Urban Flooding
Assessing Climate Change and Extreme Rainfall Events

Andrew Wiens, P.Eng.
January 26, 2018
Outline
Outline

Case Study:
- City of Surrey: Climate Change Rainfall Adaptation Strategy

Other Project Examples:
- City of Burnaby

Insurance & DFA

Summary

Special Thanks to:
Case Study: Climate Change Rainfall Adaptation Strategy
## Project Objectives

| 1 | Review **impacts** of City’s climate change rainfall projections as applied to three case study areas |
| 2 | Evaluate performance of stormwater system |
| 3 | Develop and evaluate adaptation measures |
| 4 | Develop screening level assessment to identify **high risk** areas |
City of Surrey

- Area: 317 sq.km.
- Population: over 500,000
Study Areas

Area 1:
- Single Family Residential Housing
- Houses and storm infrastructure built during the 1970’s and 1980’s
- Some basements

Area 2:
- Single Family Residential Housing
- Houses and storm infrastructure built during the early 2000’s
- Some basements

Area 3:
- Commercial/Multi-Family Housing
- Few basements
Future Climate Change Projections

Average increase in projected rainfall statistics:

<table>
<thead>
<tr>
<th>Planning Horizon</th>
<th>Increase Relative to 2013 IDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030’s</td>
<td>20%</td>
</tr>
<tr>
<td>2050’s</td>
<td>35%</td>
</tr>
<tr>
<td>2080’s</td>
<td>68%</td>
</tr>
</tbody>
</table>
Why does this matter?
Why does this matter?

- **Key objective** is not pipe sizing – it is **identifying impact** to **society** (economic losses)

- River & coastal flood risk is well understood; rainfall flooding risk not so much...
Why does this matter?
Why does this matter?

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Top Flood/ Storm Events for Insurance Payouts

Loss & Loss Adjustment Expenses
Source: IBC Facts Book, PCS, CatIQ, Swiss Re, Munich Re & Deloitte
Values in 2015 $ CAN
Top Flood/Storm Events for Insurance Payouts

Loss & Loss Adjustment Expenses
Source: IBC, Facts Book, PCS, CatIQ, Swiss Re, Munich Re & Deloitte
Values in 2015 $ CAN
The Hydrologic Model
Hydrology: Rainfall

Short Duration Rainfall Intensity-Duration-Frequency Data

Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

VANCOUVER INTL A
BC
1198395
1953 - 2013
59 years / ans
Latitude
49° 11'N
Longitude
123° 11'W
Elevation / Altitude
4 m

Return Periods/
Périodes de retour
Years / ans
100
50
25
10
5
2

Intensity (mm/h) / Intensité (mm/h)

Minutes
Duration / Durée
Hours / Heures

Environment Canada

Canada
Hydrology: Rainfall

- Different Terms for Probability
  - Return Period
  - Flood Frequency
  - Exceedance Probability
Hydrology: Rainfall

- Different Terms for Probability
  - Return Period
  - Flood Frequency
  - Exceedance Probability

100 Year Flood

The magnitude of flooding which has a 1% chance of occurrence in any year
Hydrology: Rainfall

- Different Terms for Probability
  - Return Period
  - Flood Frequency
  - Exceedance Probability

100 Year Flood

The magnitude of flooding which has a 1% chance of occurrence in any year

Key Point: Annual Probability
Hydrology: Runoff

• Definition:
  “The volume of rainfall which flows off an area.”

• Varies By Catchment Parameters
  • Area, Slope, Soil Type, Land Cover

• Varies By Rainfall
Hydrology: Climate Change

<table>
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<tr>
<th>SEVERITY</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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<td>Catastrophic 0.800</td>
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<td>21</td>
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<td>42</td>
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<td>Hazardous 0.400</td>
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<td>15</td>
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<td>Major 0.100</td>
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<tr>
<td>Minor 0.025</td>
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<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
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<tr>
<td>Measurable 0.0125</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>7</td>
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<tr>
<td>No Effect</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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</tbody>
</table>

Adapted from PIEVC Risk Table, Engineers Canada
The Hydraulic Model
The Hydraulic Model

The Traditional Approach
The Hydraulic Model

The Traditional Approach

- 100% collection efficiency
- No exchange of flow between minor and major system
- Excess flow stored at nodes
- No transference of flow to next d/s node
The Hydraulic Model
The Traditional Approach
The Hydraulic Model

The New Approach

Major System can flood roads and properties

CB
Pipe
MH
CB
Pipe
Minor System
The Hydraulic Model

The New Approach

Why Model this?
- Don’t we have a Major System?
- Isn’t it supposed to be safe?

Major System can flood roads and properties

CB
Pipe
MH
CB
Pipe
Minor System
Imperial Street between Walker and Canada Way
What does Flooding Mean?
The Flood Damage Calculations
The Flood Damage Calculations

Overview...

- Depth-Damage Curves
Depth Damage Curves

Depth-Damage Relationship by Landuse
(average of sub-types - includes structure and contents)

Water Depth by Floor, m

Basement
Residential
Commercial
Ind./Inst.
Park Structure

Damage, $/m²
Average Annual Risk

![Graph showing the relationship between annual probability of occurrence and damages.](image-url)
Average Annual Risk

\[ \text{Total Damage} = \frac{Y}{2} \sum_{i=2}^{n} [D_i + D_{i-1}] \times \left[ \frac{1}{R_{i-1}} - \frac{1}{R_i} \right] \]

- Where:
  - \( n \) = The total number of return periods
  - \( D \) = Damage at a given return period ($)
  - \( R \) = Return Period (i.e. 50, 100, etc.)
  - \( Y \) = Record of Interest (years)
The Model Results
The Model Results
Analysis

- Hydraulic Analysis to estimate flood extents
- Flood Damage Calculations

<table>
<thead>
<tr>
<th>Time Horizon</th>
<th>5-year (20% AEP)</th>
<th>100-year (1% AEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>2030</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>2050</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>2080</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>
The Model Results
Area 1 - Older Residential Area

Does it Matter?

5-year (2013)
The Model Results
Area 1 - Older Residential Area

5-year (2013)
The Model Results
Area 1 - Older Residential Area

5-year (2080)
The Model Results
Area 1 - Older Residential Area

100-year (2080)
The Model Results
Area 2 - Newer Residential Area

5-year (2013)
The Model Results
Area 2 - Newer Residential Area

5-year (2080)
The Model Results
Area 2 - Newer Residential Area

100-year (2080)
Mitigation Options
Available Adaptation Options

- Backflow Preventers
- Lot-Level Storage
- Sump Pumps
- Basement Window Well Protection
- Bylaw Changes to Reduce Flood Vulnerability
- Modify Overland Flow Paths
- Lot Grading Strategy
- Purchase & Abandon Property
- Minimum Building Elevation
- Upgrade Pipe Conveyance
- Pipe Storage
- Peak Flow Diversion
- New Community Ponds
- Retrofit Existing Ponds
Sewer Backflow Preventers
Mitigation Options
Sewer Backup Valves

- Benefit–Cost Ratio: 200 to 400
- Easy Implementation
Upgrade Pipe Conveyance
**Mitigation Options**

*Pipe Upgrades*

- Sized for 5-year 2080
- Benefit-Cost Ratio = 15 to 50
MBE Strategy
Mitigation Options
Minimum Building Elevation

- Sized for 100-year 2080
- Benefit-Cost Ratio = 15 to 80
- Long Implementation
Modify Overland Flow Paths
Mitigation Options
Modify Overland Flow Paths

- Sized for 100-year 2080
- Benefit-Cost Ratio = 15 to 80
- Long Implementation
Disaster Financial Assistance (DFA) and RESIDENTIAL FLOOD INSURANCE

The purpose of DFA is to help individuals and small business owners recover from uninsurable disasters. The DFA program operates under the Emergency Program Act and the ensuing Compensation and Disaster Financial Assistance Regulation and is required to provide compensation in compliance with this legislation. DFA eligibility criteria, as defined in the Act and the Regulation, have been applied consistently and fairly throughout the province since 1995.

Section 8 of the Regulation states that "eligible costs does not include costs or expenses … for which insurance was reasonably and readily available".

Until recently overland flood insurance was only available for commercial buildings.

It is expected that in the next two years this insurance will be reasonably and readily available for single family residential homes across all of BC. The phrase ‘readily available’ means that a person could obtain this insurance from a local agent or broker. ‘Reasonably available’ should not be confused with affordable. What a person can afford is subjective and specific to that person. What is important is that the price of the insurance was reasonable considering the risk.

EMBC is closely monitoring the availability of overland flood insurance in BC and will continue to deliver DFA in accordance with existing legislation. If a flooding disaster occurs and DFA is authorized for a disaster event, an applicant who could reasonably and readily have purchased overland flood insurance would NOT be eligible for DFA.

Over the next several years as additional insurance options roll out, EMBC will apply discretion in how it determines eligibility. For example, a homeowner or tenant would not be expected to amend their existing policy as soon as overland flood insurance becomes available. But DFA may be denied if overland flood insurance was available on renewal and they chose not to purchase it.
Questions?

- So,
Questions?

• So,
Questions?

- So, I'm moving to Calgary…
Why evaluate overland flow?

Don’t assume “safe” overland flow
Summary

- Why evaluate overland flow?

It’s not always a problem
Summary

- Why evaluate overland flow?
Questions?
Contact Andrew Wiens, P.Eng.

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