Flood Risk Assessment and Ranking of flood vulnerable clusters

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Presentation Outline

- Project overview

- Methodology

- Resulting data

- How are we using this data?



TRCA Jurisdiction

41 Flood-Vulnerable Clusters

41,500 Residents Affected in the Regulatory storm event

38,300 Employees Affected in the Regulatory storm event

9,900 Buildings Affected in the Regulatory storm event

195km of Impassible Road Segments in the Regulatory storm event



BRAMPTO



Project Goals

1. Update to TRCA flood-vulnerable areas database

2. Structure-level flood risk assessment for all buildings and road segments within TRCA's 41 Flood-vulnerable clusters

3. Take into account 'Tangible' damages as well as 'Intangible' damages such as social vulnerability and critical infrastructure disruption

4. Flood-vulnerable clusters ranked according to highest flood risk

Methodology - Project Team

TRCA GIS Personnel

- Mike Todd
- Andy Bowler
- Dan Clayton
- Steven Ling
- Others

IBI Group (Calgary Office)

- David Sol
- Aysia Stante
- Rob Cioffi

TRCA Engineering Services

- Rehana Rajabali
- Nathan Plato
- Rebecca Elliott
- Nick Lorrain
- Sameer Dhalla

AND funding support through the National Disaster Mitigation Program (NDMP)

Methodology - Required data



Methodology – Hazard (Riverine Flooding)



Flood Hazard Mapping (flood extent, depth, velocity grids for each return period)

Hazard

Extent



Methodology – Exposure

-



- Building footprints within flood extent (for each return-period)
- Roads within flood extent (for each returnperiod)
 - **Population within flood extent** (for each return-period)
 - Flood depth statistics at each building polygon, and at each road segment (max, min, average, standard deviation, for each return period)

















- Building Class required for building contents depth-damage curves

Residential	Description
AA	Home with living space defined as equal to or more than 4,000 SqFt
А	Home with living space defined as equal to or between 3,999 and 2,400 SqFt
В	Home with living space defined as equal to or between 2,399 and 1,200 SqFt
С	Home with living space defined equal to or less than 1,199 SqFt
D	Mobile Home (does NOT have a Basement)
М	4 floors or less Apartment Bldg (was MW)
Ν	5 floors or more Apartment Bldg (was MA)

Commercial	Description
A1	General Office
B1	Medical
C1	Shoes
C2	Clothing
C3	Stereos/TV
C4	Paper products
C5	Hardware/Carpet
C6	Retail Misc.
C7	Generalized Retail
D1	Furniture/ Appliances
E1	Groceries
F1	Drugs
G1	Auto
H1	Hotels
l1	Restaurants
J1	Personal Service
K1	Financial
L1	Warehouse/Industrial
M1	Theatres
N1	Institutional
01	Hospital

- Structure type required for building structure depth-damage curves

Exposure		Туре	Description (Struct-Type)				
		А	Residential 1-storey als	Structure	Description (St	ruct-Type)	
		B	Ranch-style	on dotai c		Struct Type)	
		С	Split Level				
	Deputation	D	Residential	S1	Office /Retail		
Infrastructure / Population Assets at risk		Е	4 floors or le M Class grc S2 Industrial/Warehouse use!				
		F	5 floors or n N Class gro	S3	Hotel/ Motel		
		A	use! Mobile hom	S4	High Rise / Residentia	al	
			versions)	S5	Institutional		



- Other fields such as floor area, number of stories and presence or absence of basement were required

- Data from the Municipal Property Assessment Corporation (MPAC) purchased for all buildings within the floodplain

- MPAC data processed to generate required fields for depth-damage curves



- Offset from ground surface to first floor elevation estimated in google earth street view

- Other fields such as building class and presence of basement 'field' verified

Infrastructure / Assets

Exposure

Population

at risk



Methodology - Tangible Damages

1. Direct Damages

- Structure damages (depth-damage curves)
- Content damages (depth-damage curves)

2. Indirect Damages

- Population displacement
- Business disruption and loss of revenue



1. Direct Damages (1/2)

- Building structure damage (depth-damage functions from Alberta's Provincial Flood Damage Assessment Study (2015)
- Building content damage (depth-damage functions from Alberta's Provincial Flood Damage Assessment Study (2015)
- All damages indexed to current-year Ontario values
- Indexing approach used subset of the Survey of Household Spending (SHS) for contents damage, and the Altus Construction Guide and Statistics Canada Construction price Indexes for structure damage

2. Indirect Damages (2/2)

of affected residents used as a base

- Loss due to business disruption (used business disruption depth-damage curves based on industry productivity for commercial and industrial buildings from Canadian Guidelines and Database of Flood Vulnerability Functions (2017)
- Loss due to residential displacement (used residential displacement depth-damage curves based on displacement period residential buildings from Canadian Guidelines and Database of Flood Vulnerability Functions (2017)

Depth (m)										
0.1	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
0	2	4	7	7	7	10	10	14	14	14
35	35	90	90	120	120	180	180	180	180	180
21	35	42	60	90	90	90	90	90	90	90
60	90	120	180	180	180	210	240	270	300	300
90	120	180	210	240	270	300	300	300	300	300
0	0	14	21	30	30	45	45	60	75	90
	0.1 0 35 21 60 90 0	0.1 0.3 0 2 35 35 21 35 60 90 90 120 0 0	0.1 0.3 0.6 0 2 4 35 35 90 21 35 42 60 90 120 90 120 180 0 0 14	0.1 0.3 0.6 0.9 0 2 4 7 35 35 90 90 21 35 42 60 60 90 120 180 90 120 180 210 0 0 14 21	0.1 0.3 0.6 0.9 1.2 0 2 4 7 7 35 35 90 90 120 21 35 42 60 90 60 90 120 180 180 90 120 180 210 240 0 0 14 21 30	Depth (no.1 0.1 0.3 0.6 0.9 1.2 1.5 0 2 4 7 7 7 35 35 90 90 120 120 21 35 42 60 90 90 60 90 120 180 180 180 90 120 180 210 240 270 0 0 14 21 30 30	Depth (m) 0.1 0.3 0.6 0.9 1.2 1.5 1.8 0 2 4 7 7 7 10 35 35 90 90 120 120 180 21 35 42 60 90 90 90 60 90 120 180 180 180 210 90 120 180 210 240 270 300 90 0 14 21 30 30 45	Depth (m) 0.1 0.3 0.6 0.9 1.2 1.5 1.8 2.1 0 2 4 7 7 10 10 35 35 90 90 120 120 180 180 21 35 42 60 90 90 90 90 60 90 120 180 180 180 210 240 90 120 180 210 240 270 300 300 0 0 14 21 30 30 45 45	Depth (m) 0.1 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 0 2 4 7 7 7 10 10 14 35 35 90 90 120 120 180 180 180 21 35 42 60 90 90 90 90 90 90 60 90 120 180 180 210 240 270 90 120 180 210 240 270 300 300 300 90 0 14 21 30 30 45 60	Depth (m) 0.1 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 0 2 4 7 7 7 10 10 14 14 35 35 90 90 120 120 180 180 180 180 21 35 42 60 90 <t< td=""></t<>

Exhibit 6.4: Estimated Average Residential Displacement Periods⁷⁰

Methodology – Intangible Damages

- 1. Social Vulnerability
- 2. Community Impacts
- 3. Infrastructure



- Impacts that cannot be easily quantified by dollar amounts
- Impacts are assessed for each return-period where applicable

1. Social Vulnerability (1/2)

of affected residents used as a base

- residents were considered affected if the first floor of their place of residence would be subject to flooding
- StatsCan data used in conjunction with MPAC data to estimate # residents per building
- # of affected residents were summed at each return-period storm for each structure and cluster
- average-annual # of affected residents quantified by plotting # affected residents vs. probability of occurrence and taking the area under the curve



1. Social Vulnerability (2/2)

Average annual # of affected residents normalized based on relative social vulnerability

 Environics data used to calculate relative social vulnerability at each cluster (cluster population statistics vs. TRCA-wide population statistics) for 5 indicators of increased social vulnerability:

Income: proportion of households with income under \$20,000

Family Type: proportion of families with children

Age: proportion of residents over 65 years old

Hospital: distance from hospital or care facility (less weight)

Housing Tenure: proportion of owner-occupied homes (less weight)



2. Community Impacts

Impacted buildings that provide additional services to the community were counted at each return period. Average-annual # of impacted community services buildings were calculated at each flood vulnerable cluster

- Emergency services buildings
- Recreation Facilities
- Places of worship
- Schools
- Community Centres



3. Infrastructure (1/3)

Loss of community service due to infrastructure disruption

- focused on disruption to safe access/egress due to inundation of roads
- flood depth and velocity statistics (max, min, mean, stdev) calculated at each road segment within each floodvulnerable cluster for each return period



3. Infrastructure (2/3)

Loss of community service due to infrastructure disruption

- two metrics were used to rank disruption to roads at each cluster relative to each other
 - Average annual # impassible road segments (flood depth > 0.3m or flood velocity > 4.5 m/s)
 - Average annual overall inundation extent on roads (average flood depth * length)
- Road segments were weighted differently based on road class (local, collector, arterial, freeway)



3. Infrastructure (3/3)

Loss of community service due to infrastructure disruption

- Disruption to utilities was added as a placeholder category for future consideration
- Difficult to assess due to varied thresholds of impact for various utilities
- Significant data collection effort required to gather data of sufficient detail



Resulting Data

- Building-associated tangible damages assessed at each structure for each return-period
- Social Vulnerability assessed at each cluster for each return-period
- **Community impacts** assessed at each cluster for each return-period
- **Infrastructure** disruption assessed at road segments for each return-period

Average-Annual Damage costs and inundation numbers for each structure and/or cluster

What do we mean when we say Average-Annual Damages?



TRCA's TOP 10 CLUSTERS



1. Rockcliffe

Flood Risk Statistics

3636 residents affected

1172 employees affected

699 buildings affected

\$8.9mil average-annual building related damages

75 road segments without access





Breakdown of Tangible Damages



Cluster Fact Sheets

MARKHAM INDUSTRIAL

WATERSHED: DON RIVER CLUSTER AREA: 774.98 SQ.KM.





OVERALL RANK This is the cluster's rank in relation to all others, based on the sum of scores for each category. BUILDING-ASSO CLATED DAMAGES Dollar value of direct damage to structures and contents as well as business interruption and residential displacement INFRASTRUCTURE Length of inundated and impassible roads, transit stons, and level of risk to critical utility

DAMAGES V. PROBABILITY

HOUSEHOLD IMPACTS Number of affected residents adjusted for income, family type, age, and home-ownership COMMUNITY IMPACTS Number of affected emergency and social services, recreational and cultural facilities, schools, and community associations PREPAREDNESS AND RESILIENCY The presence of mitigation measures, past flood experience, special land use designations, and other specific resiliency factors can reduce overall risk

AVERAGE ANNUAL DAMAGES (AAD)



ANNUALIZED IMPACTS

In the Damages V. Probability chart, total flood damage is plotted against the annual event probability for the area.

Remaining category total

The Average Annual Damage (AAD) is estimated by calculating the area under the curve. This essentially weights the damages according to the probability of them occurring.

Damages from a frequent event would add more to the AAD than an infrequent event.

AAD expresses the cost of the average damage in dollars per year that would occur in a designated area over a very long period of time. In addition to economic damages due to flooded buildings, other impacts can be annualized, as illustrated.

















Toronto and Region Conservation Authority

132.89



The annusized length of road segments that at any point would be inundated by 0.3 metres or deeper floodwaters. 634.48

Estimates of Population at Risk & Threat to Loss of Life

- A recent review of the flooding in Rockcliffe area, based on the completed Flood Risk Assessment and Ranking Project, resulted in the ability to now predict the population at risk as well as estimates for the loss of life.
- Population at risk is the total residents, employees and institutional Buildings located within the flood area per storm event.
- The threat to loss of life calculations are based on flood depths and/or velocities that present a threat to loss of life (2X2 Rule) in the *Technical Guide, River & Stream Systems: Flooding Hazard Limit* (OMNR, 2002)

Estimates of Population at Risk

Number of residents, employees, and institutional buildings exposed to risk of riverine flooding within the Rockcliffe flood-vulnerable cluster (Black Creek from Black Creek Dr south of Lawrence Ave W to Scarlett Rd)

Storm Return	At risk ¹					
Period	# Residents	# Employees	# Institutional Buildings			
5-year ³	0	181	0			
10-year	589	261	24			
100-year	2223	873	76			

1 Place of residence or place of work is subject to flood depths above first floor elevation

3 A storm of this magnitude occurred on August 7th, 2018. Two men narrowly avoided death while trapped in a basement elevator at 501 Rockcliffe Boulevard.

4 Chris Tonks Arena and Blessed Archbishop Romero Catholic Secondary School

6 Chris Tonks Arena, Blessed Archbishop Romero Catholic Secondary School, Rockcliffe Middle School, Toronto District Schoolboard Alliance Stockroom, Cordella Junior Public School, Humber Blvd Baptist Church, Beech Hall Housing Cooperative

Estimates of Threat to Loss of Life

Number of residents, employees, and institutional buildings exposed to risk of riverine flooding where flood depths and velocities present a serious threat to loss of life within the Rockcliffe flood-vulnerable cluster (Black Creek from Black Creek Dr south of Laurence Ave W to Scarlett Rd)

Storm Return	Threat to loss of life ²					
Period	# Residents	# Employees	# Institutional Buildings			
5-year ³	0	154	0			
10-year	52	208	1 ⁵			
100-year	1843	836	7 ⁶			

2 Place of residence or place of work is subject to flood depths and/or velocities that present a threat to loss of life. See <u>Technical Guide, River & Stream Systems: Flooding Hazard Limit (OMNR, 2002) Appendix 6, section (1) Flooding</u> <u>as a Threat to Life, and Figure 6-2 Flood Plain Stability Chart for Humans - 2 for further information on the specific</u> depth, velocity, and depth-velocity product thresholds

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Work Influenced by the Flood Risk Assessment and Ranking Project

1) Ongoing Enhancements to the Flood Forecasting and Warning Communications

2) Flood Remediation Studies

3) Outreach Program

Using stream gauges to better understand risk areas...











Flood Remediation Studies...

Broadview and Eastern Flood Protection

 Return on investment (ROI) estimates for funding application for Infrastructure Canada's Disaster Mitigation and Adaptation Fund (DMAF)



Outreach Program...

- Necessary information to begin Flood Outreach Program to our partner Municipalities and to the Public



Questions





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www.trca.ca/flood





www.trca.ca