Squamish, BC: A Success Story for Integrated Flood Management Planning

David Roche, Kerr Wood Leidal

David Roulston, District of Squamish
Squamish, British Columbia

Population ±19,000

Rugged natural setting

BC’s Sea to Sky Corridor

“Outdoor Recreation Capital”
Squamish Flood Hazards
Dike Network

- > 20 km
- District responsibility
- Existing dikes are deficient
- Significant upgrades needed
- Reliability is key
<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>• FDRP Federal / Provincial Floodplain Mapping</td>
</tr>
</tbody>
</table>
| 1994 | • Flood Hazard Management Plan  
       • Policy/Updated mapping |
| 2004 | • Province delegates flood management authority  
       • “Poor implementation of 1994 FHMP” |
| 2014 | • Intense growth pressure  
       • New solutions needed |
The times, they are a-changin’

- Changes in Provincial Legislation / guidelines
- Significant development / changing vision
- Improved understanding of flood hazards
Because nothing is ever easy…
Because nothing is ever easy…

- Measures taken to mitigate risk can change the risk
- Mitigation can become a “moving goalpost”
So what does “Integrated” mean, anyway?

- Approach / Process
- Multidisciplinary / Collaborative
- Iterative / Optimizing
- Adaptive / Sustainable

“Systems” based process that brings together natural processes, human activities, public perception and decision-making criteria

Hazards  Consequences  Mitigation  Stakeholders  Decisions
Simply put…
An IFHMP is born

- Began 2014
- Three years
- $500K budget
- Four phases

Phase 1: • Background/Gap Analysis
Phase 2: • Coastal Flood Mitigation Strategy
Phase 3: • River Flood Mitigation Strategy
Phase 4: • Integrated Flood Management Plan
Coastal Flood Hazards

Tide, Storm Surge, SLR, and Waves

- Design Flood Level (Future)
- High Tide (Future)
- High Tide (Existing)
- SLR + Uplift/Subsidence Adjustment
- Storm Surge + Local Effects
- Wave Run-up
- Freeboard
- Flood Construction Level (Future)
- Future Natural Boundary
- Setback
Coastal Flood Hazard Assessment

Combined Method: A + B + C

Joint Probability Analysis:
A + (B|A) + (C|B|A)

Hindcasting computer model

Reality

COST

DATA

Year 2100 Designated Flood Level: 3.99 m
Dike Breach Model

- Existing river model
- Assumes dikes will be raised
- Still need information for:
  - Secondary Mitigation
  - Emergency Response
  - Risk-based Decisions

- Two models: upper and lower
- Eight separate dike breaches
- Sea dike confines lower
- River dike confines upper
Dike Breach Model Construction

- Model decides how much water goes where so
- Model must include all important behaviours

For example:
- Buildings acting as obstructions
- Flow concentration along roads
- Account for future development

For the IFHMP:
- Use a high-resolution floodplain model
- Results validated extra effort
Dike Breach Model – Breach Zone

- Breach could occur at any location
- Hazards can be higher right next to dike breach
- Shouldn’t be ignored
- Can’t model everything

- GIS post-processing
- Approximates "breach zone":
  - water levels
  - velocities
- Based on driving head in river
- Calculated at 10 m intervals along dike
Dike Breach Model – Composite Results
Dike Breach Consequence Assessment

Analysis focused on Consequence Assessment (not risk)

- Physical Danger
- Economic Damages
- Social Consequences
- Environmental Consequences
Community Engagement

Inform  Consult  Involve  Collaborate  Empower

IAP2 Spectrum of Public Engagement
Adapted from City of Burlington, 2013

Open Houses, online surveys, workshops, Council meetings, TWG, Squamish Nation meetings & more

Consensus may not be possible due to conflicting objectives!
Flood Mitigation Strategies

- Protect
- Accommodate
- Avoid
- Retreat

Adapted from: United States Army Corps of Engineers (Riley, 2008)
Typical Mitigation Strategies

- Limit Densification in High Hazard Areas: Discourage densification through rezoning.
- Improve Dike Protection: Address deficiencies and adopt a higher standard of protection.
- Accommodate Flood Hazards: Preserve floodways and raise new structures above flood level.
- Encourage Growth in Safer Areas: Plan for new development.
Proposed Sea Dike
River dikes

- No new dikes
River dikes

- No new dikes
- Hold the line
River dikes

- No new dikes
- Hold the line
- Go big or go home
Flood Risk Management Policy

1. Integrated Flood Hazard Management Plan
2. Official Community Plan
3. Floodplain Bylaw
4. Development Permit Area
   - Land Use Policy
   - Floodways
   - Building Elevations
OCP: Flood Hazard Land Use Policy

Controlled Densification Areas

Restricted Densification Areas (red)

Conditional Densification Areas (yellow)

Limited Densification Areas (orange)

Original recommendation: all red

Council prioritized development
Major dike upgrades, less control
Good decision? Bad decision?
Their decision.
Summary

- Comprehensive plan

- Groundbreaking technical work

- Final deliverables:
  - Capital plan
  - Comprehensive policy framework
Conclusions

- Natural hazards don’t scale to our desired budget
- Analyze and manage risk on a “systems” scale
- Consider how hazards, development, mitigation interact
- Plan for the future to avoid moving goalposts
- Explore all practicable solutions
- Different approaches in different areas (and that’s OK!)
- Respect the value of community buy-in
Becoming IFMP / IWMP / ISMP Champions

- Difficult problems mean difficult discussions…
- Work toward consensus, but don’t assume you’ll get it
- There is no free lunch!

- The prize is worth the fight
Thank you!