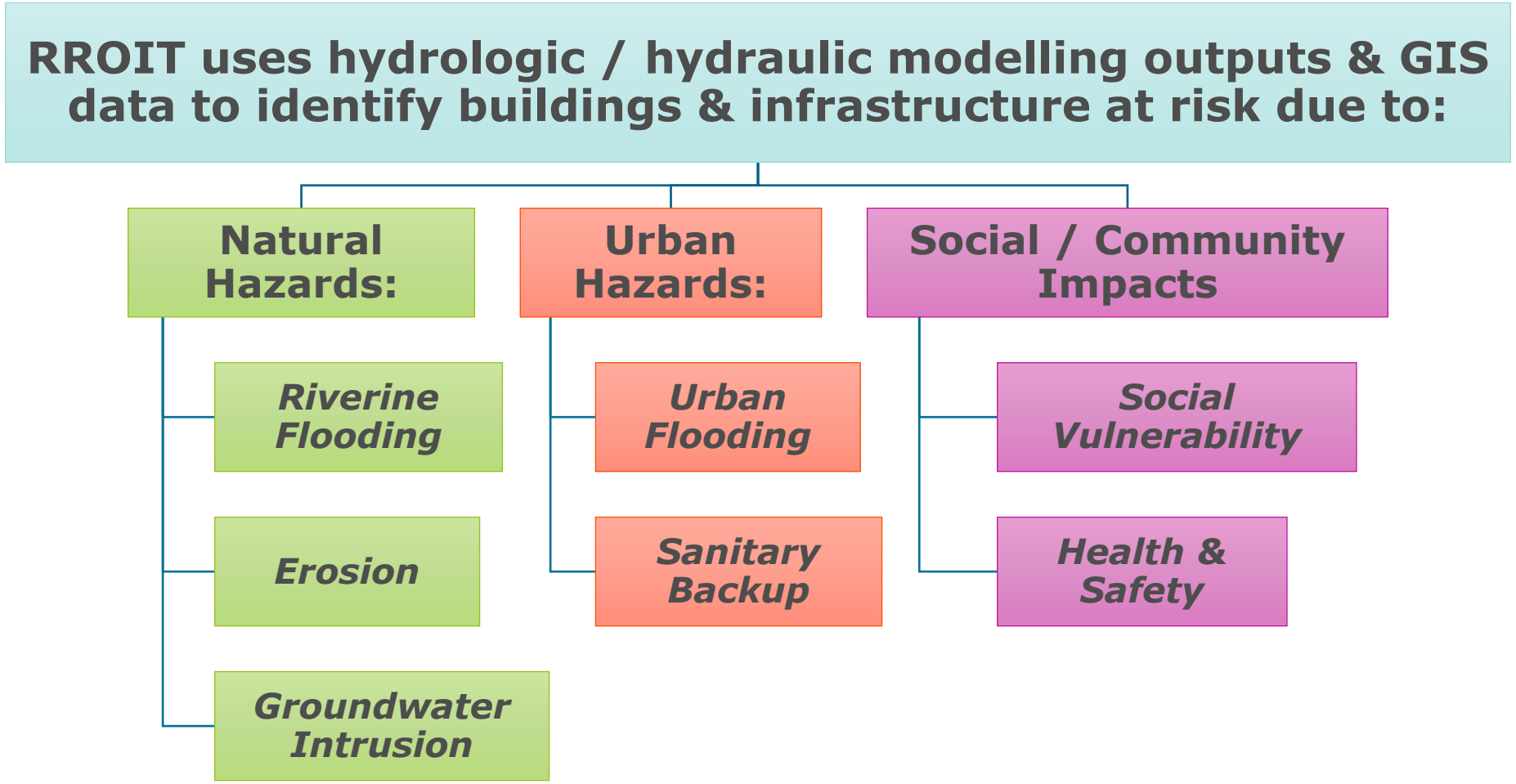
What is RROIT?

Functions & Example Outputs

What is RROIT?

- RROIT is a mathematical and GIS-based model that analyses the following in their relation to risk and/or financial impact



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What is RROIT?

24 Hour Storm – 2050s		
Current Return Period (years)	**Current Annual Probability (%)**	**2050s Annual Probability (%)**
2	50%	63%
5	20%	32%
10	10%	19%
25	4%	10%
50	2%	6%
100	1%	3%
150	0.69%	2%
325	0.31%	1%

RROIT is also able to complete comparisons between SWM scenarios to identify return on investment (payback, NPV, etc.)

- RROIT can then **calculate the financial damages** associated with each risk and report financial metrics (i.e., AAD, IRR) under both **Historical Climate, and Future Climate Change Projections** (i.e., 2050s, 2080s)
- This helps to identify **areas of greatest risk** and target infrastructure upgrades for the **best return on investment**

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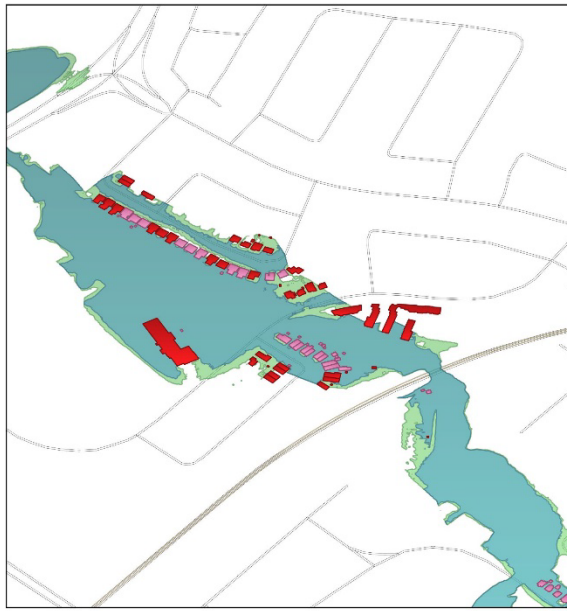
Prioritizing Risk and Collective Actions to Achieve Flood Resiliency with the Greatest Return on Investment

Step 1: Identify assets at risk of flooding / erosion

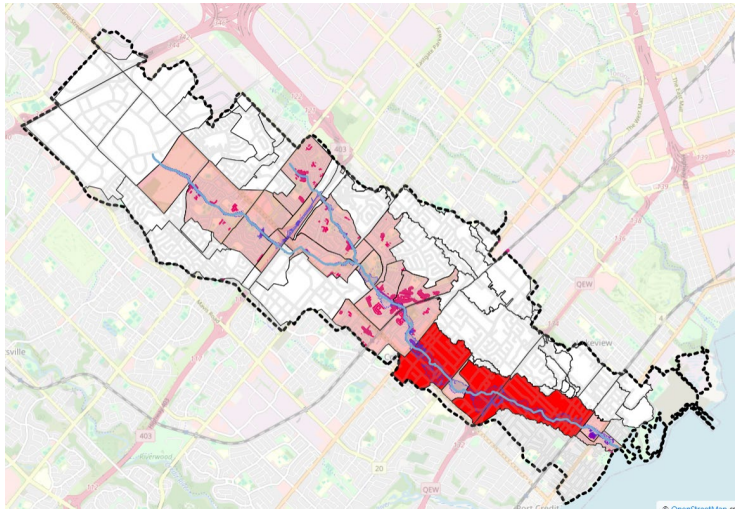


LEGEND
- Cooksville_Boundary
- Roads
- damage-riverine-buildings-100YR_FUT
- damage-riverine-buildings-350YR_FUT
- 100yr Floodplain (Current)
- 350yr Floodplain (Future 100-yr)

Step 2: Quantify property and infrastructure damages

Infrastructure at Risk	5-yr	100-yr
Buildings (#)	12	132
Roadways (m)	675	21,800
Railways (m)	0	1,985
Total Flood Damage ($)	**$13M**	**$70M**

Step 3: Prioritize high risk areas for targeted investments



Better Understanding of Dominant Risks → Identify Damage Centers in Need of Retrofits, Enhanced Emergency Preparedness or Post-Storm Relief Programs

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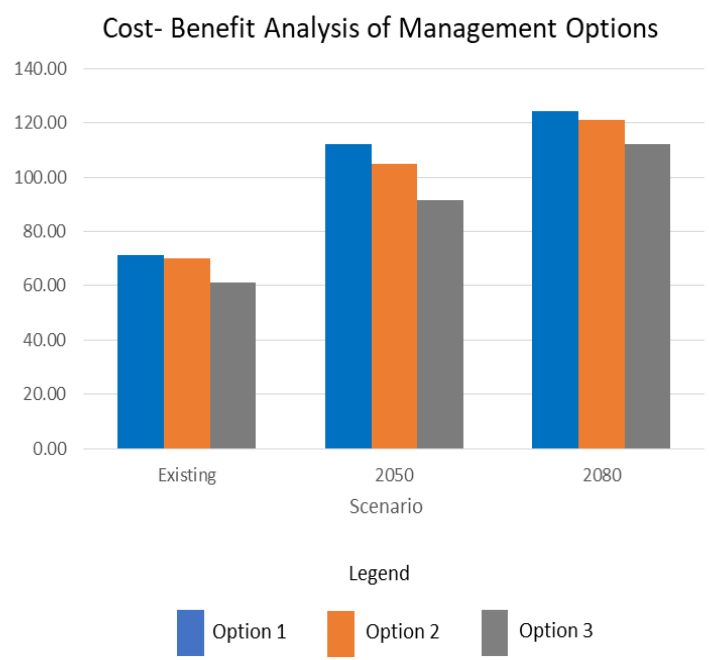
Prioritizing Risk and Collective Actions to Achieve Flood Resiliency with the Greatest Return on Investment

Step 4: Assess Cost-Benefit of Solutions



Financial Statistics under Existing & Future Climate:

- Average Annualized Damages (AAD)
- Payback Period (yrs)
- Internal Rate of Return (IRR)
- Net Present Value (NPV)

Local Stressors
- Future Development / Land Use Change
- Climate Change Rainfall

Infrastructure Capacity Improvements:
- Storm Sewer Capacity (Pipes / Inlets)
- Bridge / Culvert Capacity

Runoff Reduction:
- Upstream Quantity Control
- Low Impact Development

Land Management:
- Acquisition of Flood Vulnerable Lands
- Flood Proofing / Berming
- Natural Heritage Enhancements

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Prioritizing Risk and Collective Actions to Achieve Flood Resiliency with the Greatest Return on Investment

Step 5: Support the business case for funding applications, partner plans, and in-the-ground action

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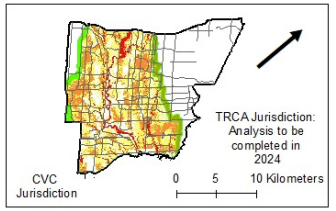
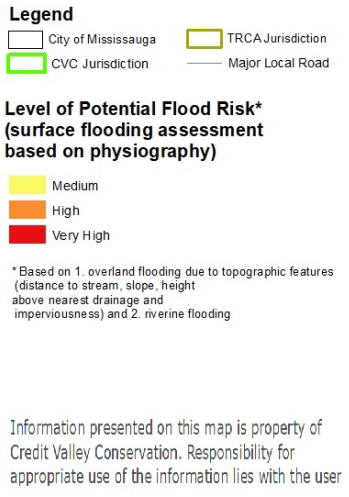
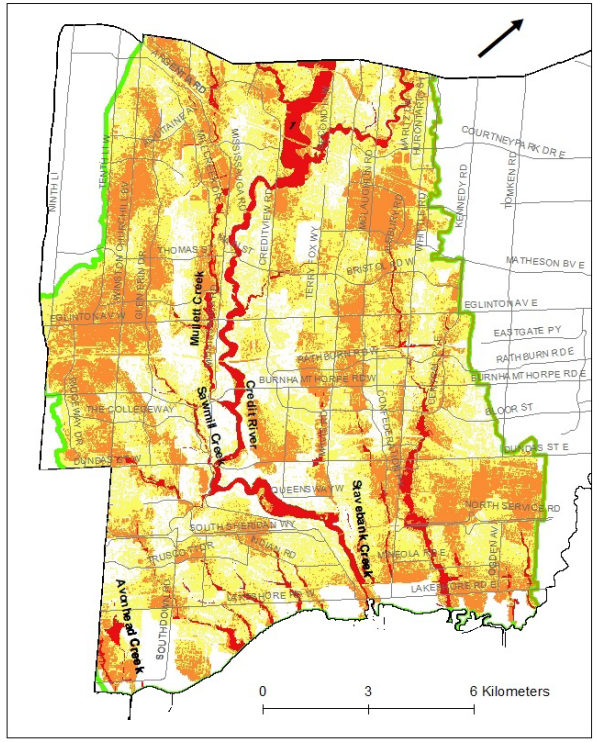
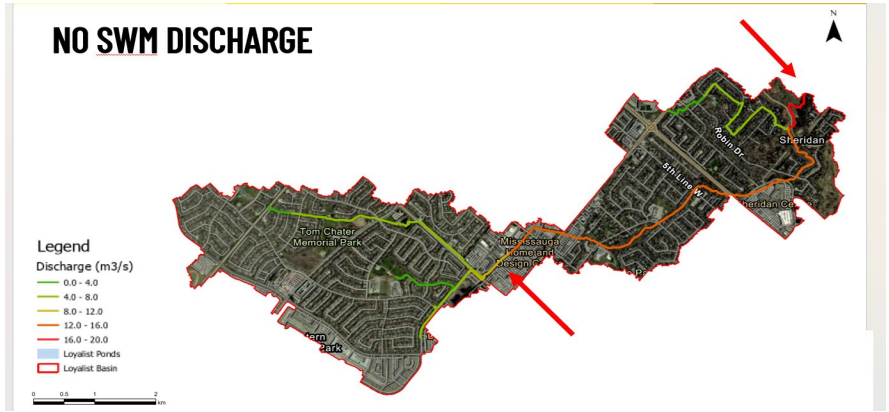
RROIT-Lite Screening Tools for Larger Scales & less Data Rich Jurisdictions









RROIT-Lite GIS-Based Screening Tools:

- In absence of detailed modelling information – GIS-screening tools have been developed for:
  - Urban Overland (Pluvial)
  - Stream Power for Erosion
- Based upon physiography / simple inputs (DEM, Land Use, etc.) and can be run at large scales (i.e., municipal wide)
- Helps to prioritize high-risk areas for further detailed study (i.e., dual drainage modelling or fluvial geomorph)

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What do you need to run RROIT?

Input Data Needs

RROIT – Input Data Sets

BASE DATA

Study Area Information:

- Digital Elevation Models (DEM)
- Region of Interest
- Aggregate Boundary
- Land Use

HYDROLOGIC / HYDRAULIC MODEL

Riverine Flood Risk:

- Floodplain
- Water Surface Elevation
- Velocity
- Subcatchments

Erosion Risk:

- Floodplain Limits
- HEC-RAS Outputs for :
  - Cross-sections
  - Bridges
  - Culverts

Urban Overland Flood Risk:

- Major System Junctions + Key Results
- Sub-catchments

Typically, from HEC-RAS, PCSWMM, Visual OTTHYMO, etc.

INFRASTRUCTURE AT RISK

Flood Risk

- Buildings
- Roadways
- Railways
- Critical Infrastructure

Erosion Risk

- Buried Infrastructure
- Parks & Trails

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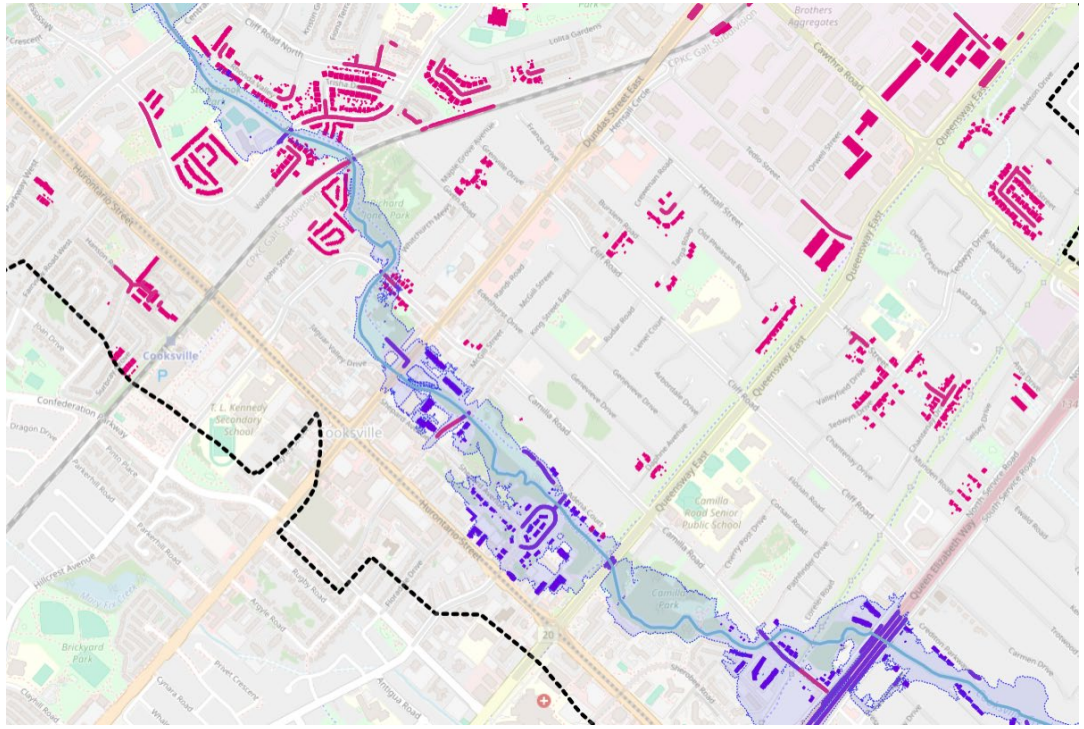
What will RROIT produce?

Example Outputs

Event-Based Flood Damage Analysis

Riverine (Purple) & Urban (Pink) Flood Risk



Where Urban Flood Risk has been analyzed (i.e., PCSWMM), Urban Flood Damages can also be quantified.

RROIT can Identity the **Flood Vulnerable Infrastructure** (Buildings, Roadways, Railways), by quantifying:

- The **amount of infrastructure at risk** for each return period storm
- The **potential damages** for each event + **average annual damages**

Infrastructure at Risk	5-yr	25-yr	100-yr
Buildings (#)	12	47	132
Roadways (m)	675	12,235	21,800
Railways (m)	0	1,570	1,985
Total Flood Damage ($)	**$13M**	**$24M**	**$70M**

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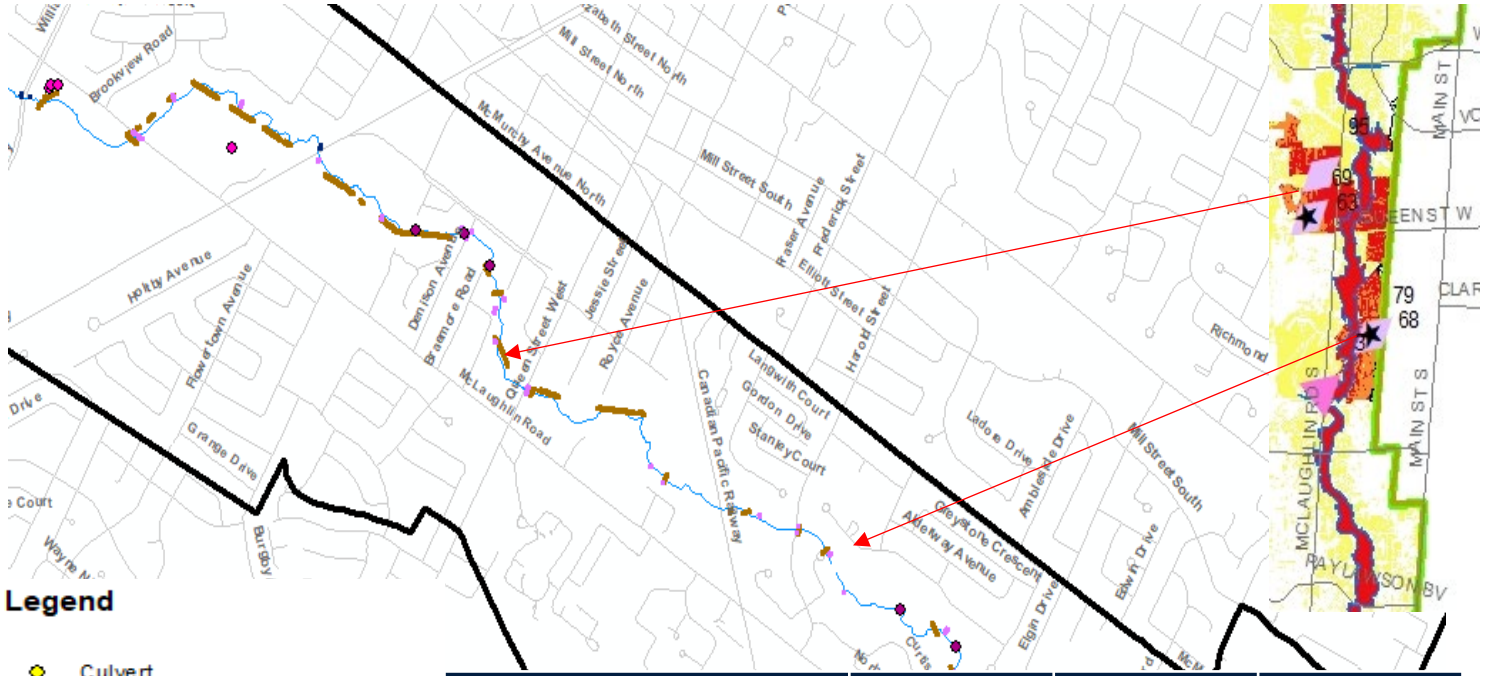
Event-Based Infrastructure Erosion Risk Analysis



Legend

- Culvert
- Water Pumping Station
- Bridge
- Trail
- Gas Line
- Telecommunication
- Storm Sewer
- Sanitary Sewer
- Fletcher's Creek
- Fletchers Creek Subwatershed
- City of Mississauga Boundary

Infrastructure at Risk	5-yr	25-yr	100-yr
Bridges / Culverts (#)	4	16	21
Sanitary Sewers (m)	175	320	560
Gas Lines (m)	15	52	78
…	…	…	…
Total Flood Damage ($)	**$5M**	**$12M**	**$15M**

Critical Infrastructure at Risk of Erosion Damage

- Informs Risk Areas to be Prioritized for Further Study / Fluvial Geomorphic Analysis & Stream Bank Protection
- Used to Prioritize Post-Storm Inspections of Problem Areas after major events
- Identifies Potential Areas requiring Emergent Repairs (i.e., sanitary sewer exposure → SWP risks)

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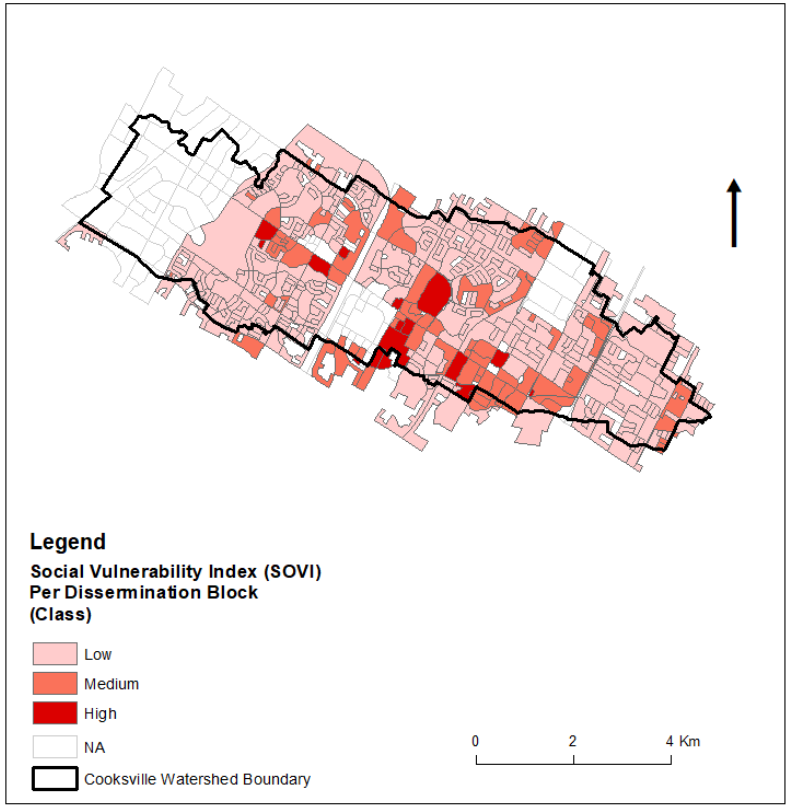
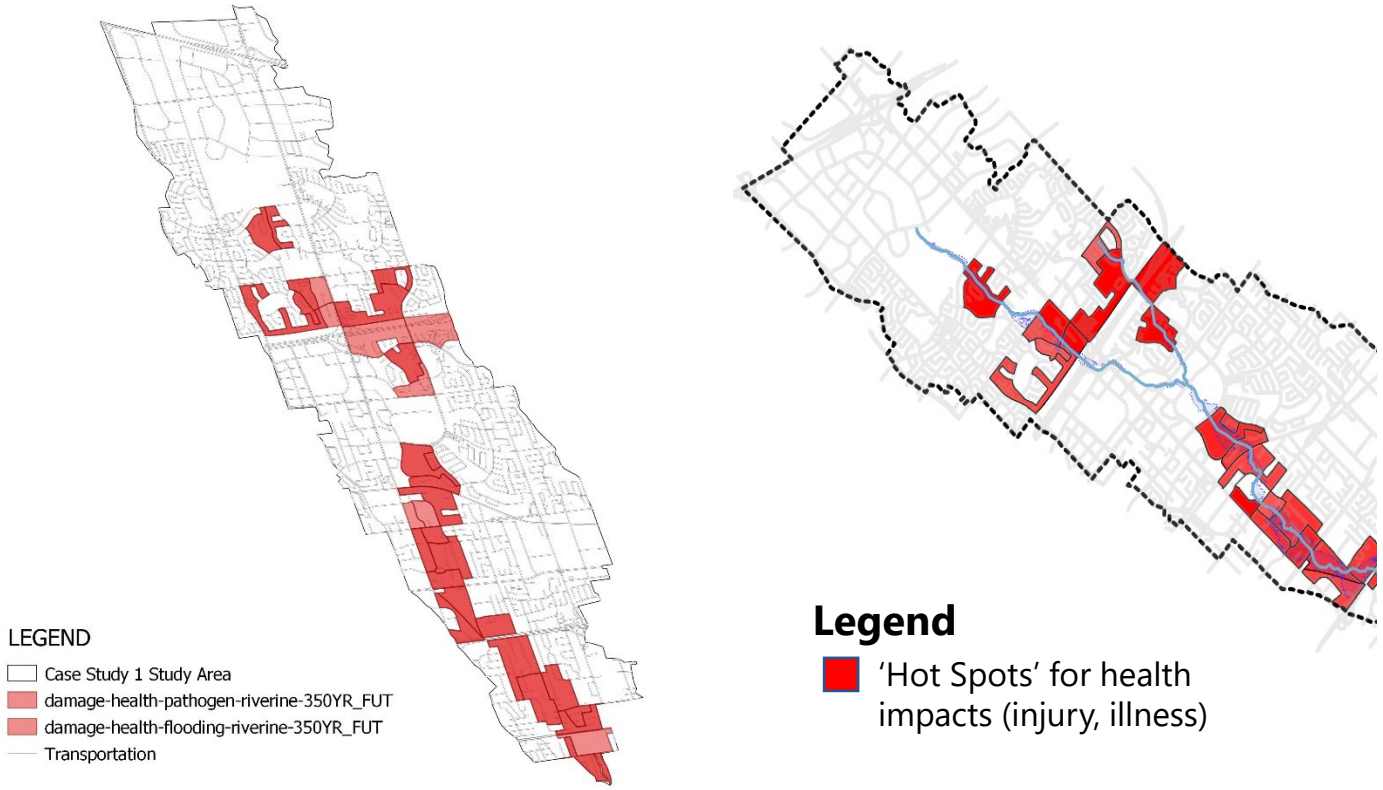
Community, Social & Health Impacts

Social Vulnerability to Flooding



Hot Spots for Health Impacts due to Flooding (Illness / Injury)



Can be used in conjunction with hazard mapping to inform social programs, post-storm relief inspections & community outreach in vulnerable / impacted areas

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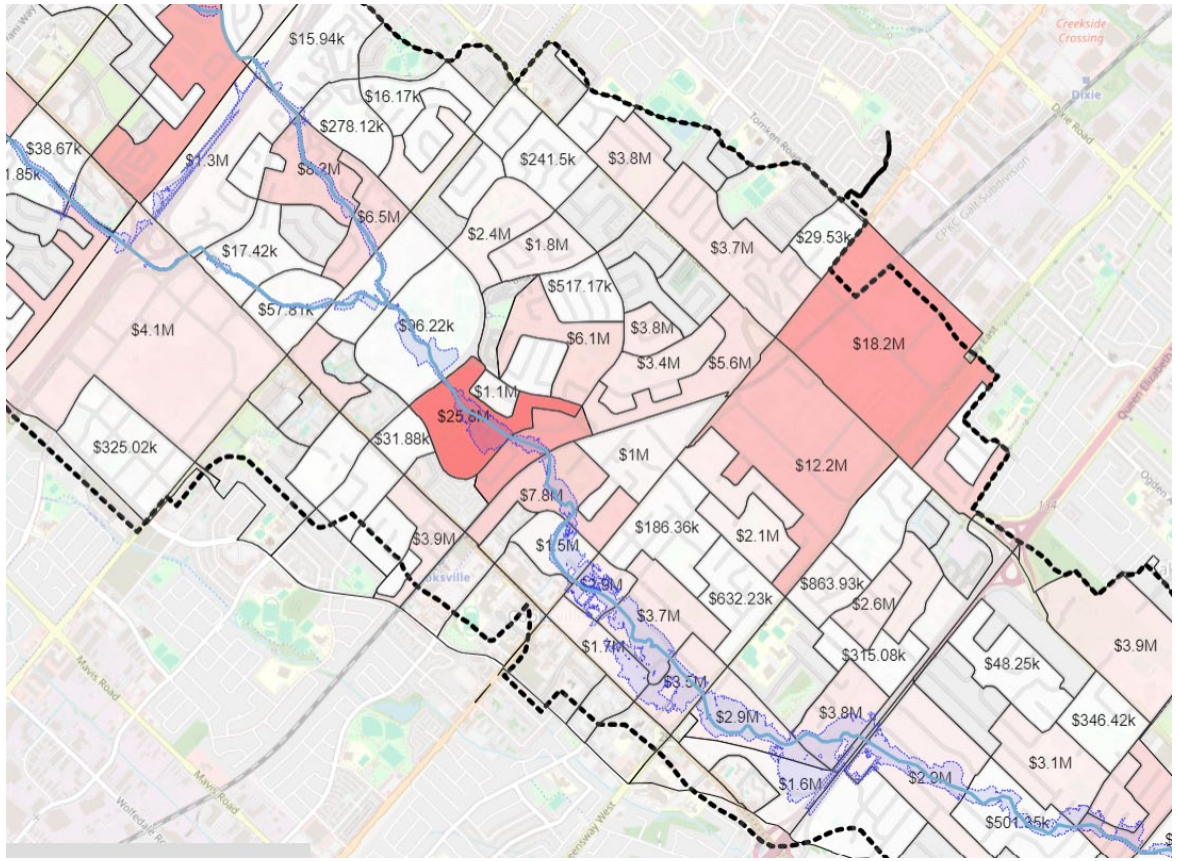
Identifying Key Damage Centers for Prioritization of Infrastructure Investment

Example of Neighbourhood Scale Damage Aggregation



- RROIT can Aggregate all damage results at a Variety of Scales (neighborhoods, wards, subcatchments, etc.)
- These would identify key areas experiencing the highest amount of damages in a storm event, to target:
  - Infrastructure Capacity Improvements
  - Flood & Erosion Protection Programs
  - Enhanced FFW & Evacuation Measures
  - Post-Storm Relief / Social Programs

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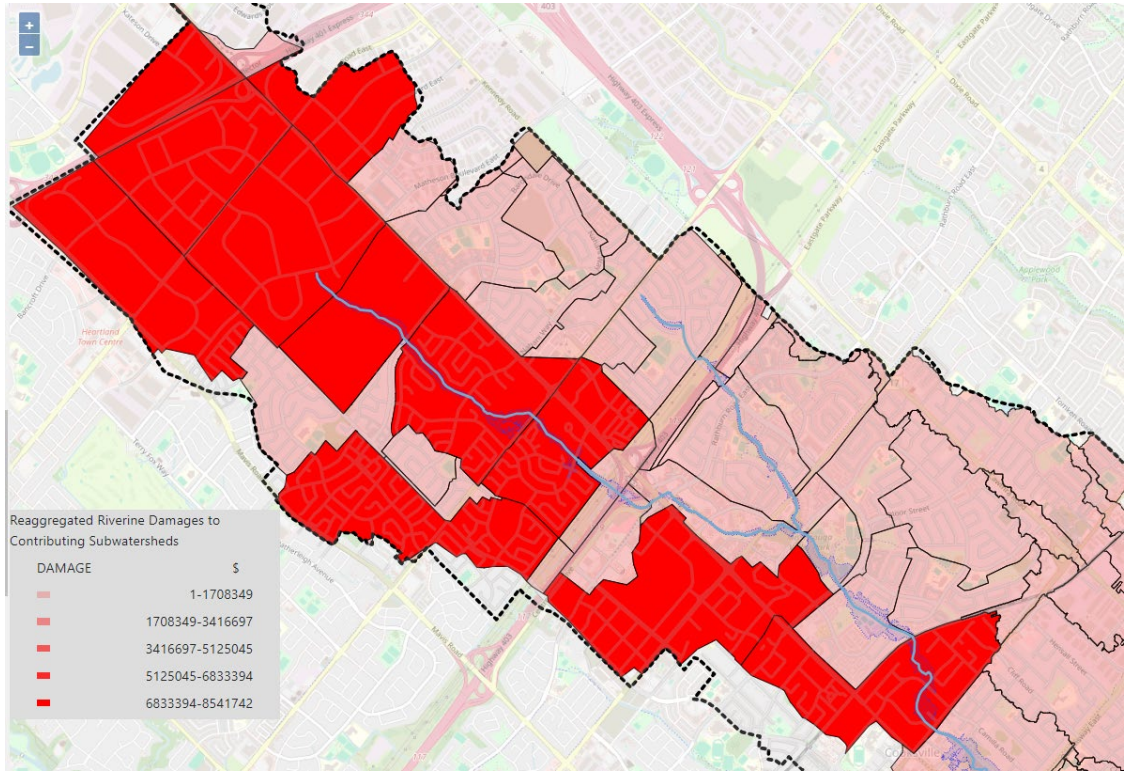
Identifying Key Damage Centers for Prioritization of Infrastructure Investment

- RROIT can also identify the contributing subcatchments to the downstream damage centers, which would be targeted for:
  - Upstream Quantity Control Retrofits
  - LID Retrofits (Erosion / Quality Control)
  - Natural Asset Protection & Enhancements

Example of Upstream Subcatchment Damage Re-aggregation



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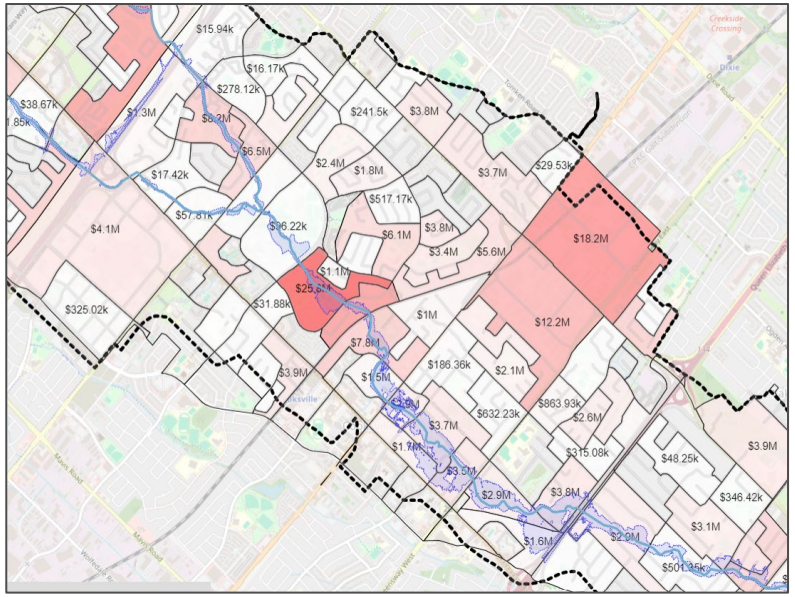
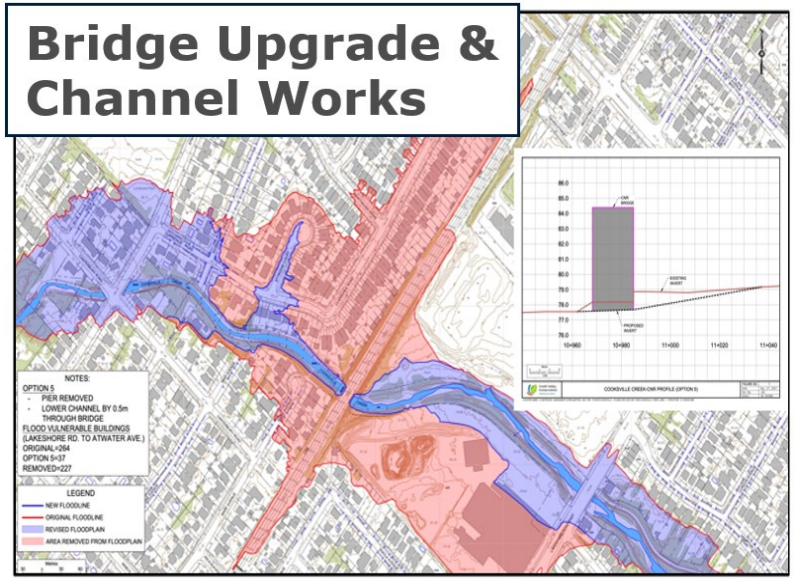
How are we using RROIT?

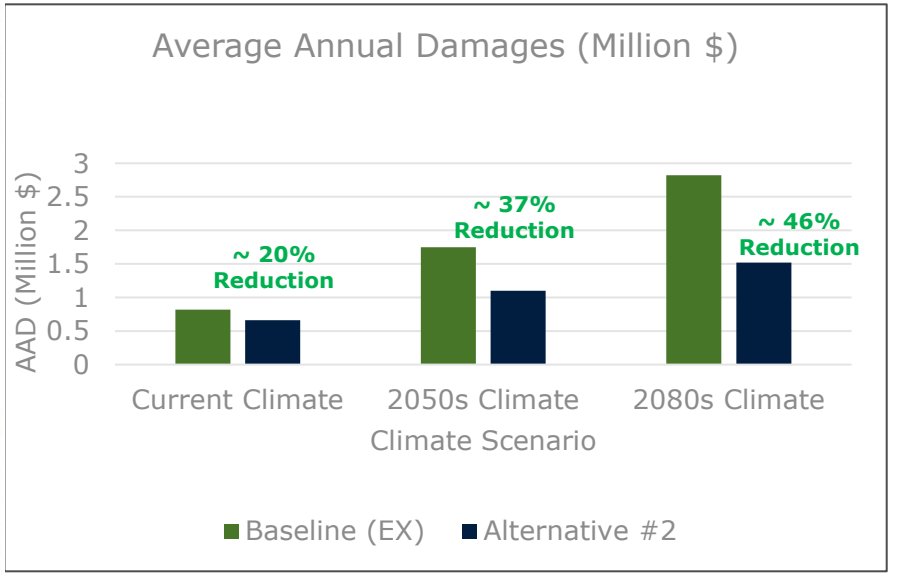
Example Applications

Examples of Strategic Infrastructure Planning for the Greatest Return on Investment



Bridge Upgrade & Channel Works





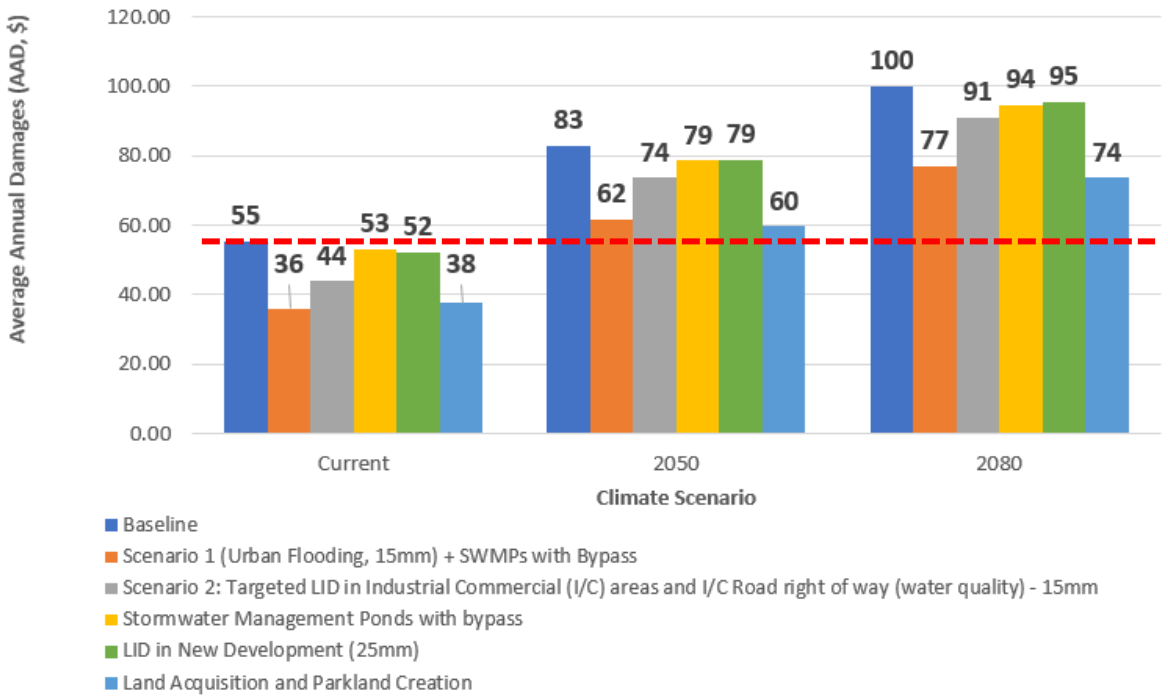
Identify Priority Risks → Identify Solutions → Assess Cost-Benefit

- Bridge / Culvert Upgrades
- Storm Sewer Capacity Improvements
- Upstream Quantity Control Retrofits
- LID Retrofits (Erosion / Quality Control)
- Natural Asset Protection & Enhancements

Watershed Scale Scenario Analysis

- As part of our Credit River Watershed Plan, CVC is running RROIT for 8 case study subwatersheds, to identify the following:
  - Characterization / prioritization of **existing damage centers**
  - Areas of **increased risk / vulnerability due to climate change**
  - **Cost-benefit analysis** for multiple SWM & NHS Strategies at a Subwatershed Scale to **inform levels of service & next steps of municipal planning**

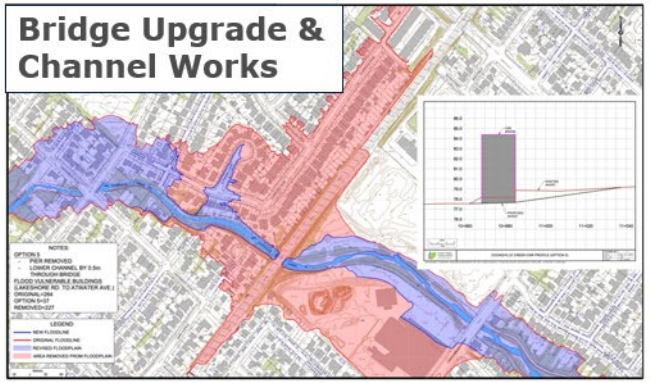
Example of Scenario Comparisons: Conventional 3% reduction in damage avoidance vs. 35% reduction using Watershed Optimization

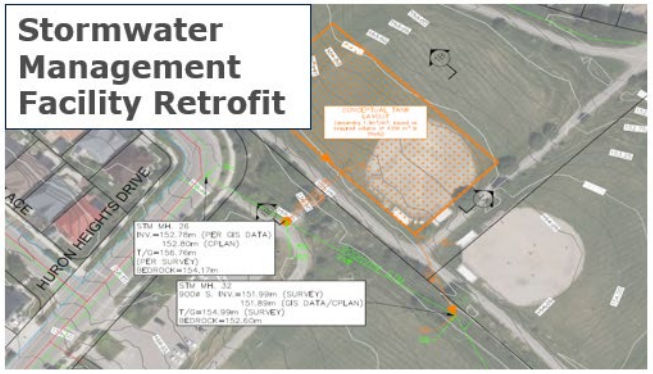


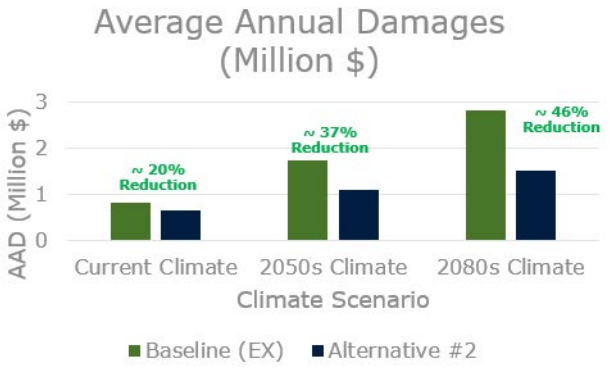
Prioritization / optimization for multi-flood risk reductions is key to achieve the best benefit and achieve desired levels of service!

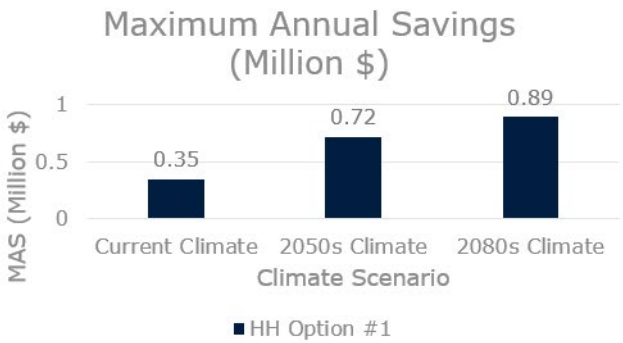
Municipal Project Spotlight – City of Mississauga Infrastructure Upgrades & Retrofits

- We've supported the City of Mississauga with Design Alternative Analysis and quantifying the cost-benefit of various infrastructure options through RROIT
  - *Led to the selection of preferred alternatives, advancements in detailed design and senior management / council endorsement!*





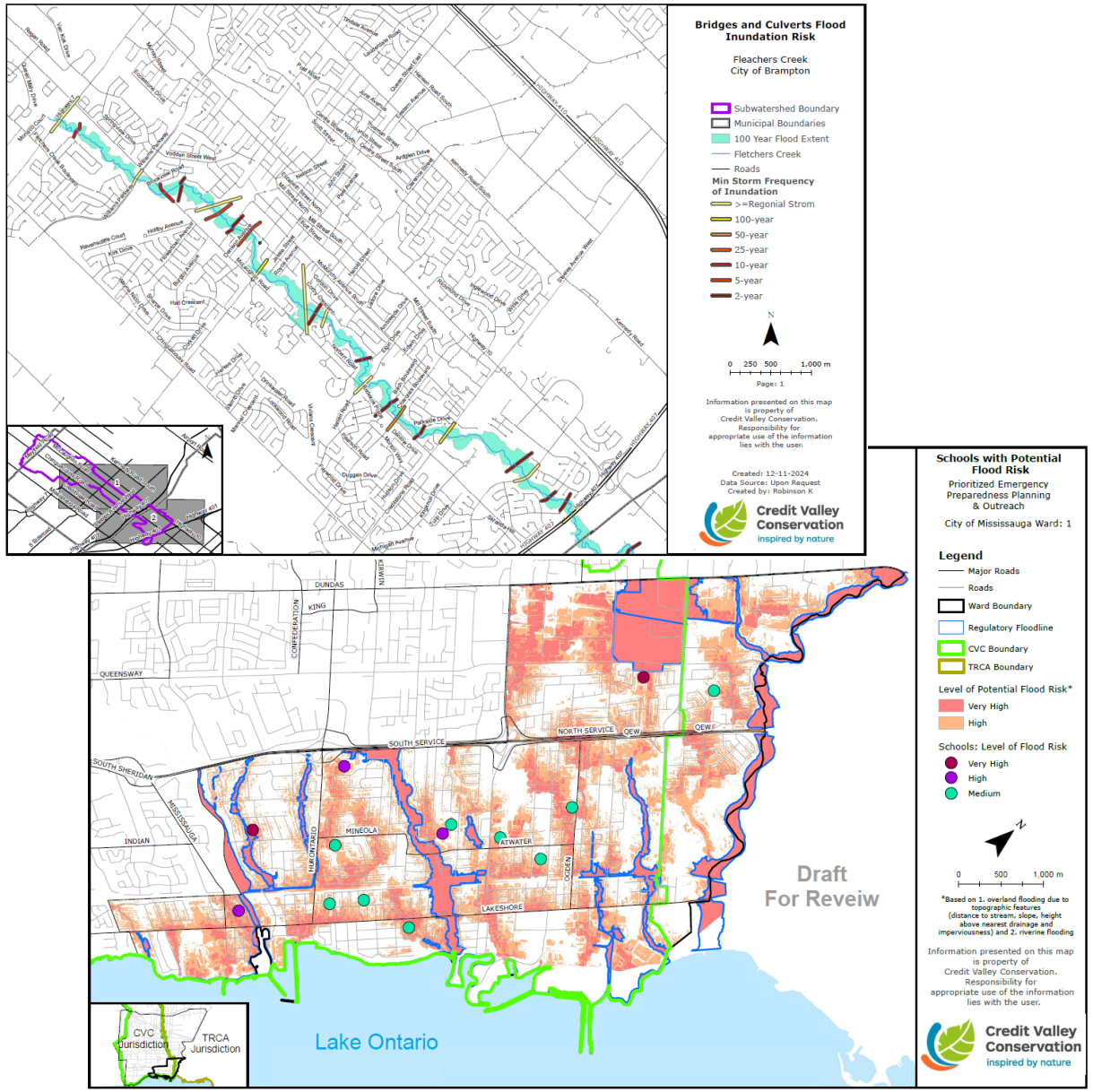




Preferred Design Alt Selected & Moving Forward to Detailed Design!

"The work was very helpful in verifying the value we expect to get out of these … capital projects and confirming to management and/or council that they are worth pursuing economically." - ***The City of Mississauga***

Supporting Emergency Management Planning



RROIT Outputs are being used to support various aspects of municipal emergency management:

- Identifying Damage Centers (Flood / Erosion)
- Roadways at Risk (Flooding)
- Critical Infrastructure at Risk (Erosion)
- Vulnerable Properties / Public Services

"These maps put us in a good place to assist schools with flood evacuation planning and general public education initiatives…I'm grateful to be part of this team!"

Nicholas Ogilvie, Coordinator, Emergency Management, Brampton Fire and Emergency Services

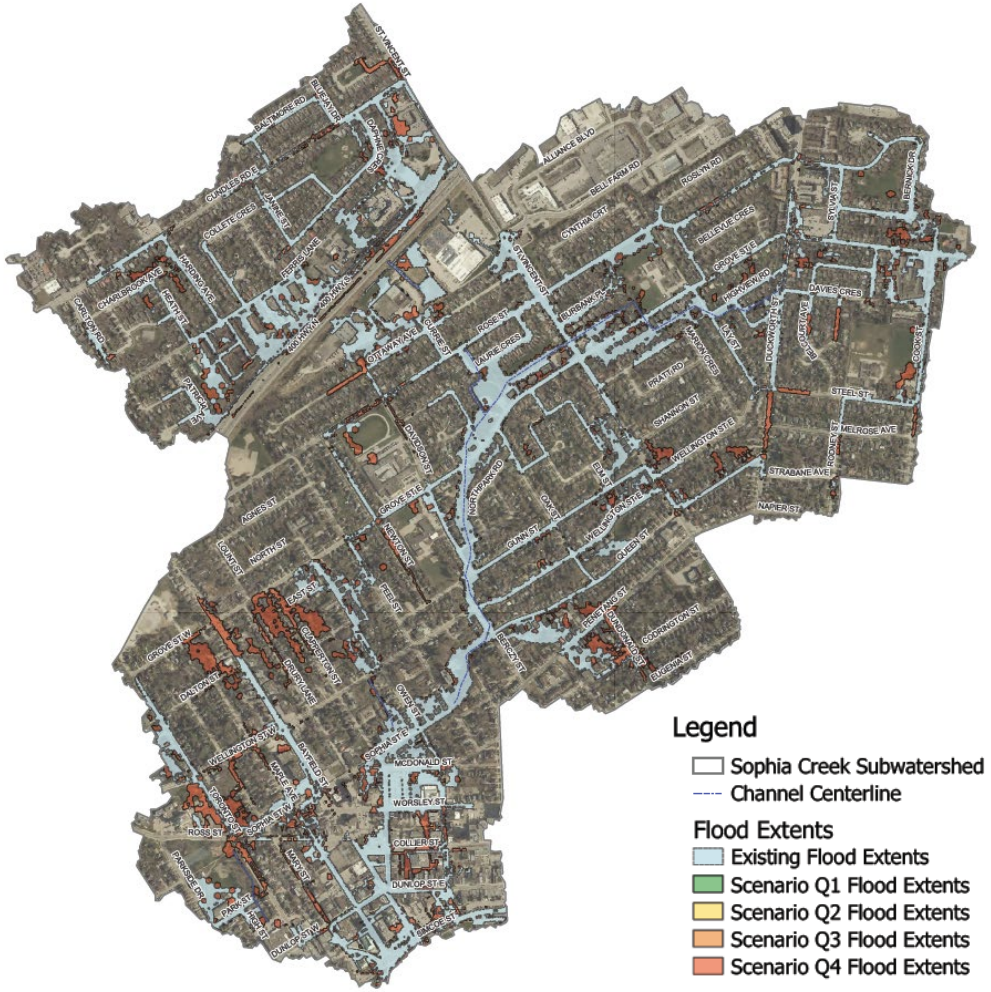
LSRCA & City of Barrie Pilot – Sophia Creek

We are working with LSRCA & the City of Barrie on a pilot project for the first external project using RROIT!

This project includes:

- Evaluation of increased flood risks / damages due to climate change rainfall
- Cost-benefit of various infrastructure upgrades, targeted SWM retrofits and natural asset solutions to inform municipal capital planning

Other Project Opportunities Planned in Partnership with TRCA & NPCA!



Lake Simcoe Region conservation authority

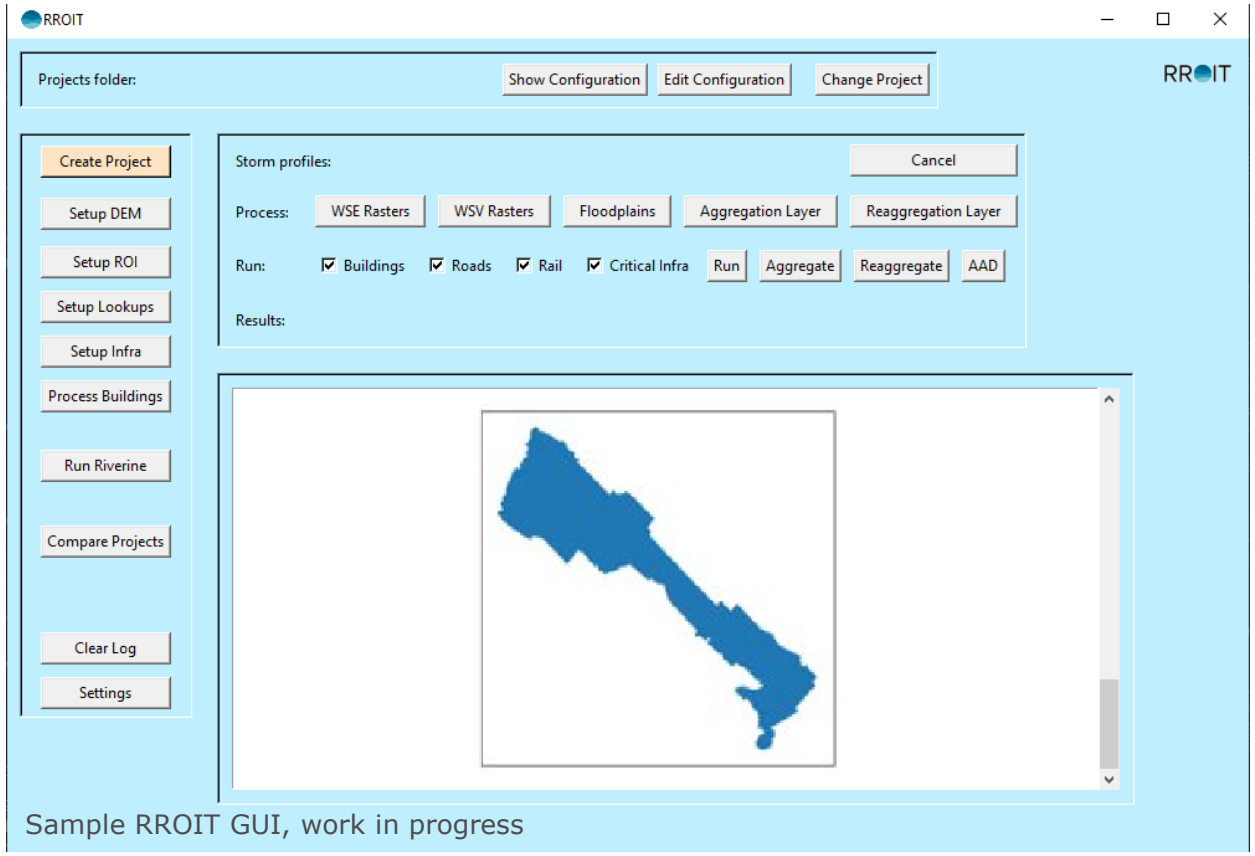
Barrie

Credit Valley Conservation

What's Next for RROIT?

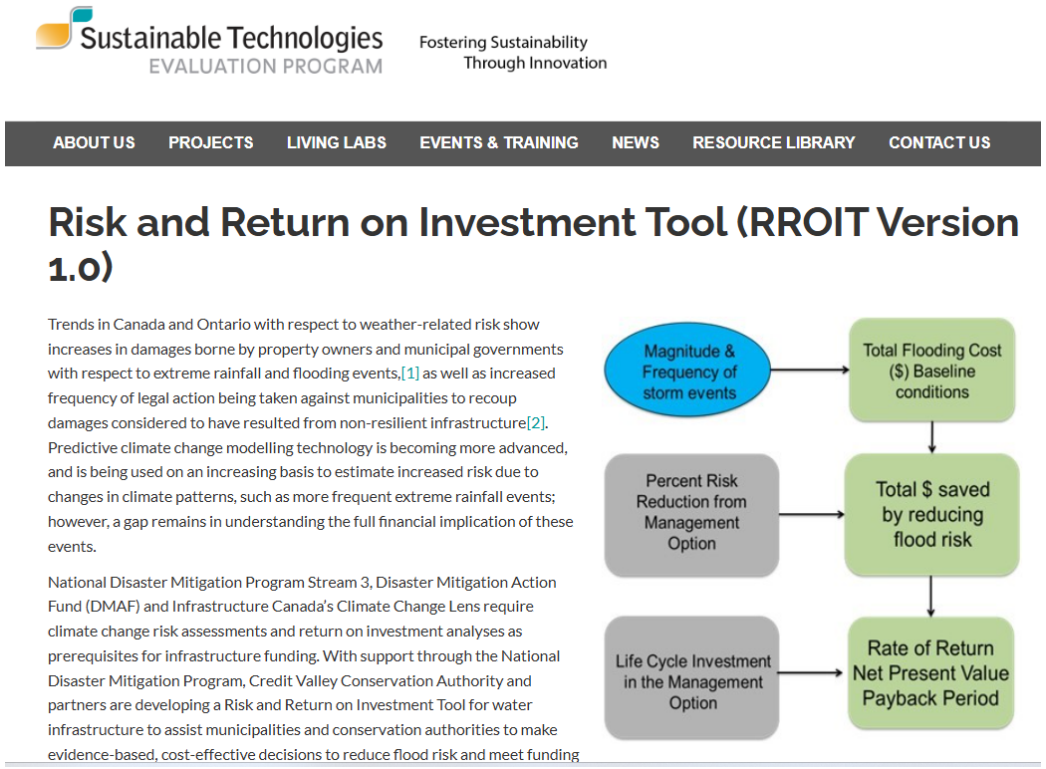
RROIT IS COMING TO A DESKTOP NEAR YOU!

- RROIT was previously a web-based application → it's now been converted to a Desktop Application
  - RROIT Desktop is python-based application with a GUI (Graphical User Interface)
- We are working with STEP to bring RROIT into the STEP Tool Kit
  - Piloting with LSRCA + other CAs in preparation for upcoming public launch



Sample RROIT GUI, work in progress

RROIT Contact Info



- RROIT will be a **Free** Downloadable Application! We are targeting its public launch in 2026, and are planning to host training sessions through STEP with:
  - Conservation Authorities → Municipalities → Private Sector & Academia
- If you / your organization would be interested in learning more, please contact us below about future training opportunities

Emma Haug-Kindellan | M.Eng., P.Eng. | she/her/hers
Engineer, Watershed and Climate Change Risk Science (CVC)
emma.haug-kindellan@cvc.ca | cvc.ca

Credit Valley Conservation

Questions?

Thank you!

Emma Haug-Kindellan | M.Eng., P.Eng. | she/her/hers
Engineer, Watershed and Climate Change Risk Science (CVC)
emma.haug-kindellan@cvc.ca | cvc.ca

Credit Valley Conservation

Our Partners in Conservation

Region of Peel working with you

Halton Region

Mississauga

Brampton

Town of Caledon

Town of Erin

Town of Halton Hills

Town of Mono

Oakville

Orangeville
Historic Charm Dynamic Future

Township of Amaranth

Township of East Garafraxa

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