Summary of Hydrological Changes as a Result of Mountain Pine Beetle and a Changing Climate in Interior Watersheds

Current Findings and Lessons Learned from 2 years of Workshops

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1. Introduction

What are researchers finding out about hydrological changes caused by the Mountain Pine Beetle (MPB) infestation and a changing climate in the Fraser Basin its sub-basins? What are the real-world impacts that we are and will be dealing with? How can we enhance collaboration to respond to, and minimize these impacts?

The Fraser Basin Council has recently hosted 2 workshops to address these questions:

- *Hydrological Impacts of Mountain Pine Beetle in the Fraser Basin* held in Kamloops in March 2010 with 30 participants
- *Fostering Collaborative Responses to Hydrological Changes in the Nicola Watershed* held in Merritt in March 2011 with 50 participants

The purpose of this document is to share the following information:

- key findings of current research and implications at the sub-watershed level
- lessons learned for the benefit of other interior watersheds
- recommendations for further research and multi-interest collaboration
- outline a communications plan for dissemination of this report

2. Key findings of current research and implications at the sub-watershed level

This section outlines the presentations made at the workshops in 2010 and 2011.

Review of Mountain Pine Beetle and Water Management Workshop, Kelowna, June 2009
Todd Redding, Watershed Management Extension Specialist with FORREX, gave an overview of the highlights and key messages from the *Mountain Pine Beetle and Water Management* workshop held in Kelowna in June 2009. The hydrological effects were summarized as follows:

- Increased snow accumulation and faster melt – will depend on annual weather patterns
- Model simulations indicate that peak flow magnitude increases with area of salvage harvesting
- Regional water quality study found little short-term effect of MPB but some indication of harvesting effects

"Take home" messages for water purveyors were summarized as follows:

- Degraded water quality will increase treatment cost
- Water managers have minimal influence on land management decisions
- Fire risk – not salvage harvest - may be the primary threat to watersheds
- Concerns exist over forest re-growth on water supply
- Climate change will influence both water quality and water quantity
- There is strong support for continued research, in particular, better hydrological model predictions and links to field research

Hydrological Changes and Uncertainty as a Result of MPB in the Fraser Basin
Markus Schnorbus, hydrology modeler, researcher and forecaster with the Pacific Climate Impacts Consortium at the University of Victoria, presented the current state of knowledge of hydrological impacts of mountain pine beetle, as well as current hydrological modeling results.

Markus indicated that the most severe MPB outbreak in BC is in the geographic centre of the Fraser Basin; if the predictions are accurate, nearly all of the pine in the Basin will be infested.

The forest stand-water balance and forest stand-energy balance are affected by the infestation as follows:

- Red- and grey-attack stands accumulate less snow than clearcut openings
- More energy reaches dead stands than healthy stands – this leads to greater snow melt rates in dead stands
- There are variable effects on mean annual water yield (streamflow) and peak melt

Hydrological impacts of MPB and forest harvesting were summarized as follows:

- Forest disturbance increases snow accumulation, melt rates, stand drainage and water yield
- Salvage and unsalvaged stands have potentially different impact/recovery trajectories
- Immediate impact (< ~20 years) highest in salvaged stands, lower in unsalvaged stands
- Long-term impact (> ~ 30 years) potentially highest in unsalvaged stands, lower in salvaged stands
- Magnitude of impact is sensitive to attack severity and presence/amount of secondary forest structure
- Impact will be site-, watershed- and management-specific

Hydrologic modeling is used to "scale up" impacts on a specific watershed to a larger area, such as the Fraser Basin. Markus described the models and how they work. Key findings of the models are as follows:

- Forest disturbance tends to shift the peak flow regime to higher magnitudes (for given return periods), or more frequent occurrence (for given magnitudes)
- Peak flow impacts increase with cumulative disturbance severity
- Peak flow impacts vary widely between sub-basins – but in general, the higher proportion of the basin covered in pine forests, the greater the impact
- Magnitude of impact correlates with relative change in disturbance area; however, unexplained variation remains
- Hydro-climatology strongly influences peak flow/freshet sensitivity to forest disturbance:
  - Most significant average freshet runoff changes occur in the Fraser Plateau area where pine is most abundant, therefore the forest disturbance is maximized;
  - Less significant average freshet runoff changes are in the Fraser headwaters and Columbia mountains with significant areas of alpine terrain (e.g., most snow falls in the alpine areas, not in the pine forests)
- As drainage area gets larger, the potential freshet discharge impacts get smaller (e.g., net impact of MPB on Fraser River flows at Hope is negligible)

Effects of MPB on snow and spring run-off

Rita Winkler, hydrologist, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) gave a presentation on snow accumulation and ablation in forested ecosystems, the impacts of MPB on forest cover, and a summary of post-MPB and post-wildfire research. Her conclusions were:

- Snow accumulation and ablation are highly variable, spatially and temporally
- Forest cover has a significant effect on snow accumulation and ablation
- Snow accumulation and ablation depend on interrelationships between the weather, snowfall pattern, and cover
- Initial changes in snow accumulation and ablation post MPB and fire may continue to change with loss of stand structure over time
- Depending on the extent of natural disturbance, the watershed and the year, changes in snow generated water yield may or may not be measureable at the watershed scale

After some discussion and questions, it was agreed:

- Climate has always been variable both year-to-year, and spatially. Trend of a changing climate is warmer winters, less precipitation as snow…but the current variability appears more significant than the long term trend
- Watershed research is done on a relatively small scale with controlled variables – it is difficult to scale-up to sub-basin or watershed level

Surface water-groundwater interaction between the Coldwater and Nicola Rivers and the Merritt aquifer

Kevin Bennett, groundwater hydrologist, MFLNRO gave an overview of work he completed that mapped the aquifer under the City of Merritt, and the relationship with the Coldwater and Nicola Rivers. Kevin presented the concepts of how surface water and groundwater are connected, including gaining, losing and disconnected stream reaches, and the impacts that extraction of groundwater has on the natural system.

Kevin's conclusions were:

- Recharge to Merritt aquifer is dominated by river loss.
- Aquifer health is dependent on river flow.
- River health in summer is influenced by aquifer health.
- Climate change has resulted in earlier freshet and a longer dry season.
- Key challenge is how do we manage aquifer to increase recharge, reduce late summer river losses?
- Water management plans need to understand & consider groundwater and surface water relationships

Impacts of changes in stream peak flows

Don Dobson, consulting hydrologist with Urban Systems Ltd., gave an overview of the sources of flows in the Nicola watershed, impacts of changes to forest cover and in stream peak flows, including some studies in the Coldwater River. Don noted that although approximately 40% of the watershed area is upstream of Nicola Lake, only 20% of the contribution to the entire watershed is from upstream of Nicola Lake. In contrast, Spius Creek and Coldwater Rivers in the southwestern part of the watershed contribute approximately 80% of the total volume of the Nicola system as measured at the outflow at Spence's Bridge, and yet comprise only 25% of the larger Nicola watershed area. There is a smaller component of pine in these 2 sub-basins.

Don concluded that in sub-basins with decreases in forest cover due to MPB:

- There will be more snow accumulation in dead forests, and in clearcut areas
- There will be earlier snowmelt, and therefore runoff will be faster, earlier and increased
- Runoff will not be synchronized at different elevations (i.e., in a natural system, low elevations melt and have runoff earlier than high elevations; with increased dead forest and clearcuts at high elevations, runoff is no longer synchronized)

Don made the following more general conclusions:

- As the forest recovers and a live forest is re-established, snow accumulation and runoff will return to more natural conditions, and stream peak flows will be slower, be later in the season, and be of decreased quantity compared to current
- For the entire Nicola watershed, increases in stream peak flow will be negligible due to the majority contributions of Spius and Coldwater sub-basins and the minor component of pine forest

- Sub-basins with more pine forest such as Guichon, Quilchena and Upper Nicola will have more noticeable impacts on stream peak flows
- Climate is the wildcard, as Rita indicated – the variability has significant impacts on year-to-year changes in snowpack. Also, whether soils are dry or wet in the fall, and when the frost hits the ground in the fall will determine whether runoff replenishes soil moisture in the spring, or whether it runs off and fills up streams, rivers and lakes

Compendium of forest hydrology and geomorphology
Rob Scherer, Watershed Management Extension Specialist with FORREX (Forum for Research and Extension in Natural Resource Management) described the compendium which was released in December 2010 as a joint publication between the provincial government and FORREX. The compendium is a comprehensive synthesis of what we know about forest hydrology and watershed management in BC. Hundreds of authors contributed, and all articles were peer-reviewed. Topics are divided into 19 chapters.

The compendium can be downloaded by volume or chapter from the following website:
http://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh66.htm

3. Lessons learned for the benefit of other interior watersheds

The following is a summary of lessons learned, as interpreted by the author, from the 2 workshops. It is subjective, but based on observations from these workshops, as well as other work in addressing water and watershed management issues throughout the Cariboo-Chilcotin and Thompson regions. It is purposefully written in layman's terms.

Despite our research, our knowledge is limited
- Watershed research is done on a relatively small scale with controlled variables – it is difficult to scale-up the results to sub-basin or watershed level. As a result, it is impossible to take research findings and apply them across entire watersheds with any degree of reliability.
- Western science is better at looking at individual elements of a natural system, but not the system as a whole

Climate is changing, but more importantly it's variable
- Climate has always been variable both year-to-year, and spatially. Trend of a changing climate is warmer winters, less precipitation as snow…but the current variability appears more significant than the long term trend
- A rancher in the Nicola watershed observed that "…that in 40 years, I haven't seen 2 years that are the same."
- Adapting to a changing climate and available resources is crucial

MPB impacts on hydrology aren't as significant as perceived
- Pine is adapted to grow in dry areas; the areas with the most significant MPB impacts generally contribute the smallest amounts to river flows
- Hydro-climatology strongly influences peak flow/freshet sensitivity to forest disturbance:
  - Most significant average freshet runoff changes occur in the Fraser Plateau area where pine is most abundant, therefore the forest disturbance is maximized;
  - Less significant average freshet runoff changes are in the Fraser headwaters and Columbia mountains with significant areas of alpine terrain (e.g., most snow falls in

the alpine areas, not in the pine forests) or in forests with less pine, and more spruce, fir, Douglas-fir and other species

- As drainage area gets larger, the potential freshet discharge impacts get smaller (e.g., net impact of MPB on Fraser River flows at Hope is negligible; net impact on Nicola River at Spence's Bridge is noticeable; net impact on Guichon Creek at confluence with Nicola River is relatively substantial)

Stream peak flows will eventually return to normal as forests recover

- As the forest recovers and a live forest is re-established, snow accumulation and runoff will return to more natural conditions, and stream peak flows will be slower, be later in the season, and be of decreased quantity compared to current levels at the peak of impacts from MPB and clearcutting.

Groundwater – surface water interactions are not well understood

- Groundwater aquifers and surface water are linked; it's all one system and the health of one depends on the other.
- Temporal variability exists – in some systems such as the Merritt aquifer and the Coldwater and Nicola Rivers, it may be hours to days between changes in groundwater and impacts on surface water; in other systems it may be weeks to months; in other systems it may be years to decades.
- Spatial variability exists – at different scales in a watershed, the relationship between groundwater and surface water may change.

Collaboration is needed to address hydrological issues

- Multiple perspectives are needed to address hydrological issues that address environmental, economic and social concerns
- Watersheds with existing multi-stakeholder committees may not have all the answers, but the level of information sharing, trust between sectors, involvement of first nations and general knowledge of their watershed are at an advantage over others where committees have not been struck

4. Recommendations for further research and multi-interest collaboration

The following are some of the recommendations from the 2 workshops, either identified by the presenters, or generated in the small group discussions:

Todd Redding indicated that continuing information needs were as follows:

- Strong support for continued research
- Role of understory and regeneration on hydrologic recovery
- Improved hydrologic model predictions of the potential effects and links to field research
- Potential implications of climate change and post-MPB forest regrowth to address low flows

Markus Schnorbus indicated that future hydrologic modeling work will include:

- Effect of secondary structures
- Hydrologic recovery
- Effects of alternative management and salvage strategies
- Dynamic and transient forests – what is impact of changing disturbance regimes
- Continued monitoring, data collection and field experimentation

Small group discussions raised the following recommendations either for research or collaboration, or pilot projects:

- Need groundwater maps and other tools and resources for a test watershed
- Development of provincial land use/cover database that shows a history of disturbances that are hydrologically relevant – both manmade and natural
- Research on new and better modeling for flood impacts and protection measures
- Research on the effectiveness of different methods of fire protection for communities, with cost effectiveness accounted for
- Encourage citizen science and use of local knowledge
- Pilot agriculture water reserves as proposed in the draft *Water Sustainability Act* in an area such as the Nicola watershed or a sub-basin
- Package parts of the Nicola WUMP and deliver to Thompson Nicola Regional District in a form that can be incorporated into land use planning, that does not consume many resources on their part
- Nicola Lake water quality monitoring
- Study to identify sensitive habitats and areas of first nation significance or spiritual value
- Cumulative effects pilot project
- Restoration activities on riparian habitat

5. Communications plan

The following will be the communication plan for distributing this document:

- Post on FBC website
- Email to MFLNRO managers throughout the interior
- Email to participants from both workshops, ask to distribute to their colleagues
- Email to Southern Interior, Cariboo-Chilcotin and Omineca Beetle Action Coalitions
- Email to FBC directors on Interior regional districts

Appendix 1 – Information Sources and Resources

British Columbia Drought Response Plan http://livingwatersmart.ca/drought/response.html

BC River Forecast Centre http://bcrfc.env.gov.bc.ca/bulletins/watersupply/current.htm

Compendium of Forest Hydrology http://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh66.htm

Environment Canada http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=65EAA3F5-1

FORREX http://forrex.org

FORREX Streamline publication http://forrex.org/publications/streamline/streamline.asp

Fraser Basin Council http://www.fraserbasin.bc.ca/

Nicola Watershed Community Round Table http://www.nwcrt.org/index.htm

Nicola WUMP http://www.nwcrt.org/wump_overview.htm

Nicola Similkameen Innovative Forestry Society http://www.nsifs.bc.ca/

Okanagan Basin Water Board http://www.obwb.ca/

Southern Interior Beetle Action Coalition http://sibacs.com/

Water Act Modernization http://livingwatersmart.ca/water-act/