Black Creek subwatershed study

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Floods in Toronto

- Flashy events in large urban cities
- July 8, 2013
  - 126 mm of rainfall in 2 hours
  - High intensity, short duration rainfall
  - I.B.C. estimates close to $1 billion in damages
  - Disruption to GO Train
  - Severe power outages
- August 19, 2005
  - 150 mm of rainfall in 3 hours
  - Estimated over $500 million in damages
  - Washout of culvert on Finch Ave.

The Canadian Press, 2013

Toronto Sun, 2009

Stormwater management

- Wet/dry ponds
- Constructed Wetland
- Low Impact Development (LID)
  - Rain barrel
  - Permeable pavement
  - Green roofs
  - Infiltration trench
  - Bioretention cell
  - Vegetative swale
  - Rain garden

Wet Pond

Green Roof

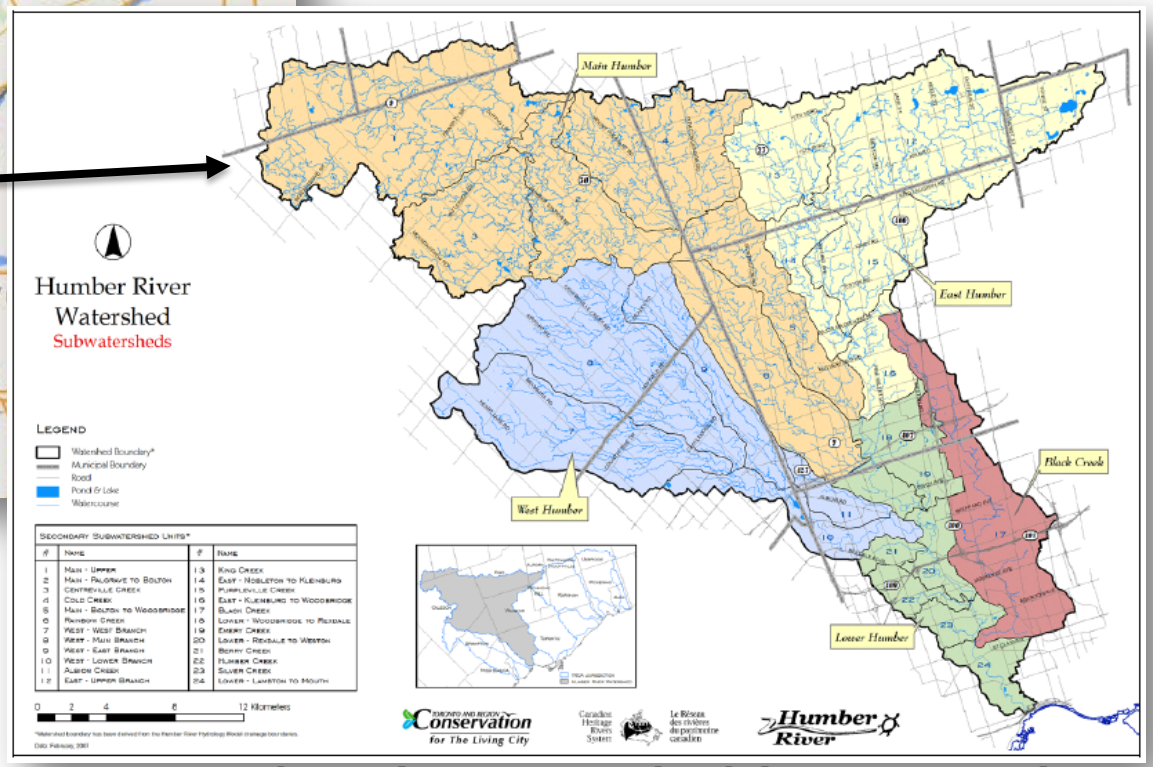
Case study: Black Creek

- **Partner:** Toronto and Region Conservation Authority (TRCA)
- Toronto is one of the most urbanized cities in Canada
- Significant modifications to Black Creek
- More frequent and intense flooding events
- Flashy runoff with high peak flows
- Peak flows controlled in upper region
- Minimal SWM in lower region
- Very limited space for large SWM

Black Creek, Toronto

Case study: Black Creek

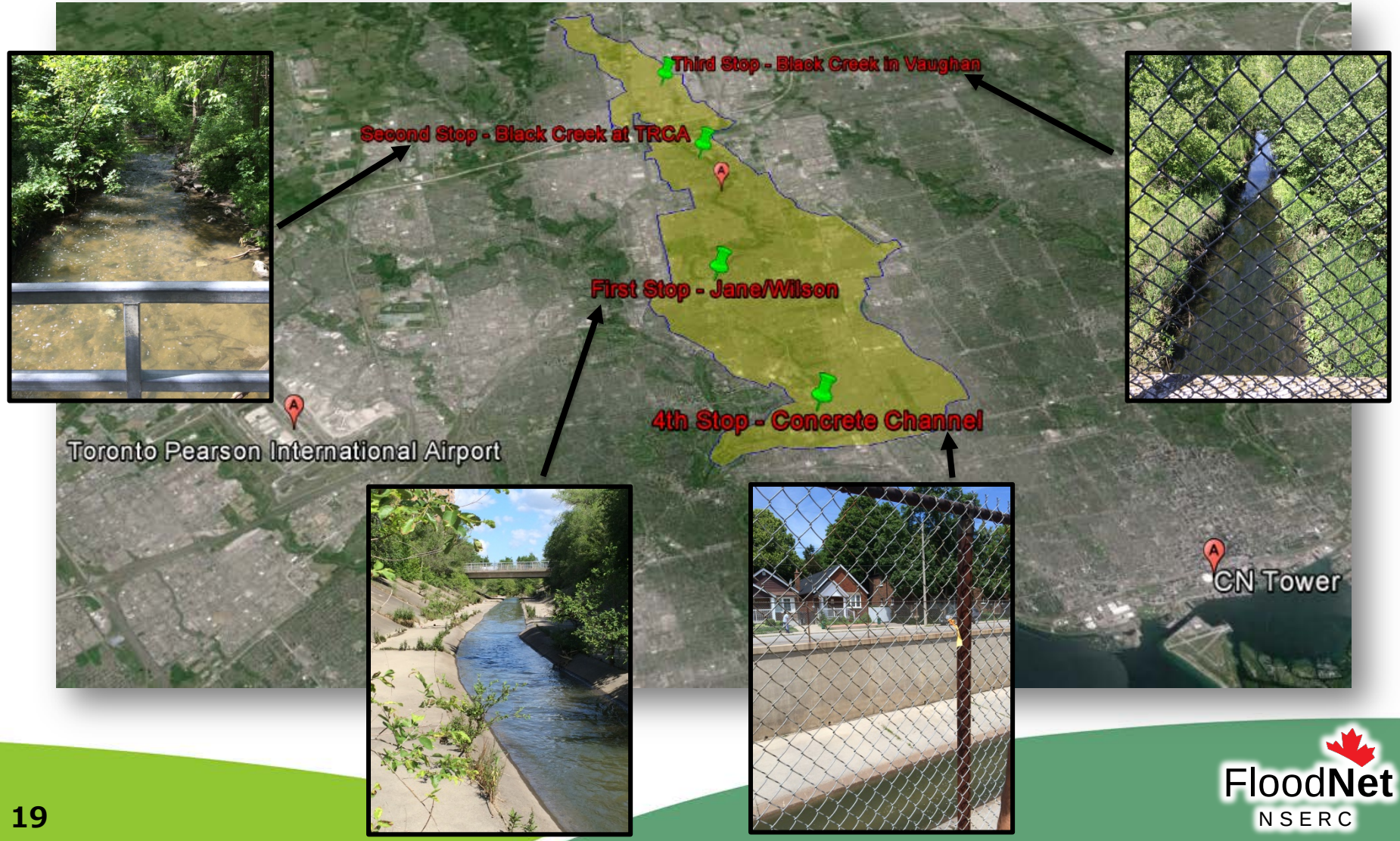
Map of Southern Ontario (Google Maps)



Humber River Watershed (TRCA, 2008)

Area of Humber: 91,100 ha
Area of Black Creek: 6,500 ha

Case study: Black Creek



FloodNet
NSERC

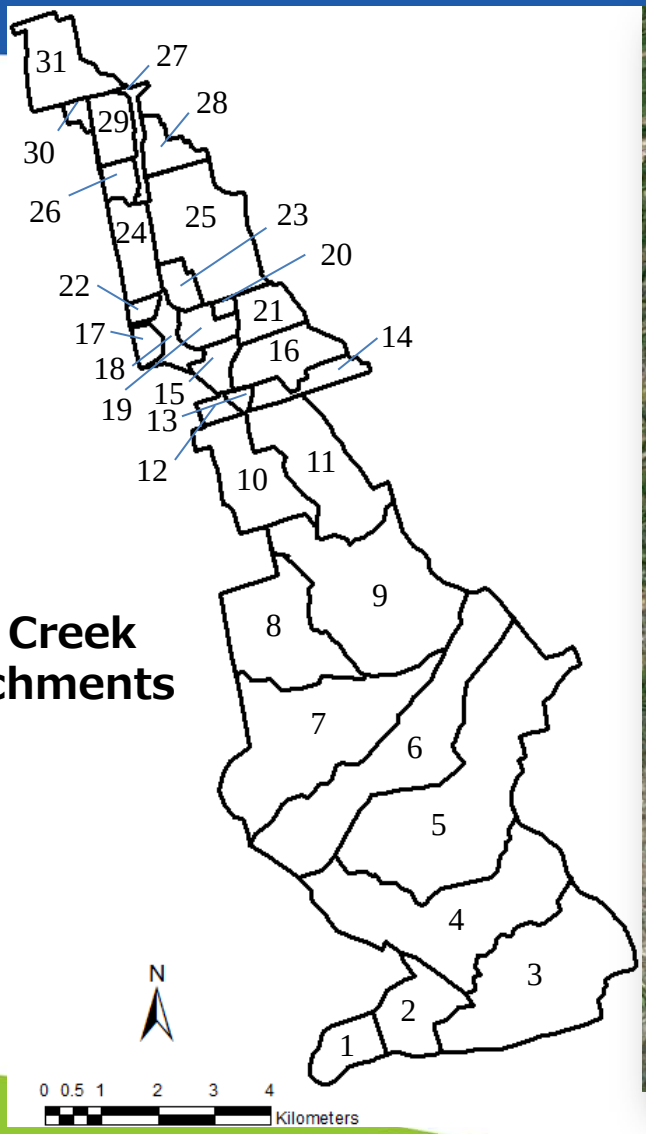
Case study: Black Creek

- **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

- **Methodology:**
  1. Land use analysis (ArcGIS)
  2. Hydrologic modeling (PCSWMM)
  3. Cost-benefit analysis

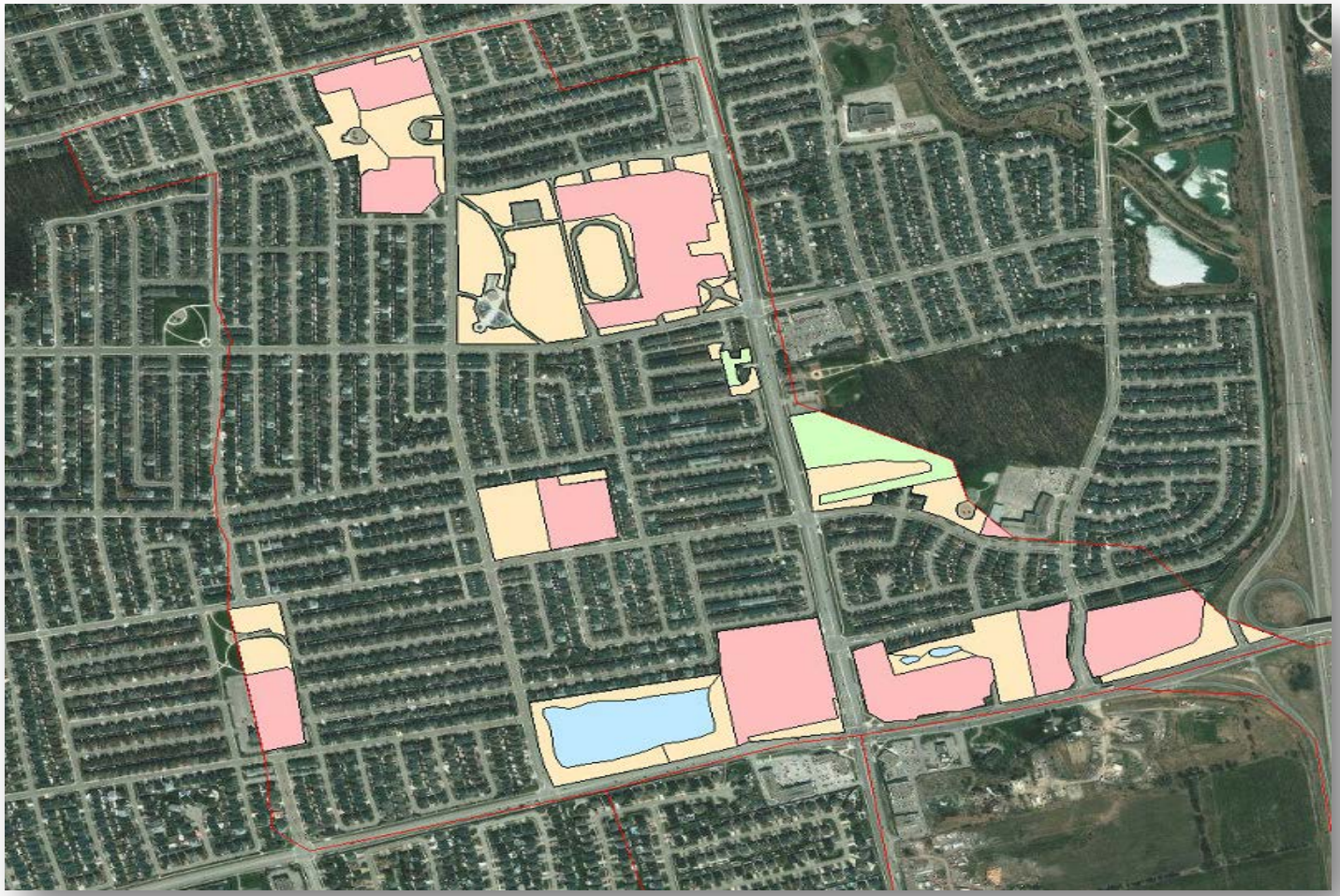
Land use analysis

Black Creek subcatchments



Aerial view of Black Creek subwatershed

Land use analysis



Digitizing subcatchment 31 in ArcGIS

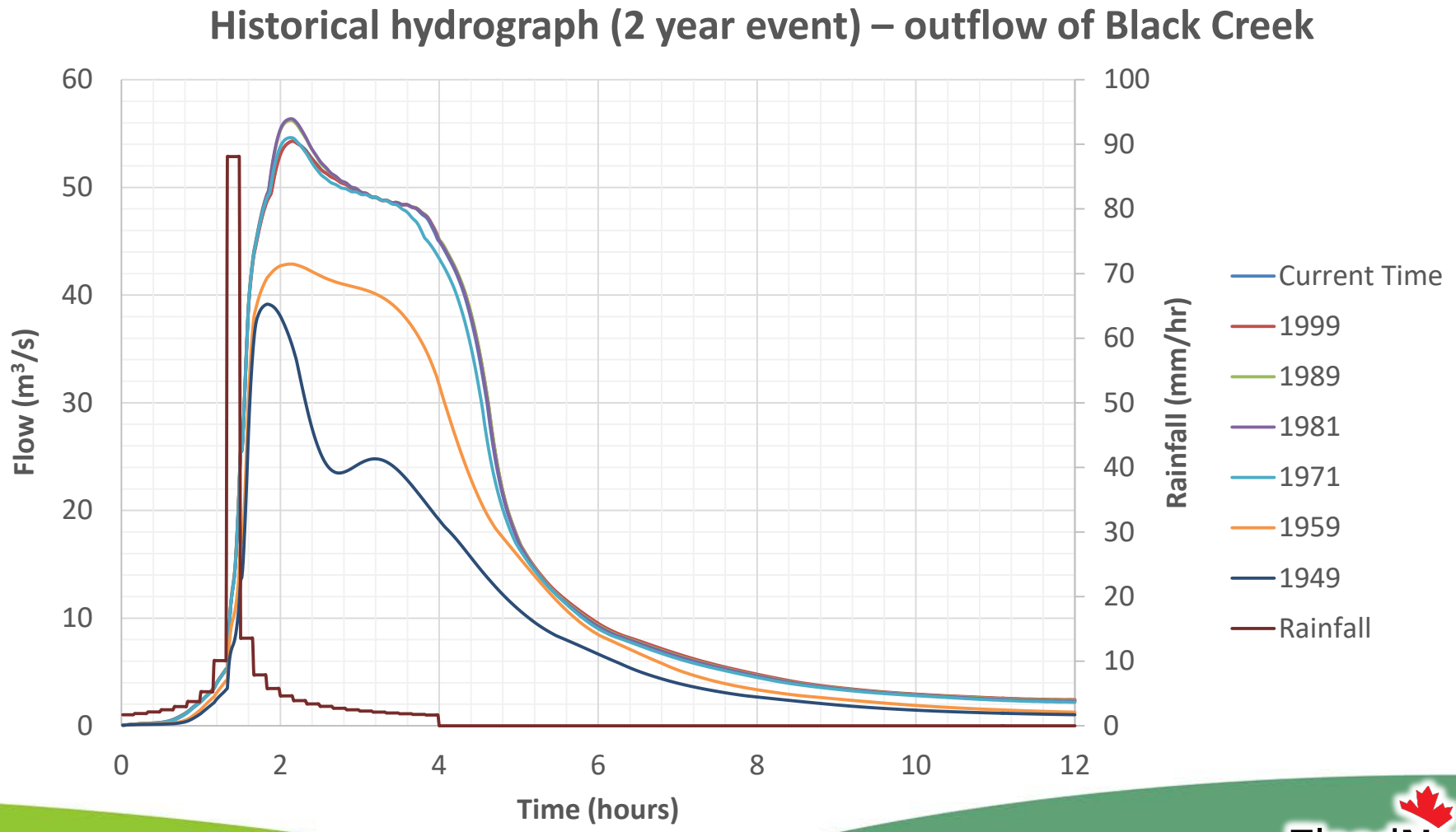
1. **Pink:** Commercial & Industrial
2. **Green:** Forest
3. **Beige:** Open Land
4. **Blue:** Water
5. **Remaining:** High Density Residential

Land use analysis

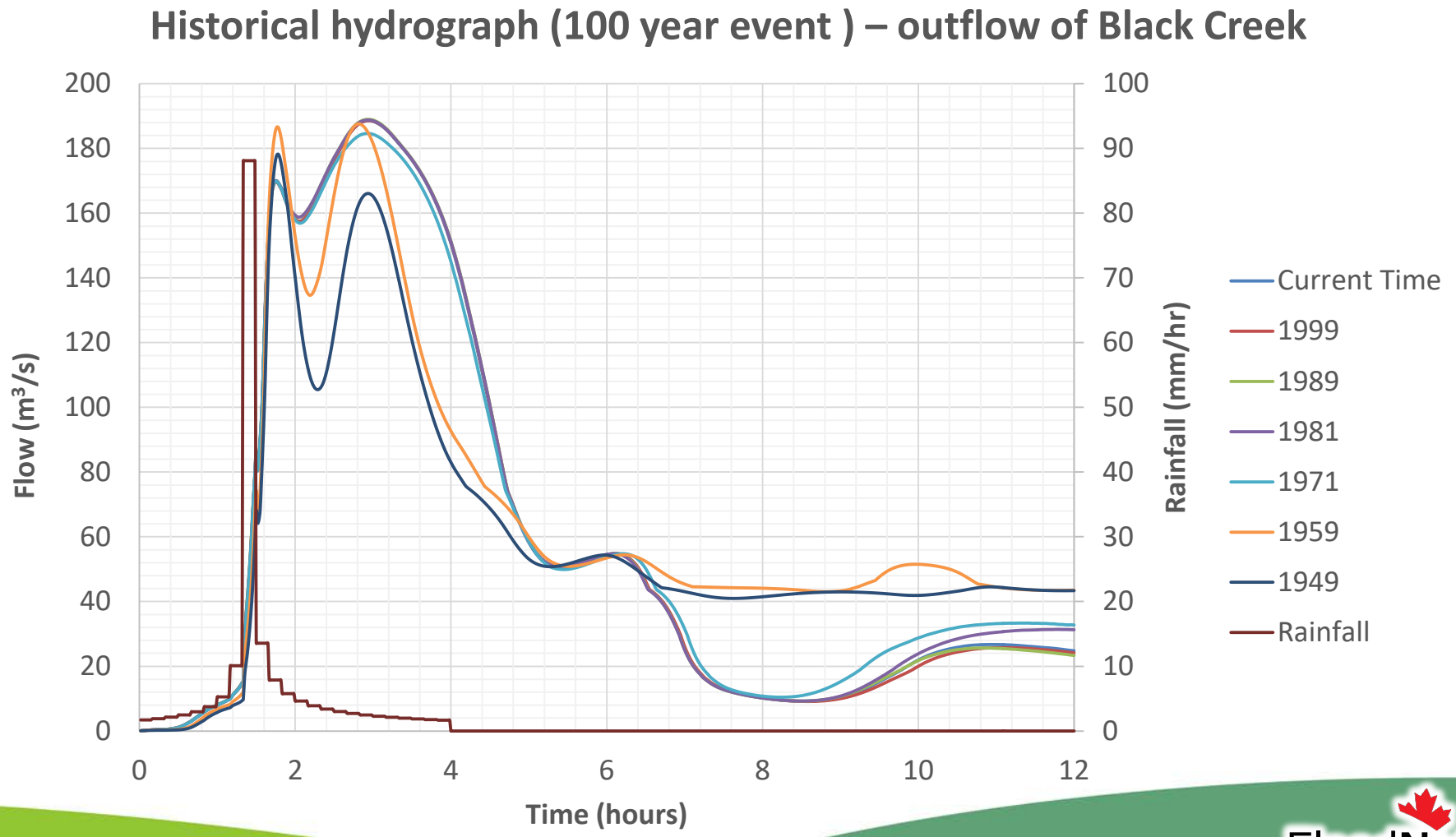
Sub. #	Total Imperviousness (%)												
	Current	Diff.	1999	Diff.	1989	Diff.	1981	Diff.	1971	Diff.	1959	Diff.	1949
1	28.4	-1.9	30.3	0.3	30.0	1.0	29.0	0.1	28.9	9.0	19.9	6.8	13.1
2	50.2	-3.6	53.8	1.2	52.6	2.0	50.6	-0.7	51.3	11.5	39.8	15.9	23.9
3	56.2	1.6	54.6	-1.8	56.4	-0.4	56.8	0.7	56.1	1.5	54.6	3.7	50.9
4	58.9	-1.1	60.0	-5.0	65.0	-0.7	65.7	3.2	62.5	10.0	52.5	31.4	21.1
5	57.2	0.8	56.4	0.3	56.1	0.0	56.1	2.4	53.7	25.5	28.2	22.7	5.5
6	53.4	-1.5	54.9	2.1	52.8	1.2	51.6	1.0	50.6	18.2	32.4	18.7	13.7
7	53.3	-1.2	54.5	-0.1	54.6	0.2	54.4	3.3	51.1	18.5	32.6	26.5	6.1
…	…	…	…	…	…	…	…	…	…	…	…	…	…
24	83.6	8.6	75.0	41.3	33.7	25.9	7.8	-0.3	8.1	-0.2	8.3	3.1	5.2
25	83.5	10.2	73.3	37.4	35.9	29.9	6.0	0.9	5.1	0.5	4.6	1.6	3.0
26	72.4	63.5	8.9	2.9	6.0	2.4	3.6	0.6	3.0	0.4	2.6	0.1	2.5
27	49.0	14.0	35.0	9.6	25.4	2.5	22.9	1.6	21.3	-0.4	21.7	9.7	12.0
28	72.9	43.1	29.8	26.2	3.6	0.0	3.6	-0.1	3.7	0.4	3.3	0.8	2.5
29	21.9	5.8	16.1	2.9	13.2	2.2	11.0	4.3	6.7	0.1	6.6	3.9	2.7
30	57.5	43.4	14.1	3.1	11.0	5.3	5.7	0.2	5.5	0.9	4.6	0.6	4.0
31	51.8	47.0	4.8	0.4	4.4	0.1	4.3	0.0	4.3	0.9	3.4	0.5	2.9

- Positive number indicates growth
- Negative number indicates decline

Historical simulations



Historical simulations



Historical simulations

- Summary of results

TIME PERIOD	Peak flow (m^3/s)	
	2 Year	100 Year
Current Time	54.3	188.6
1999	54.3	188.6
1989	56.2	189.0
1981	56.4	188.8
1971	54.6	184.6
1959	42.9	187.6
1949	39.2	178.2

- What else can be done to reduce peak flows?

Summary of LID units

LID	Area per unit (m^2)	Area of runoff treated (m^2)	Cost per unit ($)
Rain Barrel	0.29	50	150
Bioretention Cell	130	2,000	41,476
Rain Garden	10	50	500
Infiltration Trench	102	2,000	27,575
Residential Driveway	50	60	5,000
Commercial Lot	1,000	1,200	100,000
Vegetative Swale	100	1,000	6,500

- Sensitivity analysis?
- 2016 SWM budget for City of Toronto: $23,345,600

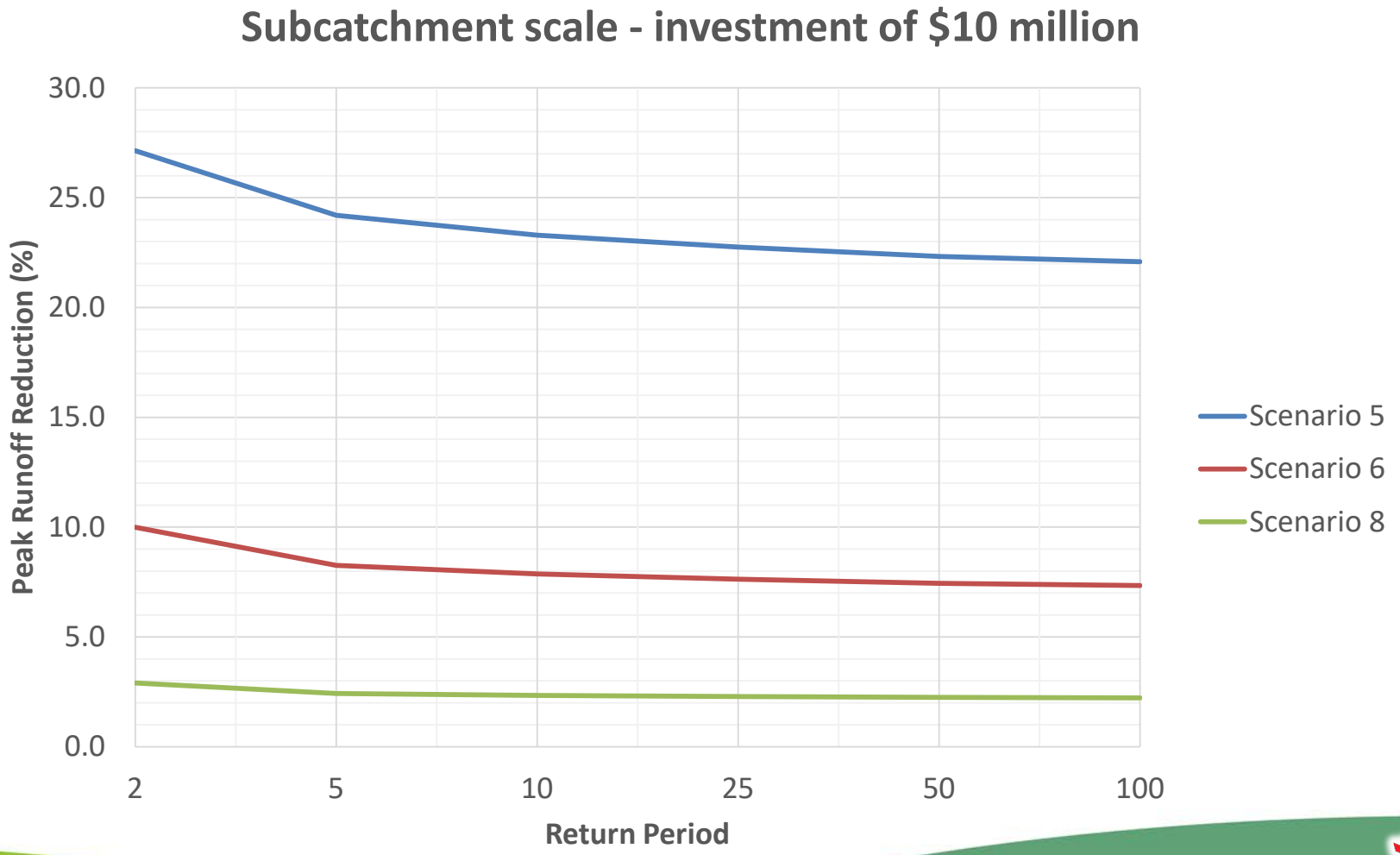
LID scenarios

Scenario #	Sub. #	Size of Sub.	Cost ($)
1	3-7, 17, 19-25	Small-Large	20,003,831
2	1-31	Small-Large	50,003,315
3	5	Large	15,000,755
4	25	Medium	15,000,258
5	21	Small	10,000,680
6	10	Medium	10,000,140
7	10	Medium	20,000,280
8	5	Large	10,000,140
9	5	Large	20,000,280
10	19	Small	20,001,300

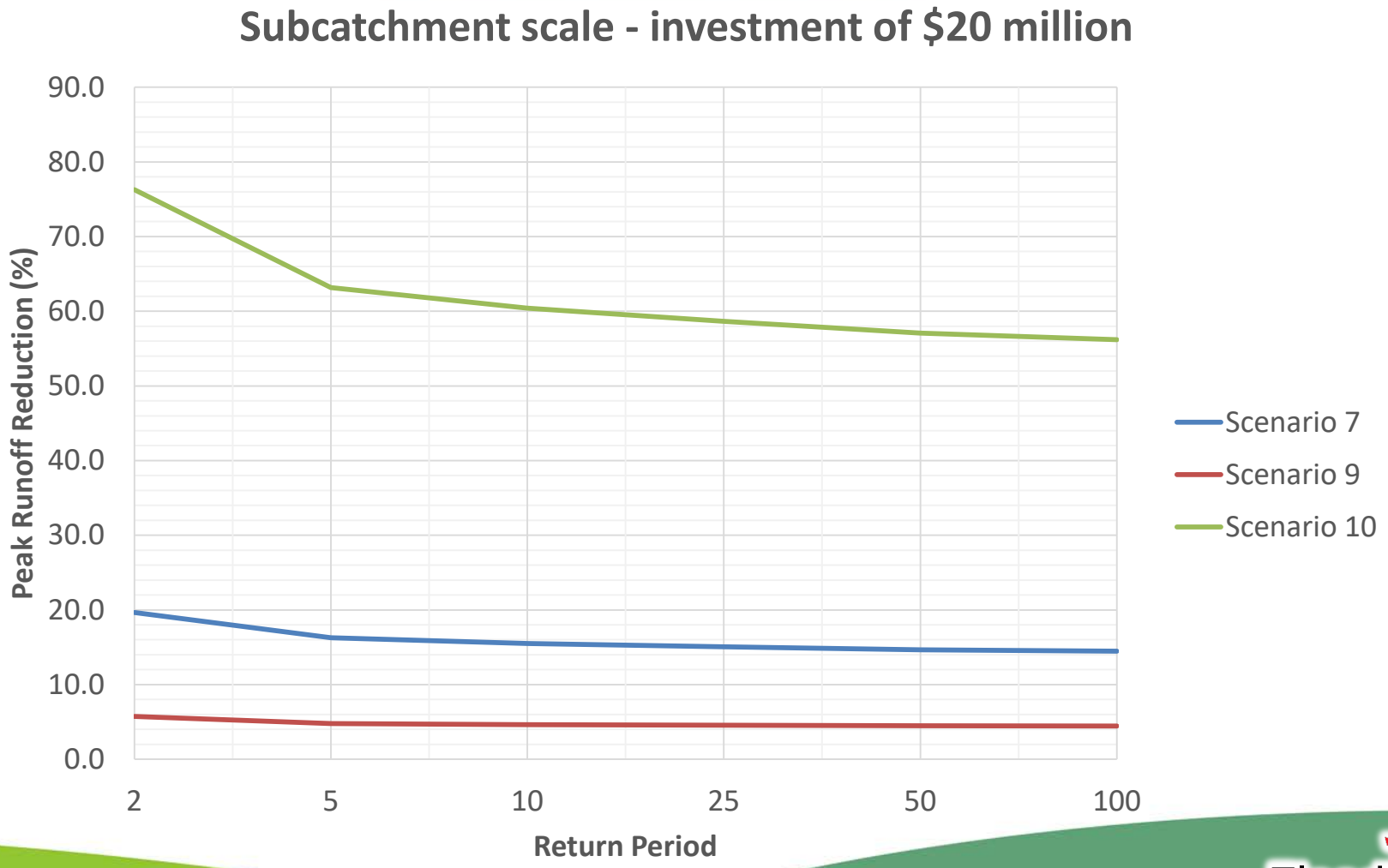
- Where to invest?

- Small subcatchment = 12 ha – 100 ha
- Medium subcatchment = 100 ha – 350 ha
- Large subcatchment = 350 ha – 836 ha

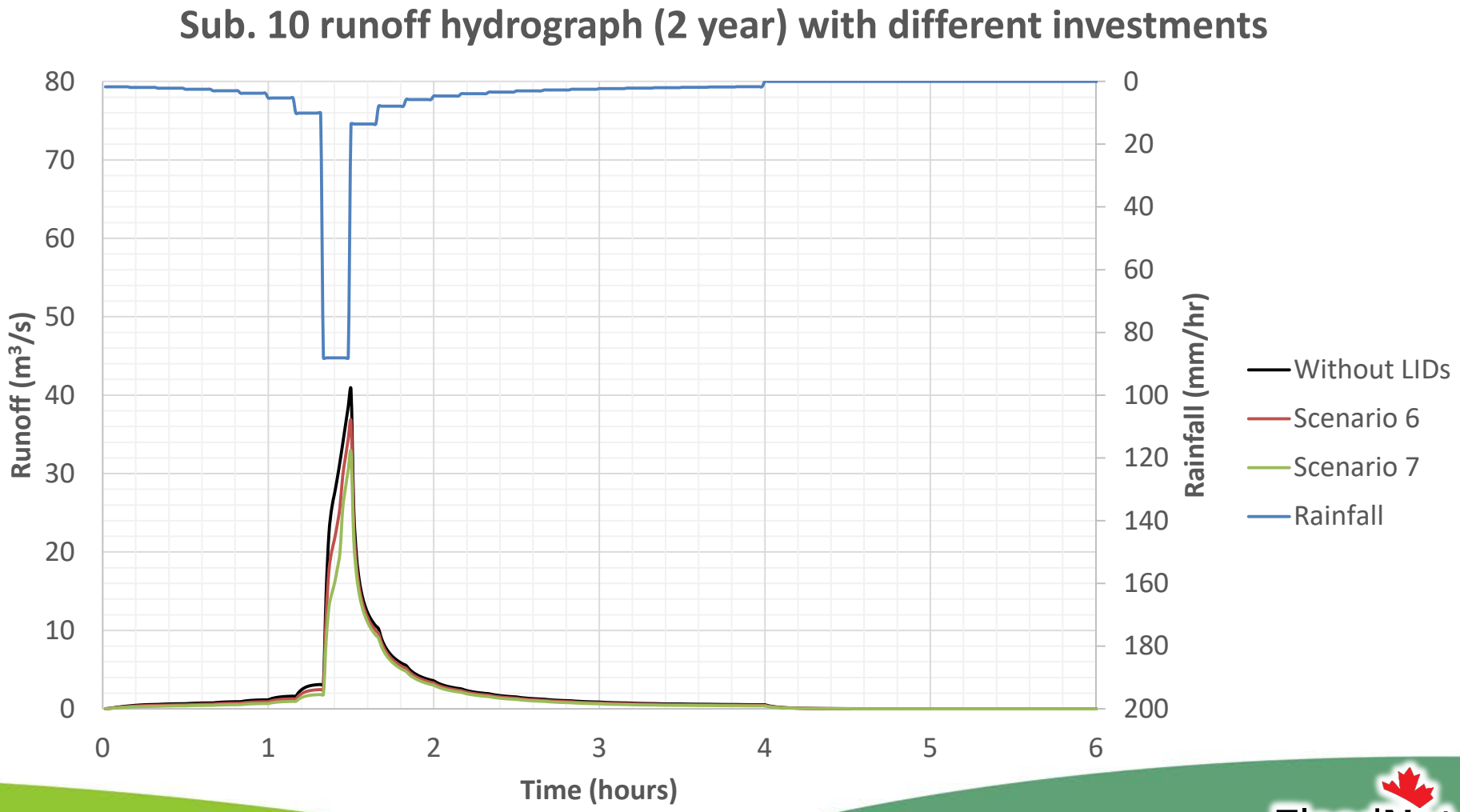
LID scenarios: modeling results



LID scenarios: modeling results



LID scenarios: modeling results



Conclusions and recommendations

- Significant urbanization in Black Creek subwatershed over time
- LIDs are effective in reducing runoff on a subcatchment scale
- Priority of investment should be located in regions with need of flood risk management
- Annual budget limits opportunity for more LID implementation

Acknowledgements

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NSERC Canadian FloodNet

Questions or discussion