Challenges of Applying a Risk-based Watershed Assessment in the BC interior

By

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Why this talk?

- Forest Practices Board finding in the Duhamel Creek investigation (FPB, 2013) recommended that the forest licensee update their watershed assessment using LMH 61 risk-based approach.
- Moving from cumulative-effects type assessment that considers multiple attributes within the watershed to the Hydrogeomorphic Risk on Fans assessment that fociusses on processes that can impact ‘elements at risk’ on the fan is an substantial change in methodology and presents some challenges for professionals undertaking such assessments.
Comparing inventory-based to Risk-based assessments
Flood Hazard definition
Factors contributing to Flood Hazard
Estimating the effects of land cover or climate change on Flood Hazard
Concluding comments
The IWAP/CWAP used inventory-type analyses to assess potential impacts of forest development on:

1) Peak flows (ECA);
2) Landslide activity;
3) Surface erosion;
4) Riparian impacts;
5) Stream channel impacts; and
6) An evaluation of sensitivity of the watershed to further forest development.

“The fan investigations provide an understanding of past hydrogeomorphic processes that formed the fan, and thus identify the processes produced by the watershed. “

Hazard assessment focuses on debris flows/debris floods.
Flood Hazard

- \( R = H \times C \)
- **What is a hazardous flood?**
  - *(Jakob et al., 2015, Rare and dangerous: Recognizing extra-ordinary events in stream channels)*
  - ‘hazards’ defined at the outset – water quality at the intake, damage to private land, failure of culverted crossing

- **Probability of exceedance of a flood of a given magnitude**
  - 1:50? 1:200? Look for indicators of the damaging flood in the channel.
Quantifying changes in flood hazard

- **Physical controls on flood frequency (hazard)**
  - Meteorology (climate)
  - Watershed physiography (soil depth, slope gradient, elevation range, aspect distribution, geology)
  - Antecedent soil moisture
  - Land cover

- **Shape of the flood frequency curve (CDF/PDF)** for a given watershed is inherently linked to these physical controls
• Analysis of meteorologic and hydrograph data (nearby) and,
• Field observations of disturbance history provides key information about the triggers for damaging/channel forming floods.
Watersheds with different physical characteristics within the same hydroclimatic region will display different flood frequency response to changes in landcover and climate.

In snowmelt regimes - net radiation (aspect). Rainfall regimes – soil and slope gradient
• To quantify how landcover or climate change will affect flood hazard need to consider how both the mean and the variability of the frequency distribution will change.

• This leads to the questions;
  – What controls changes in the distribution mean?
  – What controls changes the distribution variability?

• Understanding how the mean and variability of the distribution might change links back to the physical characteristics of the watershed.
Conceptual model of snowmelt flood response to forest removal

**REMOVE FOREST COVER**
Increase in net radiation due to conversion from longwave to shortwave dominated snowmelt

**STAND LEVEL**
- Increase snowmelt rate
- Increase mean of ffd
- Increase in volume of runoff to stream

**BASIN LEVEL**
- Change in variability of ffd due to change in timing of runoff

**Scale**

**Physical characteristics**
- Slope aspect
- Slope gradient
- Elevation
- Stand density
- Aspect distribution
- Slope gradient
- % Alpine area
- Stand density
- Basin size
- Elevation range
- Aspect distribution
- % Alpine area
- Drainage density

**Increasing effect**
- North to South
- Gentle to Steep
- Low to High
- Open to Dense
- South to Mixed
- Gentle to Steep
- High to Low
- Open to Dense
- Large to Small
- Wide to Narrow
- Mixed to Single
- Large to Small
- Low to High
Effects on flood frequency distribution given increases in the mean and changes in variability

1. Decrease in variability
   Distribution of harvesting resulting in reduced synchronization of snowmelt runoff over basin. (PDF width narrows, CDF converges).
   Possible Scenario 1:
   Small alpine basin with harvesting concentrated at lower elevations causing snowmelt runoff to advance in lower harvested areas.

2. No change in variability
   Distribution of harvesting causes no change in synchronization of snowmelt runoff over basin. (PDF width unchanged, CDF parallel).
   Possible Scenario 2:
   Moderate to large, moderate gradient basins where harvesting is distributed across elevations and aspects.

3. Increase in variability
   Distribution of harvesting causes increased synchronization of snowmelt runoff over basin. (PDF widens, CDF diverges).
   Possible Scenario 3:
   Small non-alpine basins regardless of harvest distribution or larger basins with harvesting concentrated in peak flow generating region.
Case 1 – Duhamel Creek

Potential flood hazard change in Duhamel given existing and proposed harvesting

- 19% ECA
- Concentrated on east aspect (increase synchronization)
Case 2 – Deer Creek

Potential flood hazard change in Deer given existing and proposed harvesting

- 16% ECA in Deer, 32% in Kennedy Creek
- North aspect slope (little change in net radiation but more snow)
Estimating changes in flood hazard

- Identify driving mechanisms of floods
- Disturbance history of channel
- Connection between physical characteristics of basin and runoff/flooding
- Consider how mean and variability of ffc will change.
- HRA report must document all of this in order to quantify changes in flood hazard
Flood Hazard versus Peak Flow Hazard

• Previous Watershed Assessment (WAP) involved calculating ‘peak flow hazard’ - linked to harvest level (ECA)
• Concept of changes in ‘peak flows’ associated with logging is based on literature that investigated forest harvesting impacts on peak flow magnitude through chronological pairing
• Can not use the CP-based literature (e.g. Forrex Hydrology compendium Chapter 7) to provide the scientific basis for understanding how landcover changes will affect frequency of floods.
• Professional community needs to put pressure on academic researchers to investigate landcover impacts on flood regime include frequency, magnitude, duration etc – abandon CP
Improving the HRA (comments for JPB)

- Risk-based analysis requires the identification of elements at risk and the estimation of changes to flood hazard, hydrogeomorphic hazard (frequency) associated with development
- More rigorous and quantitative than WAP Inventory-based cumulative effects assessments for determining hydrological impacts of proposed development
- Difficult to provide a holistic, watershed-scale assessment that considers issues such as riparian management or road-related sedimentation
Thank-you