2017 FloodNet AGM

Project 1-5: Spatial changes to flood prone areas in urban environments

2017 update

Andrew Binns, Yiping Guo, Slobodan Simonovic, Zihao Zhang, Tommy Kokas

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Introductions

Dr. Andrew Binns; Philip de Boer

- School of Engineering, University of Guelph

Dr. Yiping Guo; Zihao Zhang

- Civil Engineering, McMaster University

Dr. Slobodan Simonovic; Tommy Kokas

- Civil and Environmental Engineering, University of Western Ontario

Overview of Presentation

1. Background
2. Project 1-5 goal and approach
3. Project schedule
4. Black Creek subwatershed summary (Kokas)
5. City of Edmonton plan (Zhang)

Background

- The effects of changing flows due to climate change pose threats to rivers in dense urban environments (Ashmore and Church 2001)

- Intensifying development in these environments
  - Greater rates of stormwater runoff
  - Increases risk of exposure to extreme precipitation events

Toronto 2013

From: http://www.lexikubrak.com/

Essex County 2016 (Windsor, Tecumseh)

From: http://www.cbc.ca

Urban Flood Damages

- This results in greater economic losses associated with flood events, including:
  - Basement flooding
  - Damage to infrastructure (e.g., culverts, dams, bridges)
  - Erosion, river instability and loss of land

Project 1-5 Goal

- **Objective:** to **investigate spatial changes to flood prone areas** in **urban environments** as a result of changing environmental and hydrological factors

Environmental	Hydrological
Changes in land-use (i.e., urbanization)	Changing distribution of precipitation
Modification to fluvial systems	Changing magnitude of precipitation events

- Investigate **measures to reduce** the effect of these changes on **the extent of flooding**

Project 1-5 Approach

- Assess how urban landscape has been changing in Canadian cities of varying levels of urbanization
  - Toronto (ON), Hamilton (ON), Edmonton (AB)

  } Historical land-use images

- Assess how changes in land use (and associated changes in impervious area) have affected the extent of flooding

  } Modeling

- Characterize patterns of development more resilient to floods

  } Comparison

- Evaluate effectiveness of stormwater management features to mitigate extent of flooding

  } Modeling

Project 1-5 Schedule and Students

Project	Case study city	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
MSc #1 (Tommy Kokas)	Toronto	**Western / Guelph**				
MSc #2 (Zihao Zhang)	Edmonton			**McMaster**		
MSc #3 (Philip de Boer)	Hamilton				**Guelph / McMaster**	

Expected contributions

The outcomes of this project aim to include:

1. Understanding relationship between flooding and land-use in urban environments

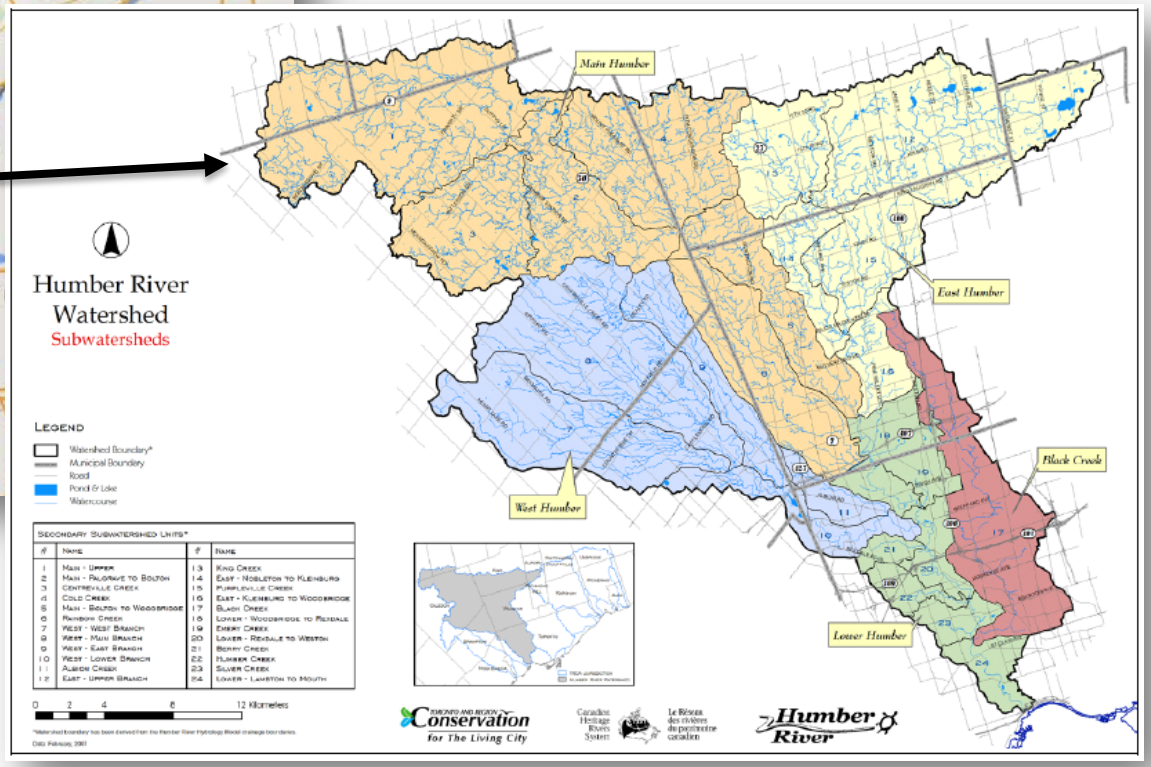
2. Provide guidance for future urban development

3. Assist in planning and development of appropriate flood mitigation measures (i.e., stormwater management features)

Black Creek Subwatershed Toronto, ON

Map of Southern Ontario (Google Maps)

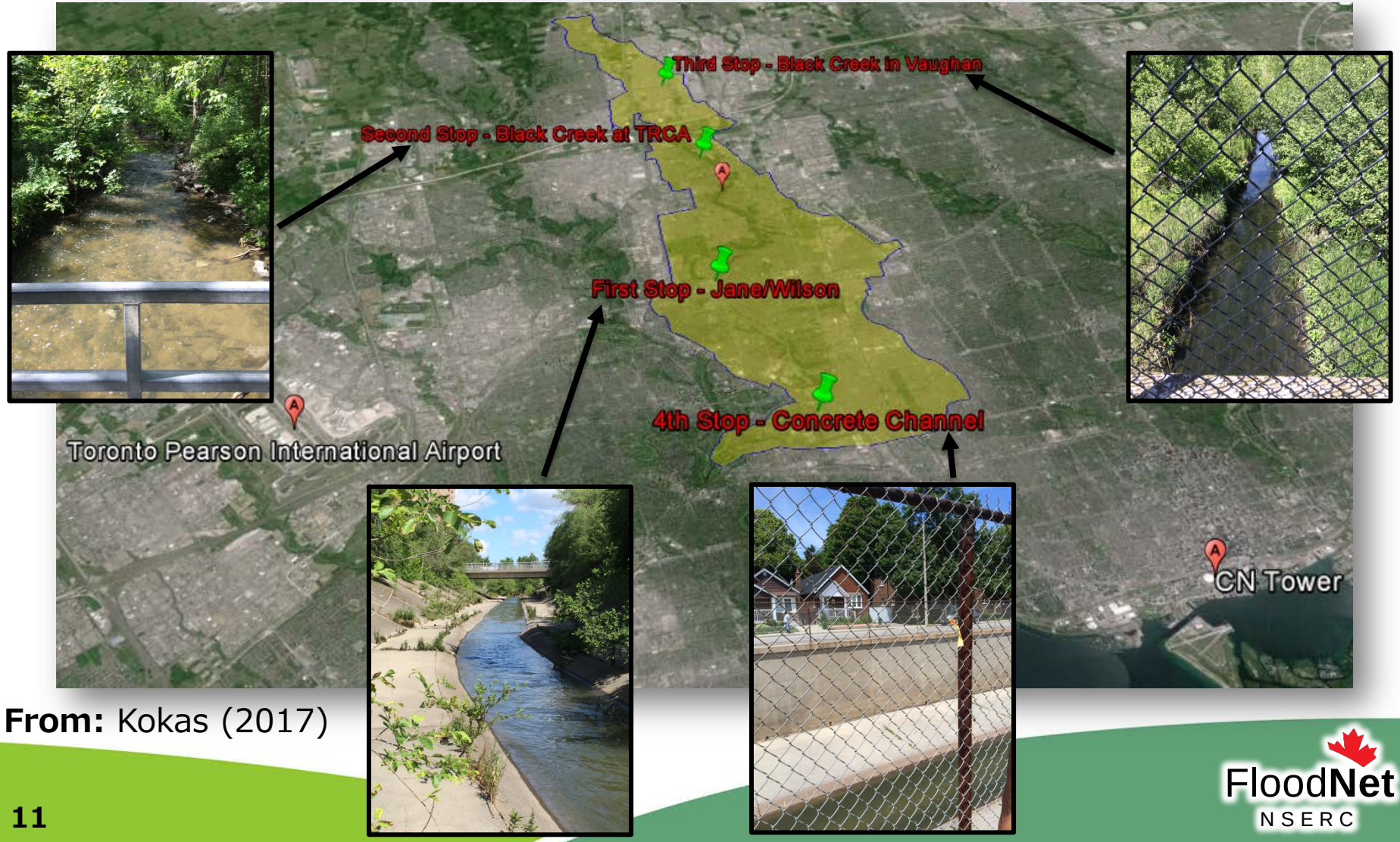
From: Kokas (2017)



Humber River Watershed (TRCA, 2008)

Drainage area of Black Creek subwatershed: 6,500 ha

Black Creek Subwatershed Toronto, ON



From: Kokas (2017)

FloodNet NSERC

Black Creek Subwatershed Toronto, ON

- **Goals:**
  - Develop greater understanding of relationship between flooding and land-use change
  - Evaluate effectiveness of low impact development measures
  - Provide recommendations based on investment vs. impact

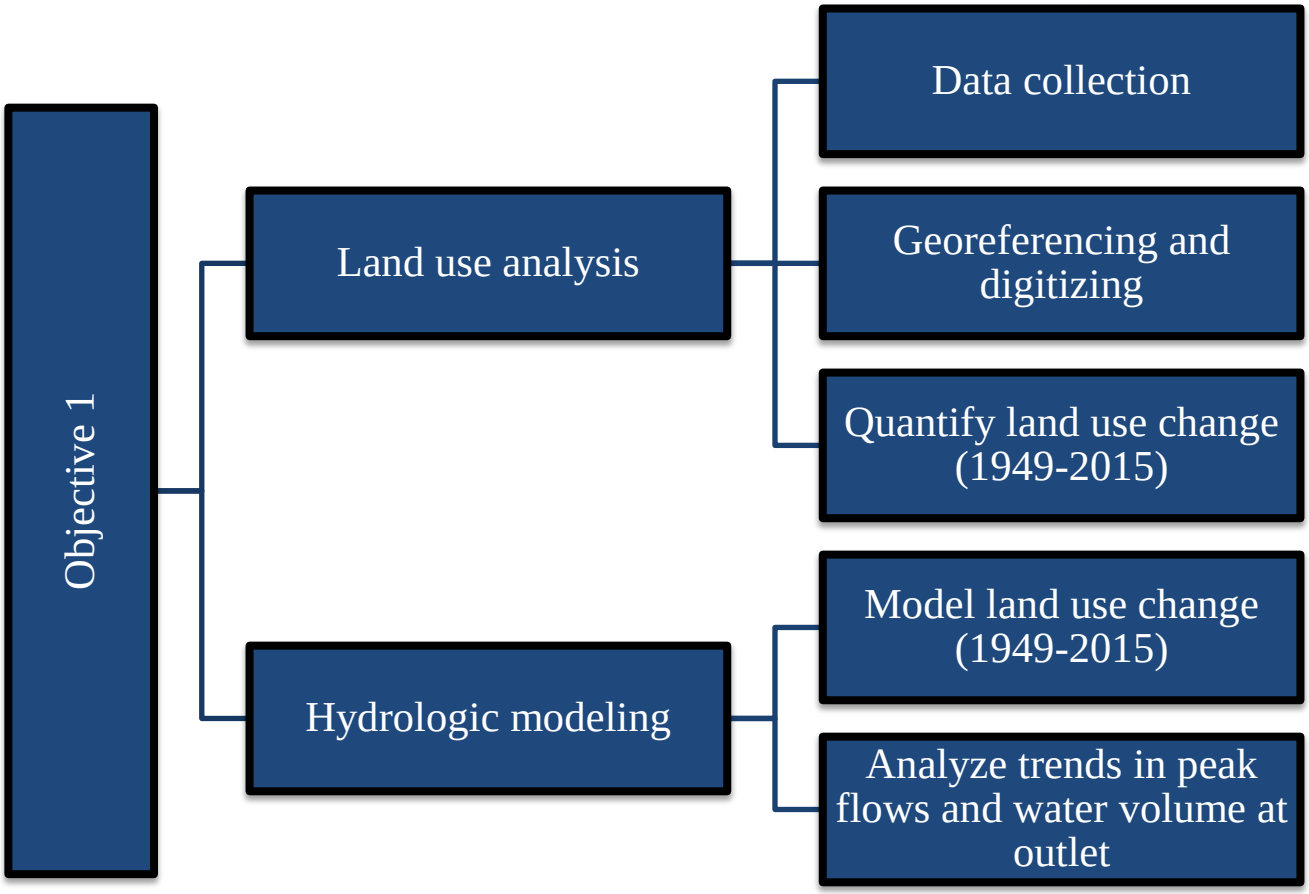
- **Partner:** Toronto and Region Conservation

Au

Toronto and Region Conservation for The Living City

Fabio Tonto
Wilfred Ho
Michael Heralall
Harris Switzman

Land Use Analysis



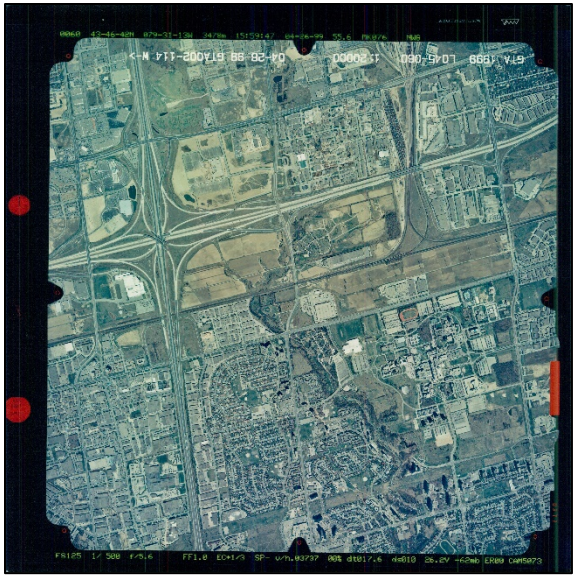
PCSWMM based on SWMM5

From: Kokas (2017)

Land Use Analysis

Toronto in 1949

Toronto in 1971



Toronto in 1999

Images from Toronto and Region Conservation Authority and City of Toronto Archives

From: Kokas (2017)

Land Use Analysis

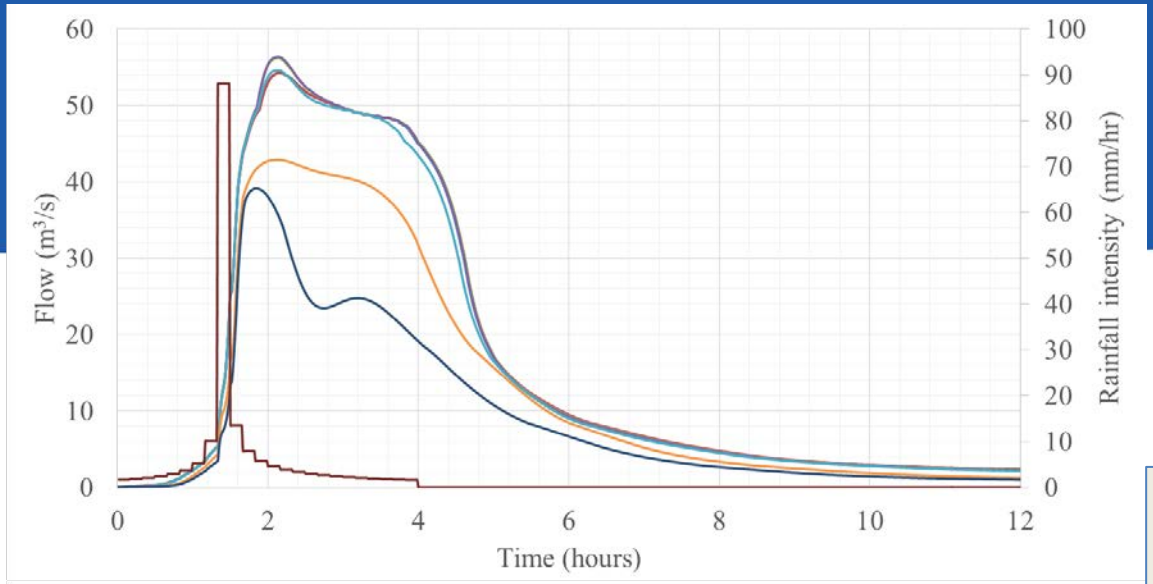
Aerial view of Black Creek subwatershed in Toronto, ON

Southern subcatchments became > 50% impervious in early 1960s

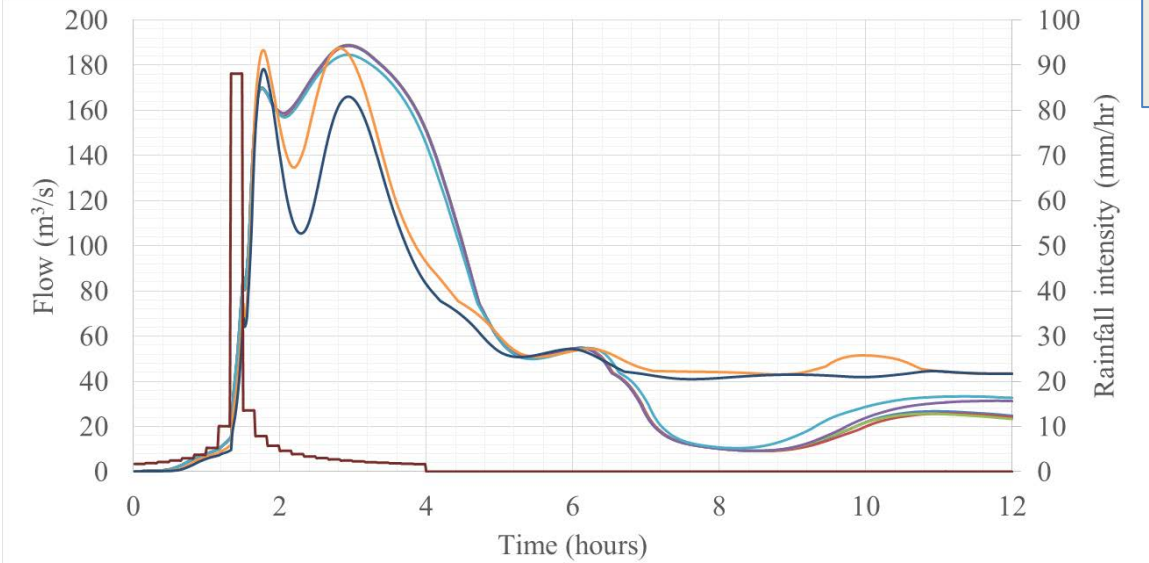
Northern subcatchments became more impervious more recently (1980s)

From: Kokas (2017)

Outlet hydrograph in response to a 2-year event



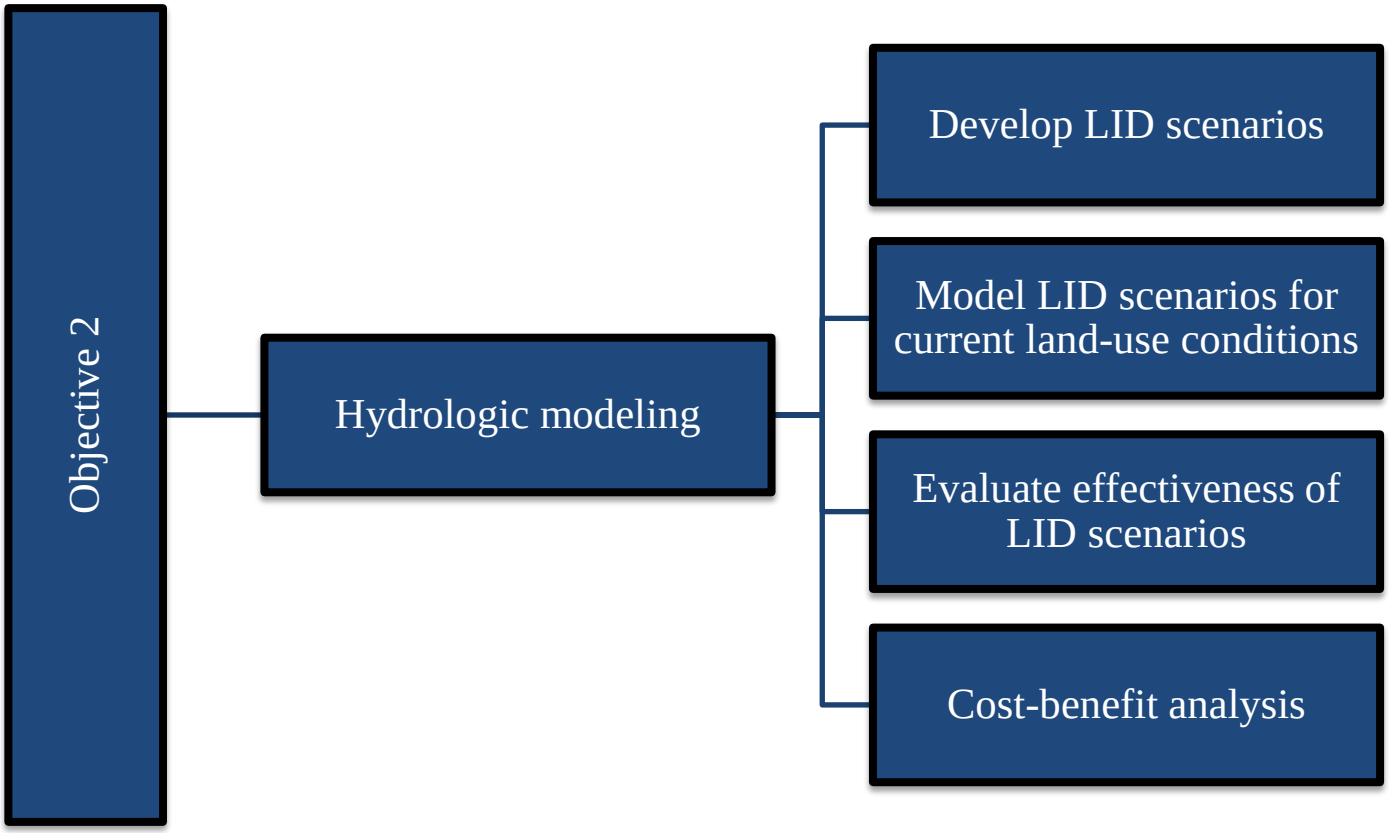
Outlet hydrograph in response to a 100-year event



What can be done to reduce the peak flows?

From: Kokas (2017)

Effectiveness of Low Impact Development (LID) Measures



From: Kokas (2017)

LID Scenarios

Scenario #	Sub. #	Size of sub.	Area (ha)	LID (# of units)							Total cost
				RB	BC	RG	IT	RD	CL	VS	($)
3	19	Small	61.4	3,250	30	0	57	0	62	77	10,004,055
4	19	Small	61.4	6,500	60	0	114	0	124	154	20,008,110
5	10	Medium	231.1	3,000	15	0	40	0	75	50	10,000,140
6	10	Medium	231.1	6,000	30	0	80	0	150	100	20,000,280
7	5	Large	835.3	3,000	15	0	40	0	75	50	10,000,140
8	5	Large	835.3	6,000	30	0	80	0	150	100	20,000,280

From: Kokas (2017)

LID units

RB = rain barrels

BC = bioretention cell

RG = rain garden pavement)

VS = vegetated swale

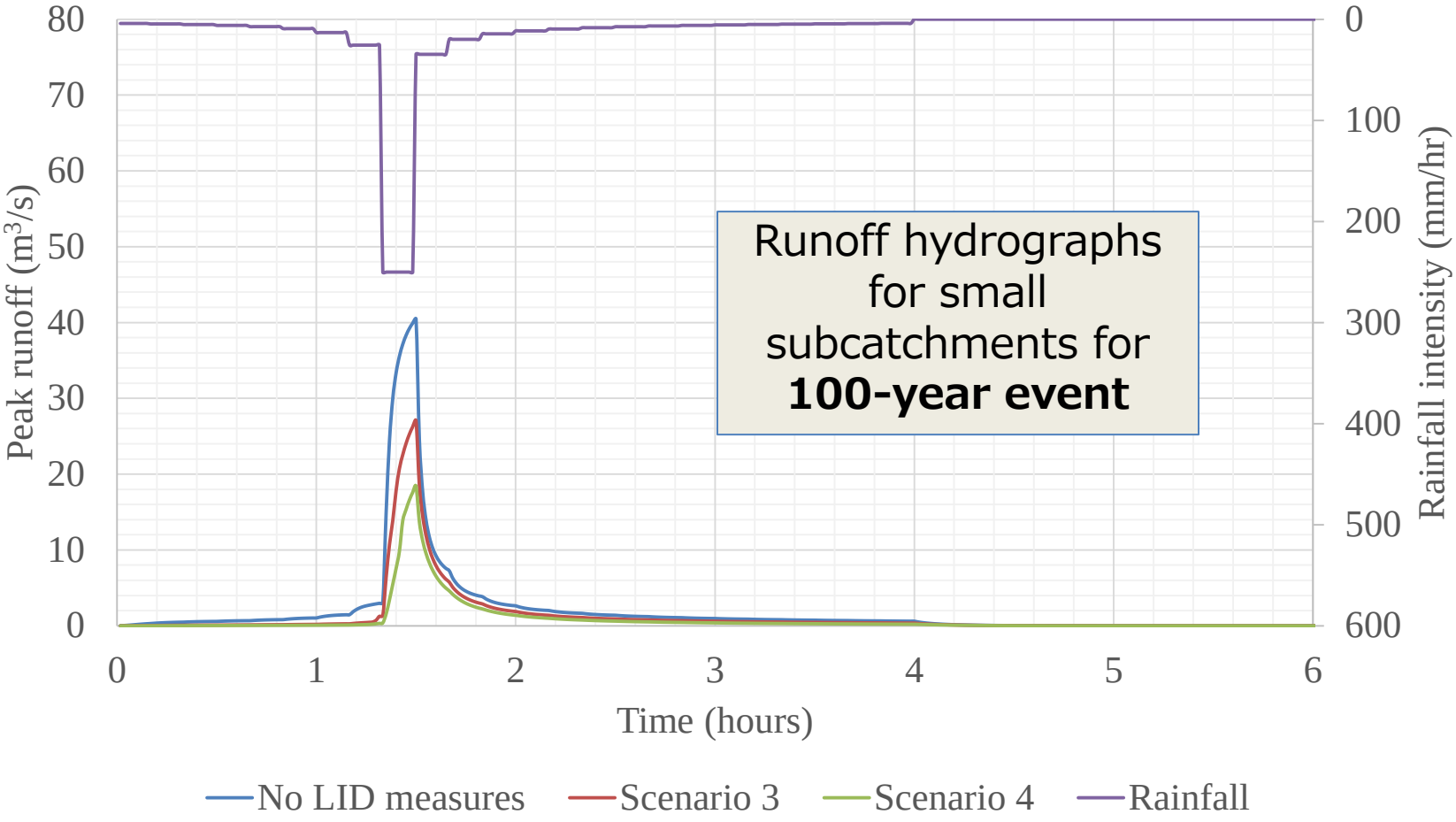
IT = infiltration trench

RD = residential driveway

CL = commercial lot (permeable

LID Scenarios

Where to invest?
Small subctachment: 12-100 ha
Large subctachment: 350-850 ha



From: Kokas (2017)

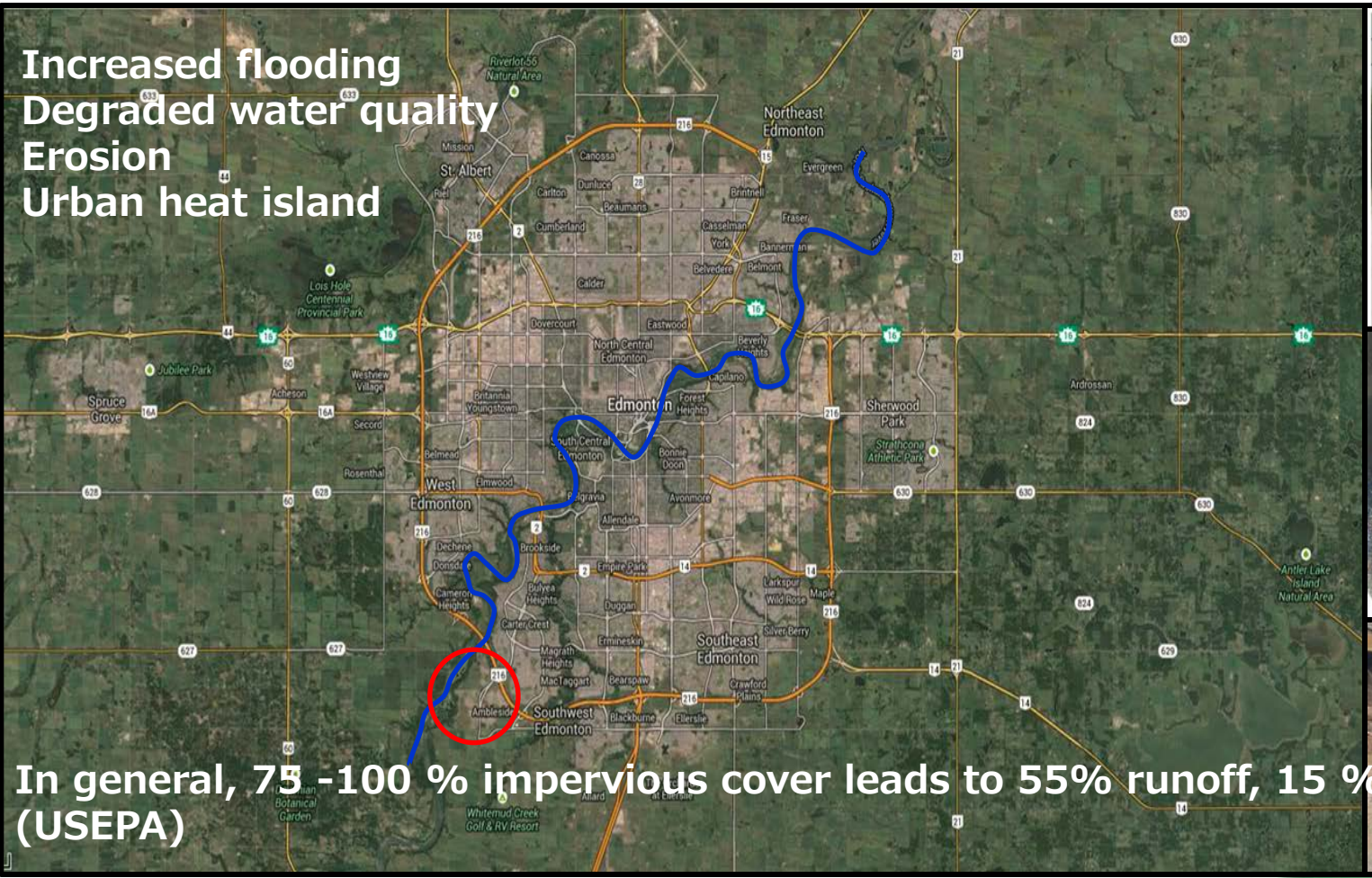
Black Creek Subwatershed: Main Conclusions

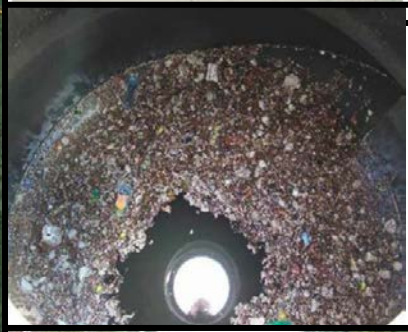
- Urban development from 1949 to 2015 transformed Toronto into a densely urbanized and impervious region
- As a result flood hazard has increased due to the changes in land-use and modification to fluvial features
- Southern region of watershed lacks SWM and contains minimal land available for implementation of large SWM measures
- LID features can considerably reduce peak runoff values in small subcatchments, however, negligible improvement in large subcatchments

Study of East River Storm Basin Edmonton, AB

Impact of Urbanization

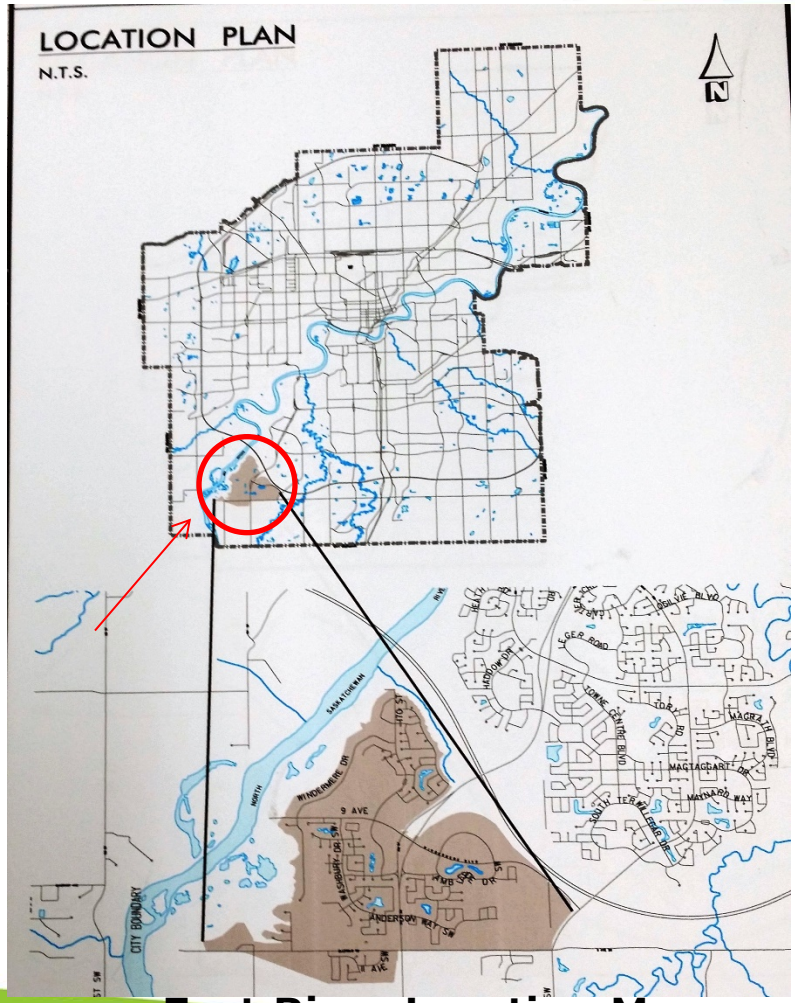
Increased flooding
Degraded water quality
Erosion
Urban heat island



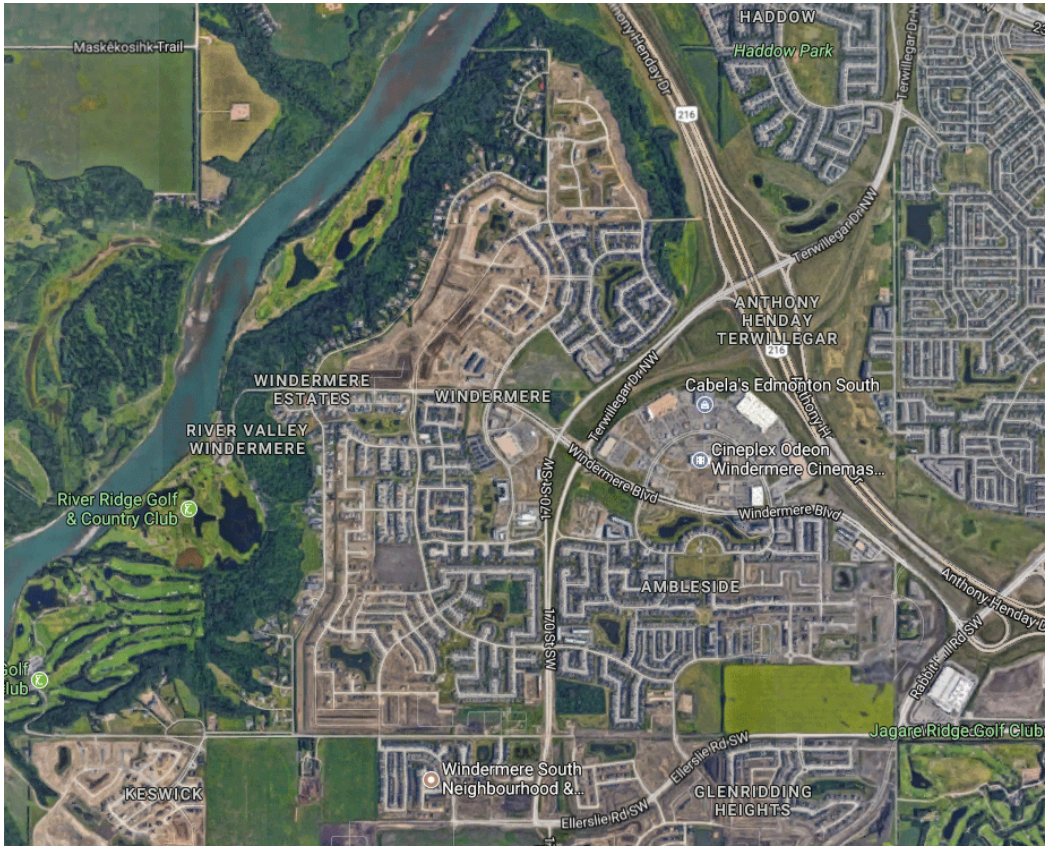


In general, 75 -100 % impervious cover leads to 55% runoff, 15 %infiltration (USEPA)

Location of the Basin



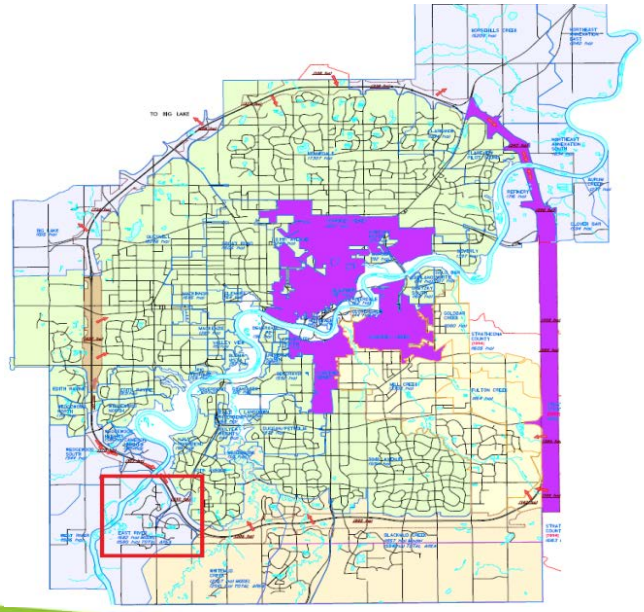
East River Location Map

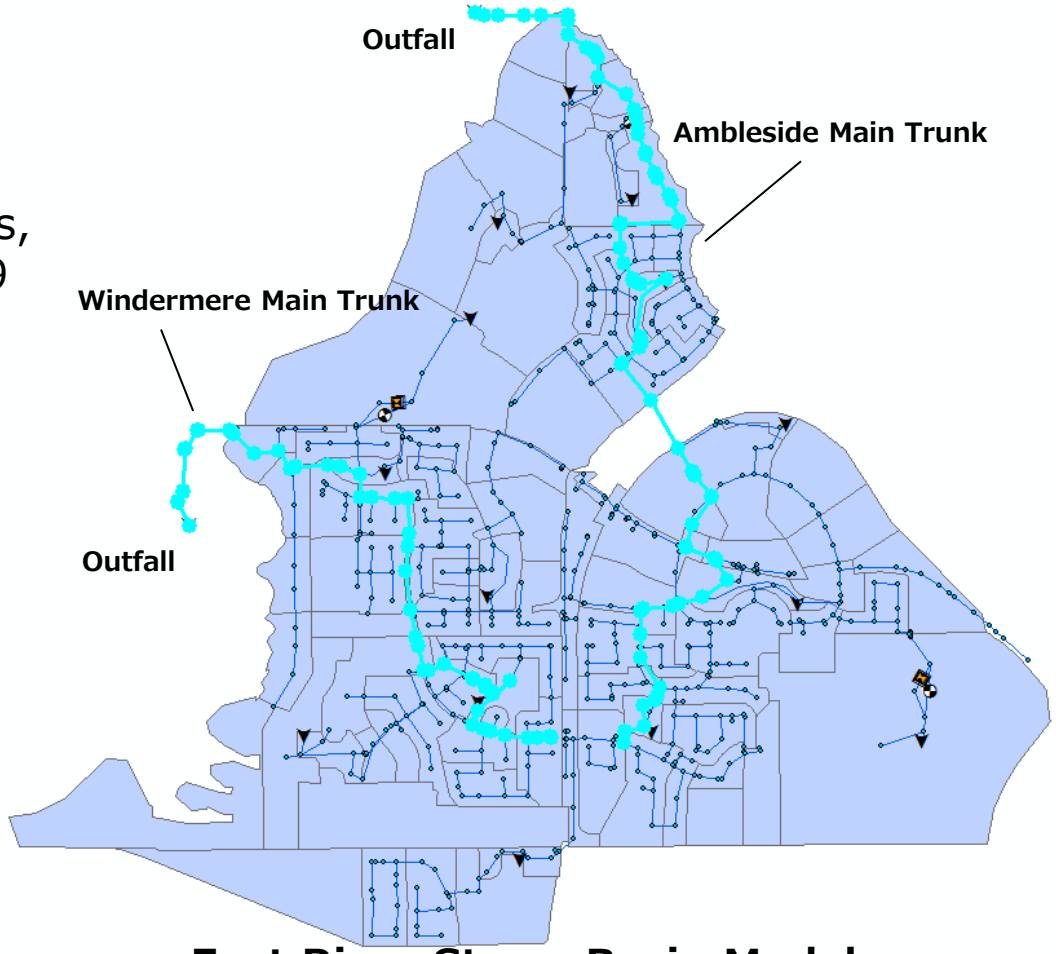


Map of East River Basin (Google satellite Map)

East River Storm Basin Model Overview

1. Total Gross Area = 1580 ha
2. Total Modeled Area = 682.3 ha
3. Neighborhoods: Windermere & Ambleside
4. Drainage Network: 84 catchments, 730 MH's, 735 pipes, 16 ponds (9 existing & 7 future), 2 outfalls





East River Storm Basin Model

Project Plan

- **Objectives:**
  - Assess the impacts of urbanization on flood hazard in urban environments
  - Rebuild the East River Storm Basin Model for different scenarios
  - Evaluate the effectiveness of various stormwater management facilities at reducing flood hazard
  - Provide recommendations (new LIDs) for both existing and future land use based on investment vs. impact

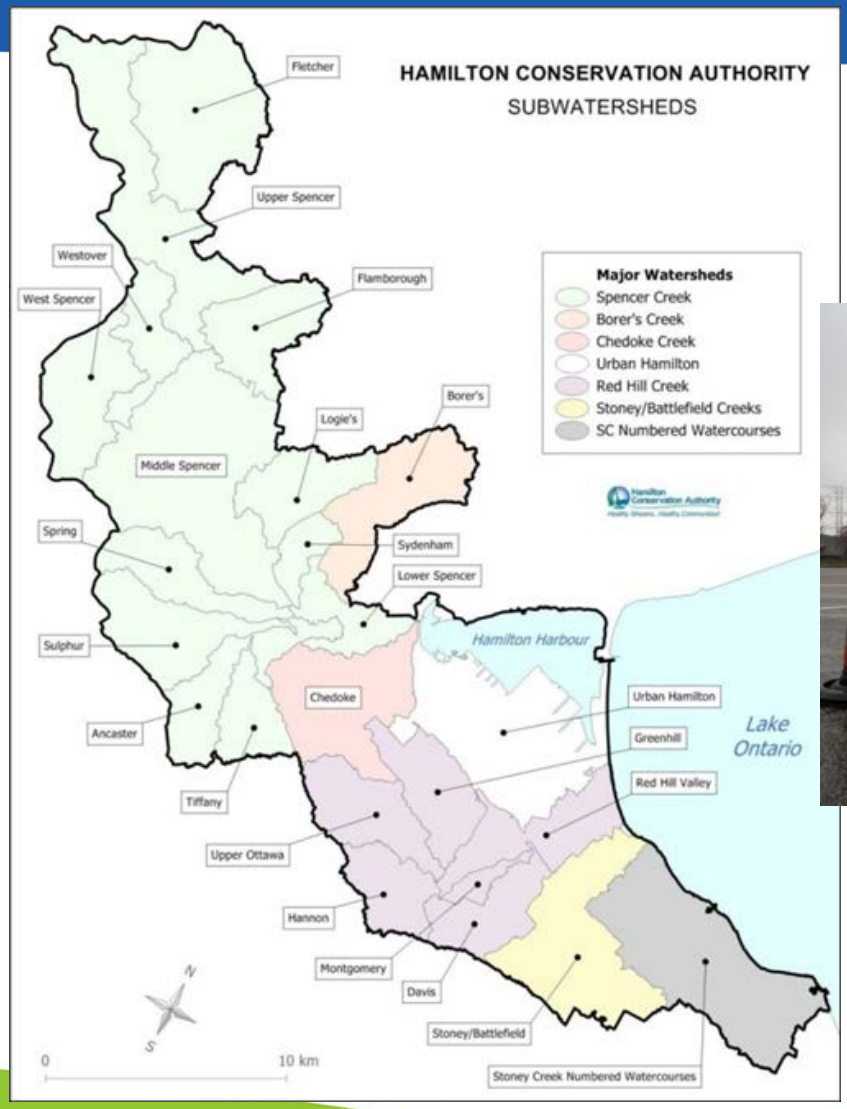
- **Methodology:**
  1. Land use analysis (ArcGIS)
  2. Hydrologic modeling (MIKE URBAN, FLOOD)
  3. Cost-benefit analysis

Comparison of Results

East River Storm Basin Study

Black Creek Subwatershed Study

City of Hamilton



Phil de Boer's Master's thesis

Source: http://www.cbc.ca

Source: Hamilton Conservation Authority

Acknowledgements

Toronto and Region Conservation Authority

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- Harris Switzman

NSERC Canadian FloodNet

Questions or Discussion