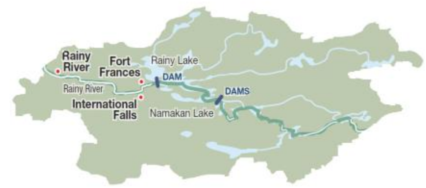
International Rainy and Namakan Lakes Adaptive Rule Curve Committee Newsletter



Issue #3 – December 14. 2016

This is the third newsletter of the Adaptive Rule Curve Committee under the Rainy-Namakan Lakes Rule Curves Study Board. This newsletter continues the focus on flood damage reduction strategies but uses a broader range of performance indicators than before. It also reviews what came from the Practice Decision Workshop in International Falls in November.

A more advanced Adaptive Rule Curve

The SVM now includes many rule curve alternatives that involve forecasting, using either some sort of perfect forecast that "cheats" by looking ahead in the data to see whether inflows will be high or even that damage will occur, or realistic forecasts that sometimes mislead but in general do reduce flood damages.

None of the perfect forecasts are real, but they illustrate three useful points or lessons learned, as discussed below. The plausible forecasts cause problems that wouldn't occur following the rule curves, but the trade-off between flood damage reduction and side effects can be manipulated and a judgment can be made about what balance to strike.

Three lessons from the impossibly perfect forecasting plans

Review of the perfect forecast plans shows that:

1. **Knowing that flooding will occur is better than knowing that average or peak inflows will be high.** There is a rule curve option in the SVM (RC7-7) that calls for the maximum allowable discharge starting on New Year's day in any year flooding will occur. This is the most perfect of the perfect forecasts because it has advance knowledge of flood damages, whereas other perfect forecasts know either average or peak inflows in advance, but don't know if the flows will be persistently high enough in the right sequence to cause flooding. RC7-7 reduces average annual damages by 40%, whereas the best of the perfect peak or average inflow forecasts reduces damages by only 27%.
2. **Significant flood damage reduction requires drastic lowering.** Perfect forecast plans encourage extreme response because there is little or no worry about the side effects of lowering the lakes unnecessarily. If you are sure there is going to be a flood, you can consider the most drastic response. To reduce damages by 40%, RC7-7 releases the maximum flow possible from the start of the year. Perfect forecast plans that lower levels 5 or 10 cm reduce damages by 1-2%. And although perfect forecasts may never

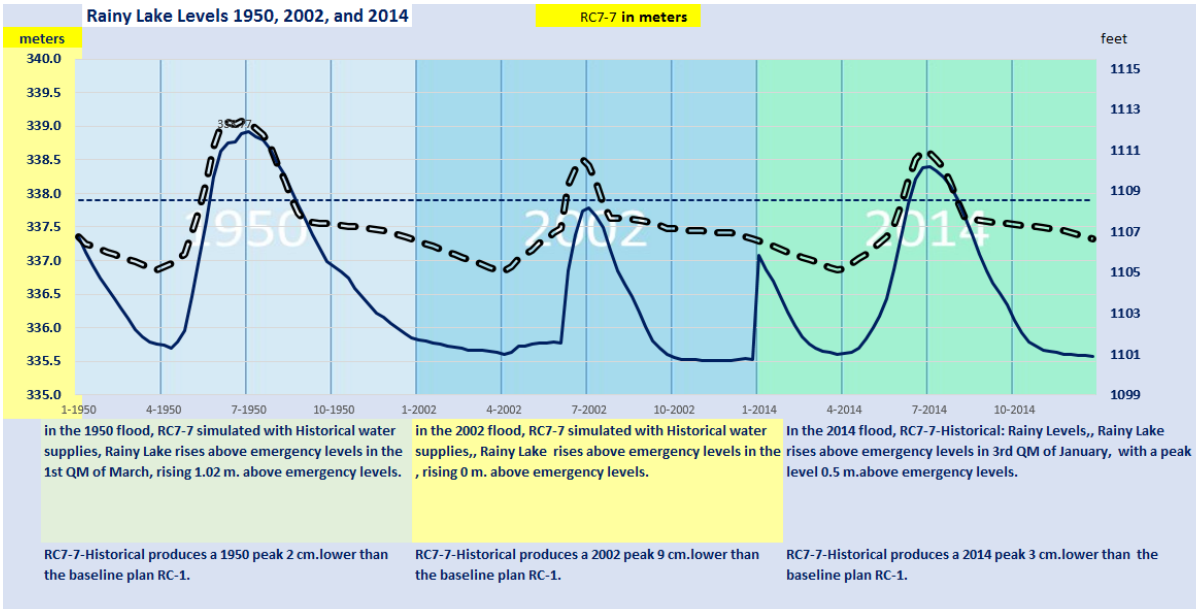


Figure 1 Rainy Lake levels in three flood years under RC7-7, a perfect forecast plan

lower levels unnecessarily, they do produce levels three feet or more below average in the first half of the year (see Figure 1).

3. **Perfect forecasts are more effective in smaller floods**. No perfect plan can do better than a 19% reduction when confronted with 1950 inflows. On the other hand, the 2002 flood can almost be eliminated. Because it was of short duration, the lakes can be lowered enough in the first half of the year that the levels barely reach flood stage in the summer. That's evident is the water levels (Figure 1). There is a substantial reduction in the peak water level in 2002, but much less reduction in 1950 and 2014.

Realistic forecasting plans

The SVM webinar on September 26th first introduced Matt DeWolfe's research showing ENSO could support a plausible alternative for predicting floods. He demonstrated that wet and dry years were strongly, but not perfectly, correlated with cool and warm ENSO's (El Niño–Southern Oscillation ocean surface temperatures) averaged over the December-January-February period preceding the potential flood and tourism season. Cool ENSOs (La Niña) were associated with flooding, warm ENSOs (El Niño) with dry conditions.

Four rule curve options were programmed into the SVM that employed the ENSO based indicator in different ways and an evaluation of the four was presented during the Practice Decision Workshop. Participants at the Workshop were interested in two of the four – the ones that focused on floods, not droughts, but while the plans reduced flooding damages, they also sometimes lowered water levels unnecessarily. This newsletter presents a more complete analysis of the impacts, and it seems to indicate that the average impacts are not great. We will look year by year as we continue to refine these plans, especially if more aggressive drawdowns are considered (see lessons learned above, *significant flood damage reduction requires drastic lowering*).

The La Niña flood plans shown at the Practice Decision Workshop lowered water levels either to the bottom of the 2000 Rule Curve (RC7-3) or below the rule curve, to the drought line. Since theWorkshop, Matt developed modified rule curves to be used instead of the 2000 Rule Curves in La Niña years. The results from all these plans are shown in Table 1.

In real life, flood forecasts can reduce damage, but only so much, and the warnings aren't clear.

How much can damages be reduced if the forecasts are imperfect and the response is more measured? We have done a fair amount of experimentation, and we have a range of answers.

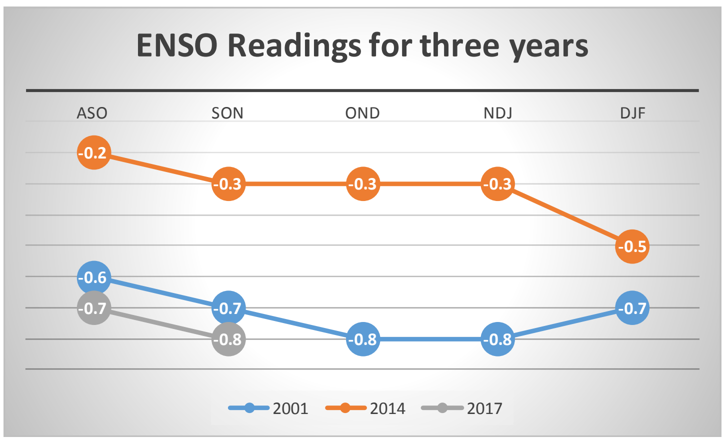


Figure 2 ENSO values preceding 2001, 2014, and 2017

The ENSO based **forecast** is the one realistic forecast to use if you're using only one. Cool December-January-February ENSOs are better predictors of flooding in the Rainy basin than heavy rainfall in the autumn and heavy over-winter snowfall. Most big floods in the last 65 years were preceded by a cool average ENSO for December-January-February (DJF), many dry years were preceded by a warm DJF ENSO. But there were many years in which a cool ENSO was followed by a year with no flooding, so if we use an ENSO based forecast we have to consider not only the benefits in flood damage reduction, but the impacts (bad or good) of lowering water levels unnecessarily. All in all, this ENSO based forecast, by itself, would have predicted a flood or dry spell correctly 60% of the time.

Ocean temperatures even at the surface don't change that rapidly, and ENSOs at the end of November are a good indicator of DJF ENSOs. NOAA just published ENSO for the end of November 2016 (SON), and it is -0.8 (Figure 2), a good indication that the DJF ENSO three months from now will be cool. In 1964 and 1972, the SON ENSO was also -0.8 and the DJF ENSO warmed to -0.3 and -0.4, respectively, so the current ENSO does not mean that we would have a flood warning next year under the La Niña plans, but it is likely enough that we should consider using it as an experiment.

Table 1 Performance of ENSO forecast plans versus the 2000 Rule Curves

	Rule Curve Plans					
Common name	2000 RC	1970 RC				
SVM Code	RC1-1	RC2-1	RC7-3	RC7-4	RC7-8	RC7-9
Performance Indicators						
Flooding damage						
average annual	$1,474,813	$1,255,250	$1,421,100	$1,433,369	$1,483,445	$1,447,902
By year						
1950	$37,610,724	$34,974,228	$36,523,550	$36,050,413	$36,909,943	$36,436,042
1954	$7,384,708	$5,602,508	$7,384,708	$7,384,708	$8,505,632	$8,505,632
1966	$3,054,189	$2,415,671	$3,054,189	$3,054,189	$3,651,161	$3,651,161
1968	$4,708,433	$3,917,964	$4,327,623	$3,942,733	$4,090,805	$3,659,928
1996	$2,820,444	$1,589,176	$2,323,369	$2,143,257	$2,363,431	$2,260,801
2001	$6,285,350	$5,266,958	$5,862,991	$5,862,991	$6,285,350	$6,112,808
2002	$10,799,343	$7,455,353	$10,799,343	$10,799,343	$10,799,343	$10,799,343
2008	$2,408,240	$2,175,374	$2,284,055	$2,243,012	$2,256,006	$2,140,167
2013	$447,993	$55,143	$447,993	$447,993	$447,993	$447,993
2014	$16,311,532	$15,027,420	$15,741,712	$15,454,703	$15,671,997	$15,060,440
			$295,597			
Hydropower - *						
Average energy MWh)	28.69	28.61	28.68	28.68	28.63	28.63
Minimum QM energy (MWh)	9.48	11.37	10.39	10.80	10.15	10.52
Average spill	57	52	56.75	56.68	57.47	57.19
Rainy shallow depths score	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72
Environmental Indicators						
Rainy						
Wild Rice	0.99	0.99	0.99	0.99	0.98	0.98
Walleye	1.00	1.00	1.00	1.00	1.00	1.00
Loon Nests	0.85	0.86	0.85	0.85	0.75	0.75
Muskrat	0.30	0.13	0.30	0.30	0.30	0.30
Cattails	1.00	0.99	1.00	1.00	1.00	1.00
Namakan						
Wild rice	0.99	0.99	0.99	0.99	0.98	0.98
Walleye	0.91	0.80	0.89	0.91	0.92	0.92
Loon Nests	0.84	0.55	0.82	0.74	0.86	0.82
Muskrat	0.00	0.00	0.00	0.00	0.00	0.00
Cattails	0.99	0.87	0.98	0.96	0.99	0.99

* - Hydropower metrics are provisional. There are known issues in estimating the tailwater elevations. The environmental performance indicators are averages, which may hide important differences in how the plans perform in certain years. Future evaluations will explore other characterizations, such as the minimum or 10^{th} percentile score.

At the Practice Decision Workshop, we used a limited range of performance indicators, whether showing flood reduction or environmental rule curve alternatives. The impacts from four La Niña plans, two from the Workshop and two new ones, are shown in Table 1.

- RC7-3 targets the bottom of the rule curve on both lakes during La Niña years.
- RC7-4 drops the lakes lower, targeting the drought line on both lakes during La Niña years.
- New: RC7-8 uses a distinct rule curve on Rainy Lake during La Niña years.
- New: RC7-9 uses a distinct rule curve on both lakes during La Niña years.

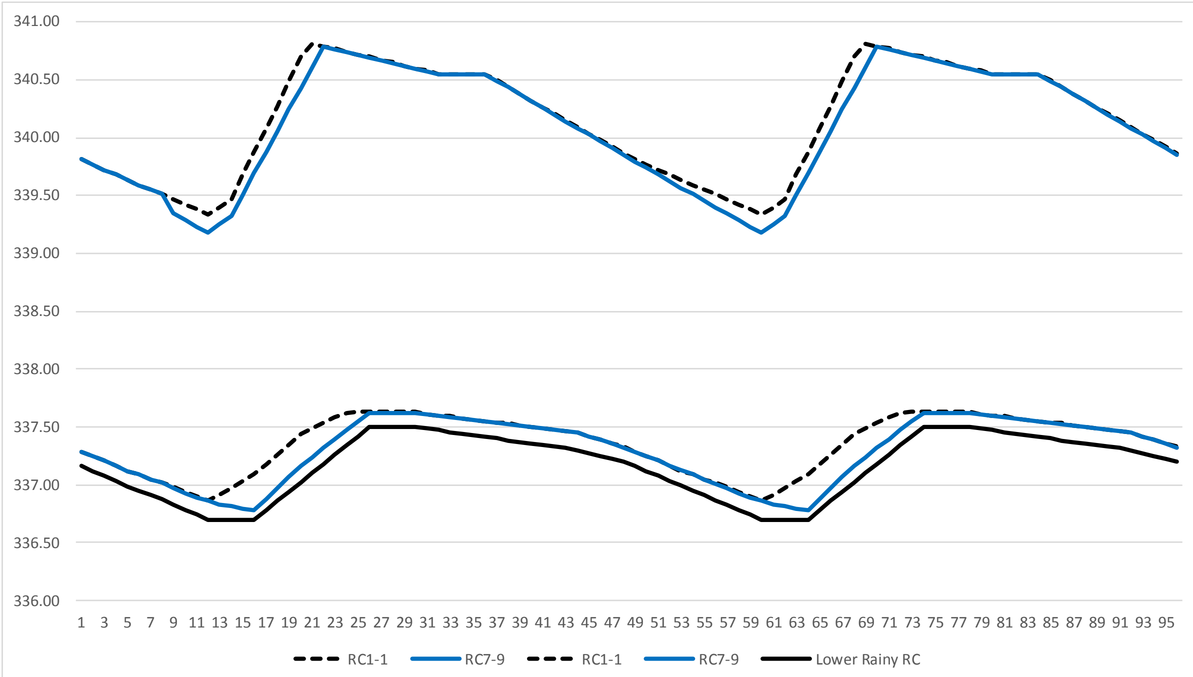


Figure 3 2000 Rule Curves (dashed black lines) and RC7-8/9 rule curves for Namakan Lake (above) and Rainy Lake (lower)

Building on the Practice Decision Workshop

The Practice Decision Workshop was held November 2, 2016 in International Falls, early enough in the evaluation process that people affected by the study can influence the trajectory of the study. The alternatives we presented were very preliminary and the results limited. People at the meeting were asked three questions:

1. Both alternatives presented today will lower Rainy Lake levels in some years, either to avoid flooding or help manage cattails. How much and how often can levels be dropped from your perspective?
2. The Adaptive Rule Curve involves some risk; in some years, Rainy Lake will be lowered because of a flood threat that doesn't materialize and sometimes the forecast will miss that year's flood. Would you want to be part of a communal effort to review the forecast and advise the power companies and the International Rainy-Lake of the Woods Watershed Board on the decision to lower the lake?
3. The Study Board practiced a decision on what to recommend to the IJC. Do you have ideas for helping the Study Board make those recommendations?

1. How much and how often can levels be dropped?

Lowering Rainy Lake levels to the bottom of the rule curve under the threat of flood was more acceptable than going much lower (such as to the drought line, as proposed in one alternative).

Lower levels do create beaches - a good thing. People who live on Namakan Lake clearly and strongly prefer the 2000 Rule Curve levels and did not want lower levels.

2. Community involvement in deciding whether to lower levels because of ENSO

Participants were interested in using the ENSO forecast but there were concerns, both because the forecast can mislead and because lowering the lakes can impact the environment and increase river flows. There was general support for having a community group engaged with the Water Levels Committee (of the Watershed Board) and power companies to try to reach a consensus on how to react to whatever flood forecasting system was in use.

3. Ideas for improving the Board's Recommendations

There were many suggestions, organized below. The Study Board is currently in the process of considering how to handle each of these; for now, this is simply a listing of what we heard.

Rule curve ideas. We were asked to consider more flexibility within the rule curves.

- Rather than just the 25-75% band, consider using the lower portion
- Change the shape of the curve in any particular year, if conditions warrant
- Make releases from Namakan Lake based (to some degree) on conditions in Rainy Lake
- Allow operators more bandwidth so long as they are well within the rule curve within some number of weeks
- Keep the 2000 Rule Curves for Namakan Lake but draw Rainy Lake down
- Keep working on forecasting

Evaluation ideas. We got some feedback on what performance indicators should be considered.

- Fisheries are important to the region in so many ways. Make sure we consider how any changes to rule curves will affect fisheries
- Where are sturgeon in the SVM? Will they be protected if they are not modeled?
- Consider developing a whitefish spawning performance indicator, in particular, a 2D indicator for Namakan Lake
- Consider a performance indicator that reflects the impact of water levels on mercury concentrations in fish

Comments on how one factor will be weighed against another. After all the numbers are calculated, how will the Board trade increases in one area for losses in another?

- Does the Board have a formula for making tradeoffs?
- Can stakeholders influence what the Board considers important?
- How do we consider things that can't be modeled in the SVM?

Climate Change. How will it be factored into the Board's recommendations?

- It should be incorporated into the shared vision model
- The Board should ask climatologists for help

Rainy River. Will the Board consider the River? Will this study help those who live along the river?

- Is there a way to better communicate anticipated rule curve changes to Rainy River community?
- During a high-water event, the faster the information can be transferred to downstream communities on Rainy River the better

Other ideas

- Consider Adaptive Rule Curves which coordinates levels and flows for Rainy and Namakan Lakes
- Low Water: Sailing season on Rainy Lake from a weather perspective ends in October. If the lake level approaches the bottom of the rule curve from August 1st on, access first to docks and then to launch sites is limited so sail boats must be pulled out early
- How is IJC planning to incorporate Anishinaabe Traditional Knowledge (ATK) into their review?
- Traditional Ecological Knowledge could be integrated into the study criteria and the weighed criteria analysis
- Will we be looking at prescribed minimum flows? It is currently grey and needs better explanation. With the mill shut down, the minimum flow should be looked at again.
- Keeping water levels low manually for several years, if then followed by natural lows for a few years, would hinder reputation of resorts (become known as having low spring levels); need to consider minimum low water levels required for installing navigation buoys
- Long term communication plan needed; consider a public advisory group for the Water Levels Committee.
- The public does not adequately understand the difficulty of managing water levels when a high intensity rainfall event occurs. Try to make that clearer in presentation of any new curve.