FLOOD IMPACTS ON BUILT INFRASTRUCTURE – AN OVERVIEW

PRAIRIES REGIONAL ADAPTATION COLLABORATIVE WEBINAR NOV. 22, 2018
THE ROLE OF INFRASTRUCTURE PLANNING IN FLOOD MITIGATION

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Built Infrastructure

- Physical networks for modern society
- Hard infrastructure includes roads, railways, buildings, bridges, dams, utilities, etc.
- Soft infrastructure may include data, financial systems, digital networks, governance systems, etc.
- This presentation focuses on flooding and climate change impacts to built infrastructure
Examples of Flood Impacts

“1.8-million Canadian households are in flood-prone areas, and most of them do not know it.” L. Perreaux, May 12, 2017 Globe & Mail


SK Provincial Disaster Assistance Program
$335 million expended from 2009-2014
136 local States of Emergencies declared
Prov. Auditor, Saskatchewan, 2015 Report Vol.1, Table 5


Operationalizing Adaptation
Canada’s Prairie Region - Historic Precipitation Records

- Instrumental Prairie data is about 100 years
- Typically, spring snowmelt is the main peak runoff event in the prairies
- Recent shifts have been observed with summer runoff and flood events
  - Smith Creek Basin
  - Earlier spring snowmelt runoff
  - Abnormally large rainfall flood volume events
  - Source: Dumanski et al, 2015
- Wet or saturated antecedent conditions increase flood risk with new runoff events

Yorkton Creek Annual Volume, dam$^3$ (Env Can 05MB001). (Saskatchewan Water Security Agency, 2017)
Historic Prairie Climate (800 yrs. inferred from tree rings)
- a wider natural variability than instrumental records

800 years of inferred Oldman River flow from Tree Ring data. Zero is 1971-2000 hydrological baseline.
- Above Baseline are wetter years in blue. Below baseline are drier years in pink. (Sauchyn, VACEA)
Insurance Bureau of Canada – Insured Losses demonstrate a need for adaptation

■ Approximate average insured losses are increasing:
  – 30 Years ago: ~400 million/yr.
  – Last 10 years: ~ over 1 billion/yr.

■ 2011 - $1.7B paid, a Canadian record for extreme events (floods, fires, wind)

■ 2013 - $3.2B paid, when the Calgary Flood event was tallied [http://assets.ibc.ca/Documents/Studies/IBC-The-Economic-Impacts.pdf](http://assets.ibc.ca/Documents/Studies/IBC-The-Economic-Impacts.pdf)
Case 1: Quill Lakes & Wetland Flooding 2004-16

- Closed basin, extremely saline water
- Water levels rose 6.5 m from 2004-2016 but still not at its natural spill elevation
- Flooded:
  - 11,000 ha of private land
  - 23,500 ha of public land
  - 22,700 ha remain “at risk”
- Impacting:
  - Houses, farms, agricultural infrastructure & operations
  - Water wells, sewer systems
  - Rural municipalities, towns, villages
  - Highways, rail lines, bridges, culverts, etc. (> $4m spent on roads)

(Walker Projects, 2018)
Case 2: Southey Basin – Spring Flood 2015

- Impacts were affected by prior wet years and wet antecedent conditions:
  - Roads, highways, farms and rural infrastructure
  - Residences, streets, farm land
  - Water wells; sewer services
  - Parks; campgrounds, etc.

- Recovery required:
  - Major flood water pumping initiatives
  - ~$2 m pumping over 3 months in one RM alone

(Walker Projects, 2018)
Case 3: City of Moose Jaw – Proactive Responses

- Severe 1974 Flood (after near record snow):
  - 1 m water downtown; record levels of Moose Jaw River
  - 60 city blocks, 480 homes
  - 1400 people evacuated

- Mitigation responses included:
  - Land acquisition to move people, properties, development out of the flood zone
  - Diking & diversion flood protection works
  - Protection of critical infrastructure (water and wastewater systems), etc.

- These adaptations reduced future impacts
  - Zoning, dikes, diversions, flood contingency plans
  - Impacts of the 2011 record floods were mitigated

(Walker Projects, 2018)
How does Climate Change Affect Flooding?

- Model projections depict a warming global climate.
- The Intensity, Frequency, and Duration of local and regional extreme climate events are also changing.
- Model projections of future climate suggest an increase in severity of extreme hydro-climate events.
- Our economic well-being depends on our adaptive capacity.
- Being prepared for extreme events will strengthen local and regional resilience.

There is one global climate system, and it is changing.

Image: NASA
Climate models: a warming future, +2 to +4 °C
- Warmer, wetter winters; Hotter, drier summers; Greater variability with potential risks of more extreme events (floods, storms, droughts)

Annual temperature for the SSRB. The baseline (1961–90) conditions are mapped on the left. These median scenarios were derived from the Canadian Global Climate Model (CGCM) version 3.1/T47 and greenhouse gas emission scenario B1(2).

(Sauchyn, VACEA)
Climate change increases flood risks - a need for Adaptation

- Vulnerability:
  - Society’s susceptibility to extreme climate events (e.g. flooding) is defined as “vulnerability.” When an event exceeds coping capacity, economic and social systems are impacted. Floods may cause catastrophic impacts to infrastructure.

- Adaptive capacity:
  - Society’s ability to cope, adapt and be resilient to negative impacts from extreme climate events.

- Adaptive capacity to flood risks requires:
  - Improving our understanding of risks, impacts, mitigation measures and best practices to strengthen local and regional resilience.
Scenario Planning and Risk Assessment – key initial adaptation tools

- Diverse stakeholders have local knowledge of historic risks and vulnerabilities

- Stakeholders’ values motivate adaptation decision-making (Corkal & Sauchyn, in press)

- Risk Assessment, climate science down-scaling, Modeling, Mapping:
  - Tools: e.g. MRAT: storm sewer & stormwater infrastructure tool
  - Flood insurance

- Determine specific proactive adaptation actions
Adapt with Preparedness Planning

- Learning from past risks and experiences
- Incorporate climate science into adaptation planning
- Local and Regional emergency preparedness and response plans (e.g. to flooding) will guide adaptation
- Mainstream “adaptation planning” into operations
- Continually review & improvement actions
- Implement Adaptations over time
  - Near-term 0-5 yrs.
  - Longer-term 5-20 yrs.
Adapt with Zoning, Smart Development and Education

- Adapt for resilient communities and watersheds
- Zoning is critical
  - Map and know your high water flood zone
  - Relocate development out of flood-prone areas
  - Do not build or develop in flood-prone areas
  - Enforce zoning by-laws
- Protect critical infrastructure from flood risk
- Preserve natural features to buffer runoff
- Educate industry, citizens and all stakeholders
Engineering Adaptations

- Engineers Canada, Public Infrastructure and Engineering Vulnerability Committee. https://pievc.ca/
- Protocols to assess infrastructure vulnerability to extreme weather vulnerability and adaptive capacity
- Winnipeg’s floodway
  - *built 1962-68 costing ~$63 million*
  - *Preventing tens of billions of flood damages in Winnipeg since 1968*

https://cscehistory.ca/national/red-river-floodway-winnipeg-mb/
Institutional Adaptations

- Mainstreaming adaptation is:
  - occurring with all orders of government and industry
  - guiding decision-making, funding & operational planning

- Protect Hard & Soft Infrastructure

- Engage Diverse Groups of Stakeholders
  - Participatory planning and purposeful collaboration
  - Assess risks (historic and future)
  - Down-scale climate science for regions
  - Implement local & regional adaptations

- Continuous improvements

The near-term inevitability of climate change has become part of both the scientific consensus and the political mainstream.
RM Adaptation Example

- Timber Bridge to Culvert Crossing
- Engineering Codes for Design Flow
- Current 2010-16 floods “dwarfed” historic floods; seen as increasing risk

To adapt to flood risk uncertainty, a “no regrets” feature was incorporated:

- A road section was lowered to serve as a spillway for large runoff events
- Traffic would be impaired but the culvert crossing and upstream infrastructure will be better safeguarded from future flood risks

(Walker Projects, 2018)
Are you vulnerable?  
What is your adaptation future?

- Proactive adaptation is not new – but it is more critical with climate change
- Resiliency & smart adaptation strengthens coping capacity for:
  - *natural climate variability, and*
  - *changing climate trends*
- [http://prairieclimatecentre.ca/](http://prairieclimatecentre.ca/)
- Proactive adaptation in infrastructure planning
  - *mitigates flooding and reduce risk*
  - *benefit social systems and citizens, and*
  - *strengthen economic resilience*
Selected References


- Municipal Climate Change Action Center/All One Sky: Climate Resilience Express - [http://www.mccac.ca/resources/Climate-resilience-express](http://www.mccac.ca/resources/Climate-resilience-express)


- Preventing Disaster Before It Strikes: Developing a Canadian Standard for New Flood-Resilient Residential Communities (N. Moudrak & B. Feltmate, 2017) Intact Centre on Climate Adaptation


- Walker Projects Inc. , 2018 (Saskatchewan Provincial Disaster Assistance Program cases)