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Appendix G

Watershed Analysis Report

DEMP

Hydrologic Effects of Forest Harvesting for Tolko Industries Ltd. High Prairie OSB Division and Buchanan Lumber

Report Prepared for:
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Reviewed by:
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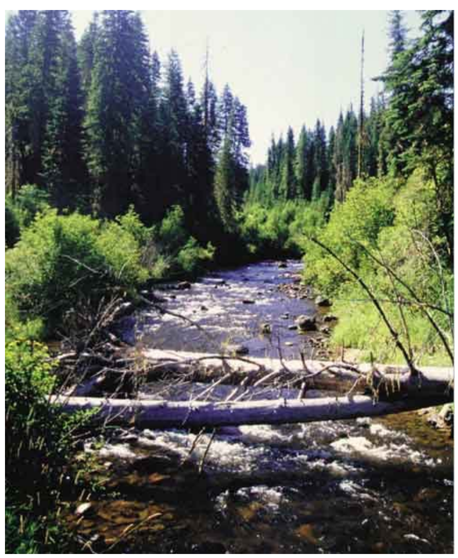

Disclaimer

The assessment of hydrological impacts of harvesting presented in this report reflects the output from a hydrologic simulation model and does not necessarily reflect actual impacts that may be observed. Although the representativeness of output from ECA-Alberta has been evaluated in parallel simulations with other widely adopted forest management oriented hydrologic models (U.S. EPA WRENSS) by Dr. Uldis Silins (Dept. Renewable Resources, University of Alberta) and shows robust and favorable agreement with these other models, ultimately, the reliability of estimates produced using this and other similar models depends on the availability of representative climatic/hydrometric data, representativeness of regional forest growth characteristics with Alberta provincial average growth and yield data, and representative forest harvesting plans. In this context, the author has evaluated the hydrometric data used in this analysis and considers these data to be a reliable reflection of hydrologic conditions for the analysis. Limitations or errors due to deviation in actual forest scale growth rate from provincial average growth rates or limitations imposed by spatial/temporal scale of analysis are outside the author's control. In particular, the spatial distribution of harvested blocks, as well as the presence of additional disturbances (fire, insects, etc.) will also affect water yields.

Furthermore, it should also be re-emphasized that the ECA-Alberta model projects average annual streamflow changes over time based on un-routed flow, assuming average climatic/hydrologic conditions in the region and the rate of stand regeneration. Therefore, changes in annual water yield due to disturbance will vary from simulations based on the actual variability in climate and the degree of departure from average climatic conditions.

It should be noted that Silvacom Ltd. was responsible for preparing the climatic and hydrometric data used in this analysis, setting the ECA-Alberta parameters and running the model simulations for each of the watersheds. Although the author was consulted with regards to the suitability of climatic/hydrometric data as well as the suitability of model parameters, it was the author's responsibility to interpret the results provided by Silvacom Ltd.

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Discussion

The results from the hydrologic simulations vary widely between operating areas and watersheds within those operating areas. This variability is due to a combination of factors including regional differences in climate and long-term average annual streamflow, watershed size, as well as the proposed harvest level within each watershed.

In general, average annual precipitation declines from the west to east. The Sweathouse receives the most precipitation, followed by the Whitemud/Birch, Kimiwan, Salt, and Utikuma operating areas. These climatic differences are reflected to a certain degree in differences in average annual streamflow across the five operating areas. The Sweathouse has the highest average annual yield followed by the Whitemud/Birch, Utikuma, Salt, and Kimiwan operating areas. Although changes in annual streamflow are primarily driven by changes in annual precipitation, differences in topography, surficial geology and vegetation between operating areas will also affect how changes in annual precipitation are reflected in changes of annual streamflow.

In order to evaluate the effects of proposed harvesting on changes in annual streamflow, each of the operating areas was divided into smaller watersheds. These watersheds vary considerably in size from 0.61km^2 to 271.6km^2. In addition, many of these watersheds are actually sub-catchments within larger watersheds delineated by the Prairie Farm Rehabilitation Administration (PFRA) (i.e. the same watersheds used to define baseline streamflow data used as an input for this analysis). As a result, scale becomes important when looking at the effects of proposed harvesting on increases in annual streamflow.

The next section evaluates the hydrologic effect of the proposed harvesting schedule in terms of projected yield increases for each of the five operating areas. Confidence intervals were used to determine whether proposed harvesting resulted in increases in projected streamflow that were significantly different ($\alpha=0.05$) than the long-term average streamflow while accounting for natural variability. For the purposes of this analysis, one stream was used per operating area. The criteria for selection were based on the stream with an average annual yield closest to the average of the operating area, with the longest record. The projected yield increases were then compared with a 15% increase in annual yield to determine the number of years in record that met/exceeded the projected percentage increase and a 15% increase.

Sweathouse

Hydrologic simulation of forest harvesting for the Sweathouse operating area showed a maximum increase in annual water yield of 16mm or 10.9% (16.9% ECA) for Watershed 13 in year 2024, while all of the other watersheds showed projected yield increases of 7.9% or less. The range of natural variability in annual streamflow is very large (32mm/yr – 321mm/yr) (Figure 1). As a result, the maximum projected increase in annual yield due to harvesting (10.9%) is not significantly different (α=0.05) from the long-term average annual yield. Actually, the upper 95% confidence limit is a 15.7% increase in annual yield. In addition, of the 32 years in record, 13 (41%) of the years met or exceeded the 10.9% and 15% levels.

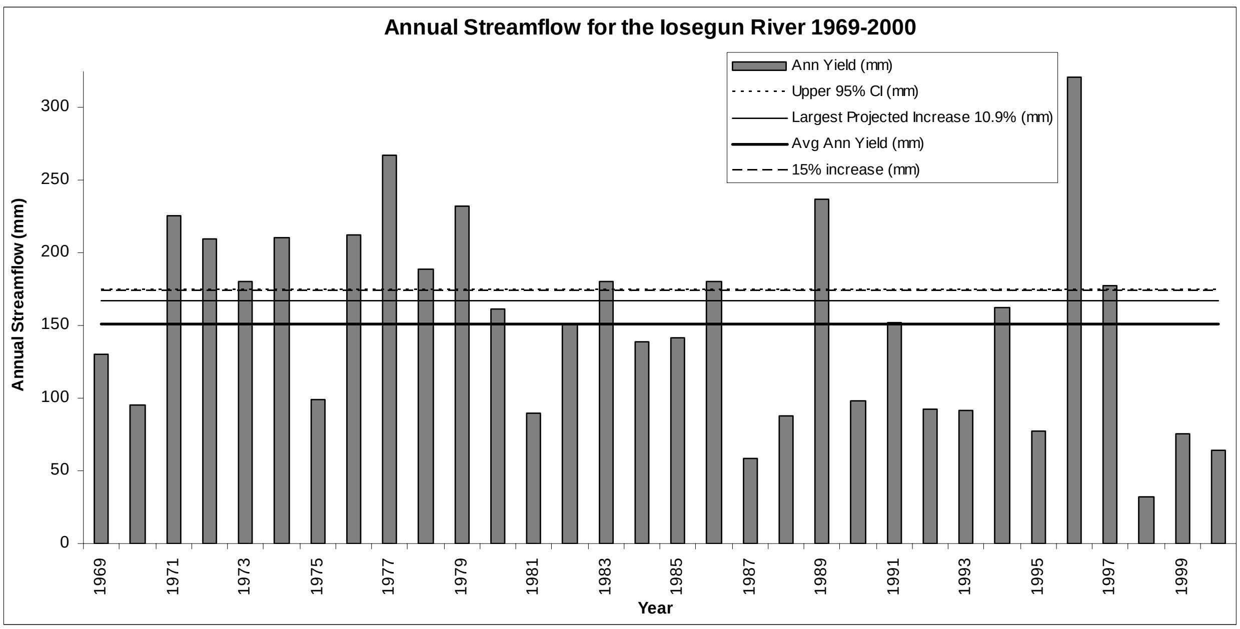

Figure 1 Annual streamflow (mm) for the Iosegun River 1969-2000.

Kimiwan

Hydrologic simulation of forest harvesting for the Kimiwan operating area showed a maximum increase in annual water yield of 15.4mm or 35.7% (13.9% ECA) for Watershed 17 in year 2019, followed by a projected increase of 14.8mm or 34.2% in year 2024. Although the range of natural variability in annual streamflow is very large (3mm/yr – 184mm/yr) (Figure 2) these projected yield increases are significantly higher (α=0.05) than the long-term average annual yield. Actually, the upper 95% confidence limit is a 26.1% increase in annual yield. Two other watersheds exceed this detection limit, #22 in 2009 (31.9%), and #27 in 2024 (34.7%). However, of the 38 years in record, 11 (29%) of the years met or exceeded 15% level and 10 (26%) exceeded the 35.7% level.

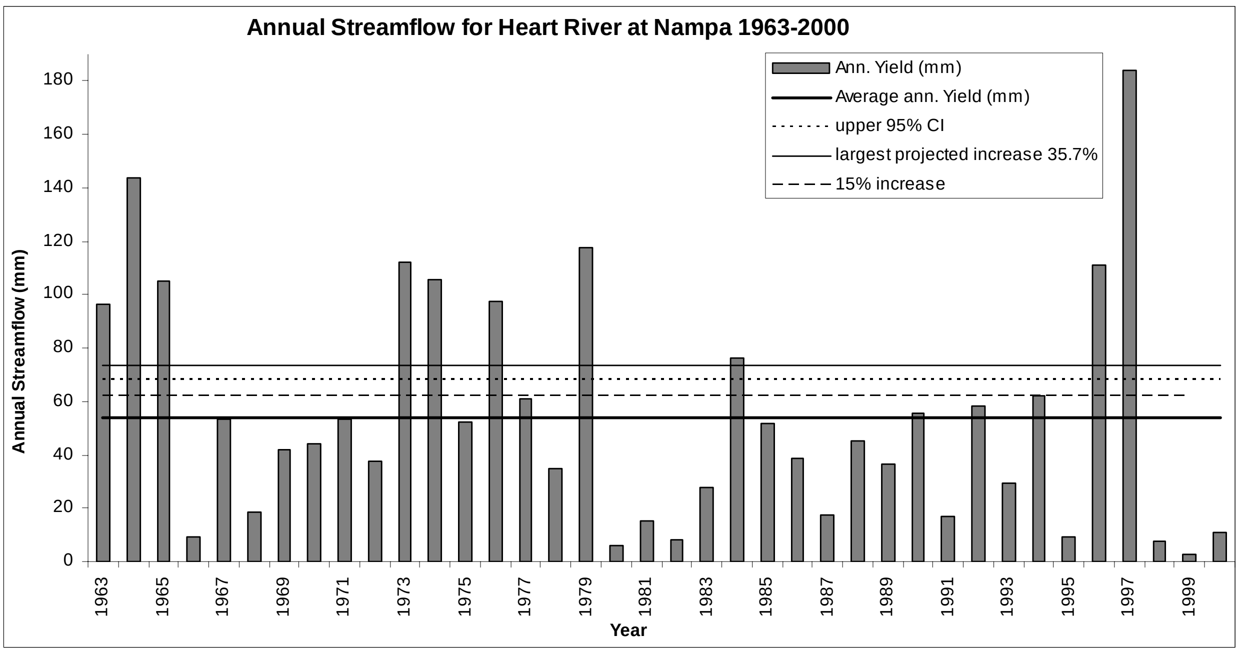

Figure 2 Annual streamflow (mm) for the Heart River at Nampa, 1963-2000

Utikuma

Hydrologic simulation of forest harvesting for the Utikuma operating area showed a maximum increase in annual water yield of 17.2mm or 27.2% (15.5% ECA) for Watershed 103 in year 2019 followed by a projected increase in annual yield of 15.2mm (24%) in year 2024, while all of the other watersheds showed projected yield increases of 18.8% or less. The range of natural variability in annual streamflow is very large (7mm/yr – 249mm/yr) (Figure 3). As a result, the maximum projected increase in annual yield due to harvesting (25.8%) is not significantly different (α=0.05) from the long-term average annual yield. Actually, the upper 95% confidence limit is a 51.6% increase in annual yield. In addition, of the 14 years in record, 3 (21%) of the years met or exceeded 15% level and 2 (14%) exceeded the 25.8% level.

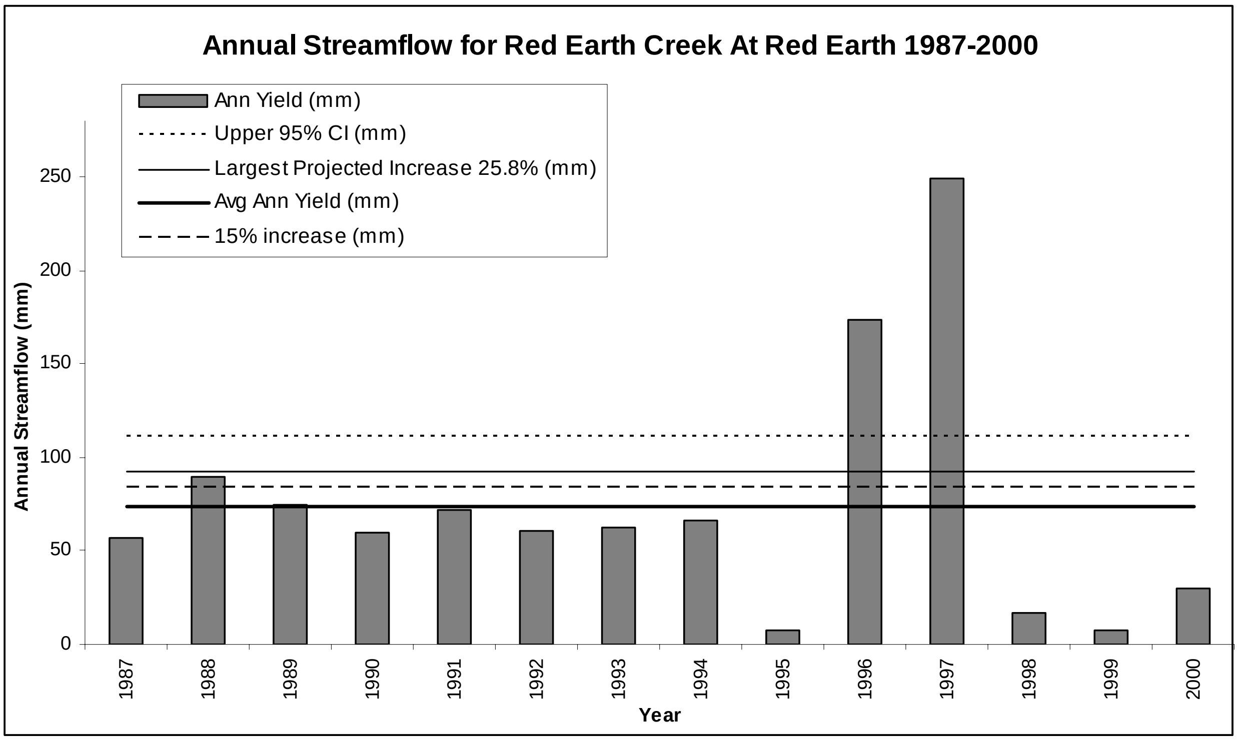

Figure 3 Annual streamflow (mm) for the Red Earth Creek at Red Earth, 1987-2000

Salt

Hydrologic simulation of forest harvesting for the Salt operating area showed a maximum increase in annual water yield of 18.2mm or 38.8% (18.7% ECA) for Watershed 135 in year 2024, while several other watersheds showed increases in annual yield ranging up to 34.9%. The range of natural variability in annual streamflow is very large (3mm/yr – 169mm/yr) (Figure 4). As a result, the maximum projected increase in annual yield due to harvesting (39%) is not significantly different (α=0.05) from the long-term average annual yield. Actually, the upper 95% confidence limit is a 58.5% increase in annual yield. In addition, of the 15 years in record, 4 (27%) of the years met or exceeded 15% level and 3 (20%) exceeded the 39% level.

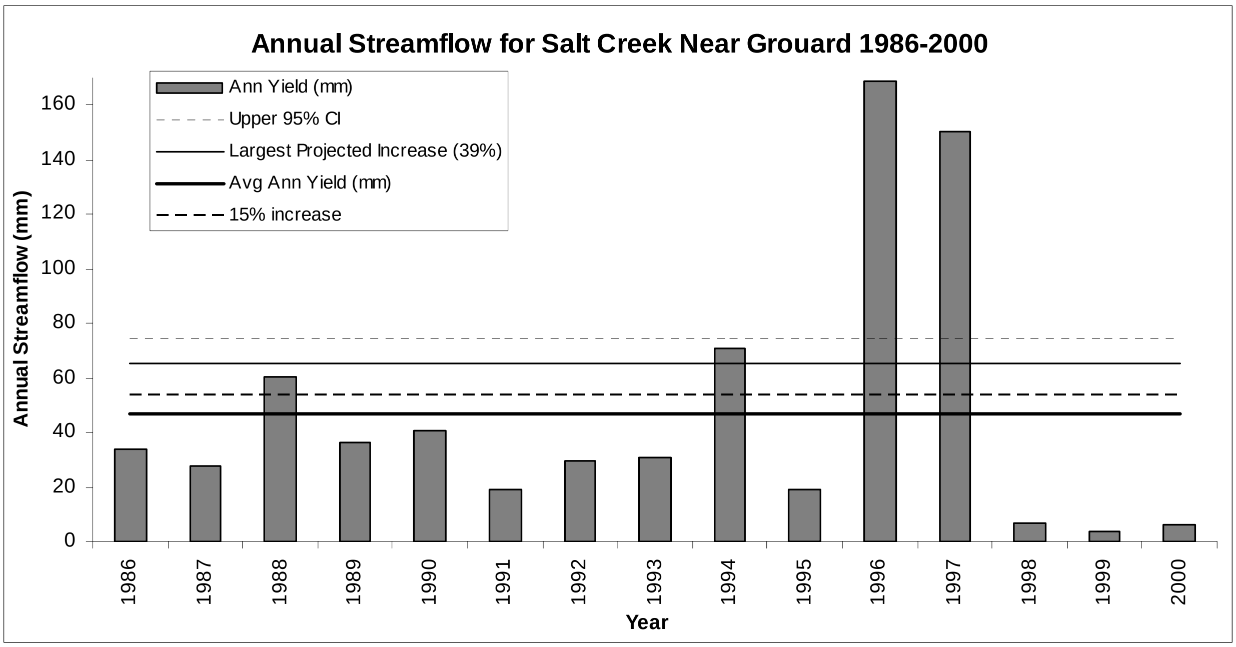

Figure 4 Annual streamflow (mm) for Salt Creek near Grouard, 1986-2000.

Whitemud/Birch

Hydrologic simulation of forest harvesting for the Whitemud/Birch operating areas showed a maximum increase in annual water yield of 29.8mm or 43.2% (26% ECA) for Watershed 151 in year 2014, followed by a projected increase of 16.2mm or 23.5% in year 2019. Although the range of natural variability in annual streamflow is very large (6mm/yr – 155mm/yr) (Figure 5) the projected yield increase of 43.3% is significantly higher (α=0.05) than the long-term average annual yield. Actually, the upper 95% confidence limit is a 25.3% increase in annual yield. Although eight other watersheds exceed the 15% level, no other watersheds exceed the 25.3% projected increase in annual yield. In addition, of the 34 years in record, 13 (38%) of the years exceeded 15% level and 10 (29%) exceeded the 43.3% level.

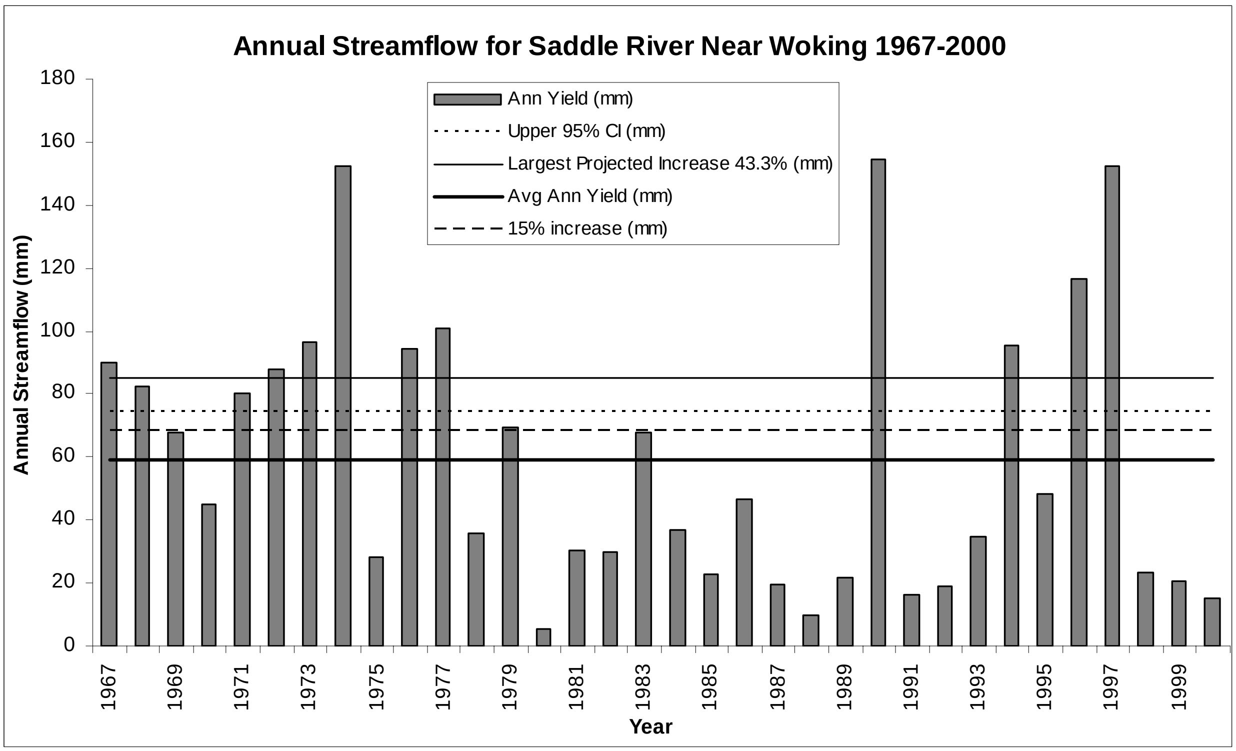

Figure 5 Annual streamflow (mm) for the Saddle River near Woking, 1967-2000.

Analysis of Risk

Ultimately the procedures used by ECA-Alberta and other forest management oriented hydrologic models (U.S. EPA WRENSS) are strategic and operate at large spatial/ temporal scales. They deal with changes in annual yield over time based on average climatic conditions and do not deal with increases in the number or magnitude of peak flows. In addition, these models deal with un-routed (i.e. they calculate a generated runoff), not routed streamflow.

However, the results from this analysis indicate that projected yield increases vary by operating area and watershed within those operating areas. Because the ECA-Alberta model deals with un-routed flow, the likely affect of this is probably more soil and groundwater recharge. If all yield was routed to actual streamflow the projected yield based on the proposed harvesting scenario for three of the five operating areas (Sweathouse, Utikuma, and Salt) are probably not significant and likely below the measurement detection limit using standard hydrometric techniques.

The other two operating areas (Kimiwan and Whitemud/Birch) contain watersheds (4 in total) that show projected yield increases that are significantly different than the long-term average annual yield. Although the projected increases (%) in annual yield for watersheds 17, 22, and 27 in the Kimiwan operating area, and watershed 151 in the Whitemud/Birch operating area exceed the 95% confidence level for significance, the absolute increase in projected yield ranges from 15.4mm to 14.8mm for the Kimiwan and 29.8mm for the Whitemud/Birch operating areas. To put these numbers in perspective, on September 2, 2004 the Town of Slave Lake received 62.5mm of rain, then 16 days later received 22mm of rain (Environment Canada, 2004[1]). Therefore it is important to look at the absolute projected change when analyzing the results of the ECA-Alberta procedure. For example, when the same harvesting scenario is evaluated using different baseline average annual yields; the watershed with the lower yield will show a larger % increase in projected streamflow. This is the case with the Kimiwan and Whitemud/Birch operating areas where baseline average annual yields are 43mm and 69mm respectively, compared to the Sweathouse operating area with a baseline average annual yield of 147mm.

It should also be noted that watersheds 17, 22, and 27 in the Kimiwan operating area and watershed 151 in the Whitemud/Birch operating area are actually sub-catchments of larger watersheds (PFRA watersheds). As a result, the scale at which the projected yield increases is viewed becomes important. At the larger watershed scale (third or fourth order), the projected yield increases are probably very small and likely below the measurement detection limit using standard hydrometric techniques.

Although, a 15% increase in annual yield has been suggested to be significant (John Taggart, Alberta Environment), the results from this analysis show that a significant (α=0.05) departure from long-term average annual streamflow varies by region. For example, a greater than 15.7% increase in annual streamflow in the Sweathouse operating area (Iosegun River) was determined to be significantly different than the long-term average, and incidentally this was the region

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[1] http://www.climate.weatheroffice.ec.gc.ca/climateData/dailydata_e.html

where John Taggart quoted the original 15% number (Spring Creek)[2]. However, significant (α=0.05) departures from the long-term average annual streamflow for the other four operating areas are 26.1%, 51.6%, 58.6%, and 25.3%, for the Kimiwan, Utikuma, Salt and Whitemud/Birch operating areas respectively.

Conclusion

The ECA-Alberta model projects average streamflow changes over time assuming average climatic conditions. While this allows for the evaluation of the incremental hydrologic effects of forest disturbance over and above that produced by climatic variation, it is important to note that actual water yield increases produced by disturbance co-vary strongly with variation in annual climate. Streamflow increases in wet years may be significantly higher than those presented here. Conversely, actual yield increases in dry years may be significantly less or non-existent. The ECA-Alberta model also predicts changes in annual yield based on average provincial rates of stand growth. Therefore, deviation from actual stand growth and regeneration from provincial average yield curves will affect the simulation of ECA's and projected average annual streamflow.

On-going research in the Boreal forest will improve the reliability and representativeness of hydrologic analysis in this region. Research led by Dr. Kevin Devito (HEAD Project) has provided valuable insights into the forest water balance of this region. In particular, the dominant role of evapotranspiration and annual changes in soil moisture storage are key factors governing the hydrologic behavior of this region. While this strongly supports the use of management models based on disturbance effects on evapotranspiration (ECA-Alberta and WRENSS), this work has also raised important questions about the usefulness of using topographically-defined watershed boundaries to define hydrologically meaningful landscape units in this region. New research proposed by the Western Boreal Forest Hydro-biogeochemistry Group at the University of Alberta will help refine a region-specific understanding of the role of disturbance on water and water-reliant resources.

Hydrologic analyses like ECA-Alberta could also be improved with further research into how regional variation in climate and hydrology in forested regions of the province from the Rocky Mountains through the upper/lower foothills, and Boreal plain regions is related to differences in acceptable harvest levels from a water resources perspective. As it is unlikely that a similar forest disturbance magnitude is likely to cause similar hydrologic effects across this gradient (i.e. 15 % streamflow increase threshold suggested by John Taggart, Alberta Environment), research that illustrates appropriate disturbance thresholds needs to be conducted across the forested regions of the province if models such as WRENSS or ECA-Alberta are to be more commonly used by the forest sector in Alberta (industry and government).

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[2] Dr. Uldis Silins, Personal communication, December 21, 2004