# PLAN OF STUDY FOR THE EVALUATION OF THE IJC 2000 ORDER FOR RAINY AND NAMAKAN LAKES AND RAINY RIVER

**Prepared for**
**The International Joint Commission**
**June 30, 2009**
**By the**
**2000 Rule Curve Assessment Workgroup**

(NOTE: This report may be referenced as: Kallemeyn, L., W.R. Darby, E. Eaton, K. Peterson, K. Smokorowski and J. Van den Broeck. 2009. Plan of study for the evaluation of the IJC 2000 Order for Rainy and Namakan lakes and Rainy River. Unpublished report prepared for the International Joint Commission by the 2000 Rule Curve Assessment Workgroup, 55+ pp.)

## EXECUTIVE SUMMARY

### *Context*

In 2001 the International Joint Commission (IJC) issued an Order prescribing the method of regulating the levels of the boundary waters of Rainy and Namakan lakes, consolidating and replacing a number of previous orders and supplementary orders. This "Consolidated Order" was effective on February 28, 2001 and contained a provision that "This order shall be subject to review 15 years following adoption of the Commission's Supplementary Order of 5 January 2000, or as otherwise determined by the Commission. The review shall, at a minimum, consider monitoring information collected by natural resource management agencies and others during the interim that may indicate the effect of the changes contained in the Supplementary Order of January 5, 2000." Fundamental questions and concerns with review of the Commission's Order, have centered on what information/data should be collected, who will collect it and how the effort will be funded.

Early efforts by the IJC and resource agencies to identify the required monitoring programs resulted in two workshops of experts held in the basin in January 2000 and May 2001. A third workshop in 2002 further refined the monitoring priorities identified in 2000 and identified "best bets" for evaluating the 2000 rule curves.

Since 2001, a number of resource agencies have been conducting studies to evaluate effects of the 2000 rule curve change. The primary focus has been on monitoring effects on the aquatic and riparian ecosystems of Rainy Lake and Namakan Reservoir. Only limited monitoring has been conducted on Rainy River, and no assessments have been done on socio-economic effects.

In a December 2006 memorandum to the IJC, the International Rainy Lake Board of Control (IRLBC) and the International Rainy River Water Pollution Board (IRRWPB) acknowledged the collaborative efforts of the resource agencies, but also noted significant gaps in the assessment work to that point. The memorandum sought direction and advice from the Commission on how to fill the gaps and how to work toward completing the rule curve change assessment in 2015.

In response, the IJC proposed development of a "Plan of Study" (POS) that could be provided to both federal governments for consideration. The IJC established a six-member Workgroup to develop the POS and approved the "Terms of Reference" (TOR) and appointments for the Workgroup in October 2007. The Workgroup's mission was to report on and prioritize the monitoring and analyses required to lead to a scientifically defensible identification of the impacts on the biological and aquatic communities of the adoption of the 2000 Order by 2015 for Rainy and Namakan Lakes and Rainy River.

More specifically, the POS was to address two main aspects. The first aspect related to monitoring studies and directed the Workgroup to:

- Consider the various monitoring programs needed to identify and assess, by 2015, the impacts of changes to Namakan Lake and Rainy Lake and Rainy River biological and aquatic communities associated with the implementation of the 2000 rule curves;
- Identify and prioritize short-comings or gaps in existing monitoring programs required to lead to a scientifically defensible review of monitoring information collected by natural

resource management agencies and others that may indicate the effect of changes contained in the Supplementary Order of January 5, 2000 by 2015;
- Identify the agencies, organizations, groups or individuals who are undertaking monitoring programs that may be best placed to fill the identified gaps or would have a role in doing so, including identifying resources they currently provide or could provide to this effort; and
- Estimate the costs associated to overcome each identified gap or short-coming.

The second main aspect was to:
- Recommend an approach for conducting the review of the 2000 Order to be completed by 2015, including:
  - The articulation of all studies to be performed and level of detail anticipated for each study;
  - Recommendations as to the agencies or organizations capable of conducting aspects of each study, recognizing that studies are to be conducted by a bi-national team;
  - The identification of sources of, or means of obtaining, needed information;
  - The priority, duration and timing of each study, considering the inclusion of phases to assist in the organizational management of the overall review; and
  - An estimate of the human and financial resources, including expertise, required to conduct each individual study and a summary for the entire review.

***Approach to Developing the Plan of Study***

Regarding the first aspect of the TOR relating to the monitoring required, the Workgroup took a five-step approach to accomplishing its task: (1) basic communications planning, (2) Workgroup brainstorming meetings; (3) holding a workshop of experts to identify and prioritize the "best bet" studies needed to fill monitoring gaps; (4) Workgroup evaluation of the "best bets" to collate priority studies into options for the Commission's consideration, and; (5) Workgroup consideration of "guiding principles" from the workshop and advice from the resource agencies for conducting the 2015 review.

The workshop of academic and agency experts was held on March 10 and 11, 2008, in Fort Frances, Ontario. After a review of background information, the participants were asked to: (1) conduct a gap analysis of existing investigations on effects of the 2000 rule curve changes on Rainy Lake and Namakan Reservoir, and (2) consider gaps relating to socio-economics and effects on Rainy River downstream. The workshop participants identified the studies most likely to measure effects of the 2000 rule curve changes ("best bets"). Additionally, they suggested some "key guiding principles" for the 2015 review.

Subsequently, the Workgroup used results from the 2008 and previous workshops to identify a list of "priority studies" that were then packaged into three options for the Commission's consideration. In identifying these options, the Workgroup made the following assumptions: (1) the IJC would prefer to examine more than one option, (2) studies by the resource agencies that have been essential components of the monitoring program but may be in jeopardy due to uncertain funding should be included in the options, (3) the companies will do a detailed analysis of the effect of the rule curve changes on hydropower costs, but it may be necessary to align expectations of the companies and the Commission, and (4) professional review of individual study designs may be required before the studies are funded and undertaken.

Regarding the second aspect of the TOR, methods for the 2015 review, the Workgroup integrated the guiding principles from the workshop with its own and resource agency experience to identify a reasonable approach and mechanism for the review. The Workgroup believes the most appropriate method for conducting the review consists of a comparison of conditions under the 2000 rule curve to conditions under the 1970 rule curve to ascertain whether, on balance, there has been net benefit to the varied interests in the basin.

The TOR also required the Workgroup to recommend an approach for conducting the review of the 2000 Order, to be initiated in 2015, including the articulation of all studies to be performed and the level of detail anticipated for each study. Based upon results of the 2008 Workshop and the identification of options for filling gaps in the current monitoring, the Workgroup does not believe it is necessary to commence a replicate set of studies in 2015, as implied by the TOR.

Given the variability of data derived from natural systems, the presence of continental and global influences in the watershed (e.g. atmospheric deposition of mercury, climate change, etc.), and changing economic conditions, some studies may be confounded by unrelated factors, and effects of the rule curve change may in some cases be unclear. In order to guard against this possibility, and to ensure that doubt about the review outcome is minimized, the Workgroup believes the review should take a "weight of the evidence" approach to decision-making.

The Workgroup believes that a reasonable method for weighing the evidence arising from the monitoring studies is to employ a simple matrix that uses study outcomes as positive, negative or neutral indicators in comparison to assist in making a decision. Independent expertise could be called upon to interpret study outcomes and populate the matrix accordingly. The Workgroup believes an international panel of professional experts should be engaged to: review study reports for the basin and the scientific literature; apply their professional expertise and experience; and employ a decision-matrix to ascertain whether, on balance, there has been a net benefit to the various interests in the basin.

Monitoring outcomes acquired prior to 2015 would contribute evidence (influence) to the matrix. The matrix would summarize the evidence for all studies so that the combined outcome could be meaningfully "weighed" by the independent panel of experts and by the Commission.

Various matrices could be used, but a simple transparent matrix which is easily understood by the public would be preferred. The summary assessment should be undertaken by subject category and by individual study for each water body (e.g. Rainy Lake, Namakan Reservoir or Rainy River). Agency monitoring results could be similarly represented or incorporated directly into the matrix.

### *Findings and Recommendations*

The Workgroup believes that continuance of the long-term agency monitoring programs should be the first order of business in preparing for the 2015 review. The resource agency representatives have indicated to the Commission at previous annual meetings in the basin that future funding for some of these studies is uncertain. The Workgroup is quite concerned that these studies or programs may be dropped by the resource agencies for financial reasons. Such a decision would not be in the Commission's interest. **Table 1** provides a list of resource agency

studies that are either ongoing or have not been started, and are intended to be part of the monitoring program to 2015.

**Table 1 -** Studies and Long-Term Monitoring Programs Being Conducted by the Resource Agencies on Rainy Lake, Namakan Reservoir and Rainy River for Which Future Funding is Uncertain.

| **Study/Program** | **Estimated Cost/Year (1000's USD)** |
|---|---|
| Long-term water quality modeling (USNPS) | 50 |
| Loon population monitoring, including reproductive success (USNPS) | 40 |
| Annual large lake fisheries sampling program (MDNR) | 26 |
| Annual fisheries sampling program – Rainy River (MDNR) | 15 |
| Long-term fisheries index netting (OMNR) | 30 |
| Mercury sampling of young-of-the-year yellow perch (USNPS) | 10 |
| Coregonid/rainbow smelt monitoring (MDNR) | 10 |
| Beaver monitoring (USNPS) | 30 |
| Creel surveys (includes both MDNR and OMNR surveys) | 145 |

**Recommendation # 1: The Commission should seek a commitment from the resource agencies that they will complete the list of studies and programs in Table 1 to provide essential baseline information for the 2015 review. If the resource agencies do not provide funding, then the Commission should add those studies to the list in its selected option.**

The Workgroup identified three options for filling gaps in the current studies and monitoring:

1. A low cost option that includes core studies for a balanced review in 2015 (Estimated Cost $ 1.125 M USD).
2. A medium cost option of core and additional high scoring studies that will support a thorough review (Estimated Cost $ 1.775 M USD).
3. A highest cost option that includes all "priority studies" leading to a comprehensive and highly defensible review (Estimated Cost $2.425 M USD).

**Recommendation # 2: The Workgroup recommends a medium cost option that includes core studies and some additional high scoring studies (Table 2).**

**Table 2 -** Additional Priority Studies (Option 2) in Conjunction with Core Studies (Estimated Costs in 1,000's USD)

| **Priority Study** | **Est. Cost** |
|---|---|
| **Core Studies:** | |
| Reservoirs - develop reservoir hydrologic model & reservoir PHABSIM habitat model | 300 |
| Model natural hydrology of Rainy River (HEC-RAS Model) vs. rule curves | 75 |
| Measure changes in benthic community in relation to curves, in the reservoirs | 100 |
| Aquatic vegetation (replicate Meeker and Harris, In Press) | 100 |
| Reservoirs – northern pike spawning habitat and reproductive success | 75 |
| Rainy River – critical spawning and nursery habitats | 300 |
| Hydropower (assumes assessment costs will be borne by companies) | 0 |
| Economic survey of impact of rule curves on tourist resorts on reservoirs | 75 |
| Relate rule curve changes to flooding and ice effects on reservoirs | 100 |
| **Sub-total** | **1,125** |
| **Additional High Scoring Studies:** | |
| Detailed bathymetric mapping of the littoral zone of selected reservoir locations | 75 |
| Assess effects on cultural resources at a small number of sites on the reservoirs | 75 |
| Assess effects on cultural resources at benchmark sites on the Rainy River | 75 |
| Assess effects on reservoir habitats for marsh-nesting birds/herps at selected sites | 200 |
| Identify critical river benthic habitats at X-sections; model effects of curve change | 75 |
| Measure Unionid (mussel) diversity and abundance in the Rainy River re: effects | 25 |
| Measure changes in fish community health (Index Biotic Diversity) re: effects | 25 |
| Measure critical spawning habitat for walleye on Namakan Reservoir re: effects | 75 |
| Examine water treatment and hatchery data for Rainy River re: effects | 25 |
| **Sub-total** | **650** |
| **Total Cost** | **1,775** |

Pros of the Recommended Option:

- The core group of studies ranked highest for likelihood of discerning cause and effect relationships.
- Fundamental questions and needs of the review will be addressed on a range of topics.
- Achieves hydrologic modeling capability which is a foundation need for a wide range of studies now and in the future.
- Studies are suitable for contracting.
- Addresses the need to assess impact on significant cultural resources.
- Expands the spectrum of effects-monitoring to address significant downstream questions.
- Relatively inexpensive cost for the number of additional studies undertaken.
- Unionid (mussel) survey is compatible with long-term monitoring done on Rainy River by Abitibi-Bowater in Fort Frances.

Cons of the Recommended Option:

- Cost of the studies in Option 2 is accumulating to a substantial level, especially if it becomes necessary to support some agency studies for which funding is uncertain.
- Likelihood of discerning cause and effect relationships with the rule curve change is not as high for the additional high scoring studies as it is for the core studies.
- Does not elevate the review to the watershed level.
- Significant coordination effort required.

The Workgroup recognized that the resource agencies do not have the capability to assess the effects of the 2000 rule curve changes on hydropower production. While such an assessment could be contracted as part of a socio-economic study, such a strategy may conflict with the proprietary rights of the Companies over their financial information. Hence it may be more appropriate to have the Companies do the assessment, with oversight of the Rainy Boards.

**Recommendation # 3: The Commission, via the Rainy Boards should develop an understanding with the Companies operating the Fort Frances-International Falls dam, that the Companies will undertake an assessment of the effects of the 2000 rule curve changes on hydropower generation, with Board oversight.**

The Workgroup believes the 2015 review needs to determine if the 2000 rule curves have indeed provided a "careful balance" among the varied interests in a contemporary context. This will be a daunting task that will require independent (out-of-basin) scientific expertise, primarily in water resource management and the environmental sciences. The Workgroup believes the review should be conducted by a panel of independent professional experts, including water resource and environmental experts, perhaps two from the U.S. and two from Canada. The Rainy Boards should be available to the panel for information as required. The panel of experts should report to the Commission.

**Recommendation # 4: The 2015 review should be conducted by an independent panel of water resource and environmental experts that reports directly to the Commission.**

The Workgroup concurs with the Commission, that as per the 2001 Consolidated Order for Rainy and Namakan Lakes, the objective of the review should be to determine if the 2000 rule curves, in comparison to the 1970 curves, have more or less effectively avoided emergency conditions associated with high and low water while providing a careful balance among the various interests including: upstream and downstream concerns, hydropower needs, flood risk, boating, and needs of the biological and aquatic communities. At a minimum, per the 2000 Supplementary Order, the review should consider monitoring information collected by natural resource management agencies and others during the interim.

**Recommendation # 5: The Commission should use a "weight of the evidence" approach to decision-making during the 2015 review. In this context, a decision matrix may be used as a tool to summarize study results and effects, and to aid decision-making.**

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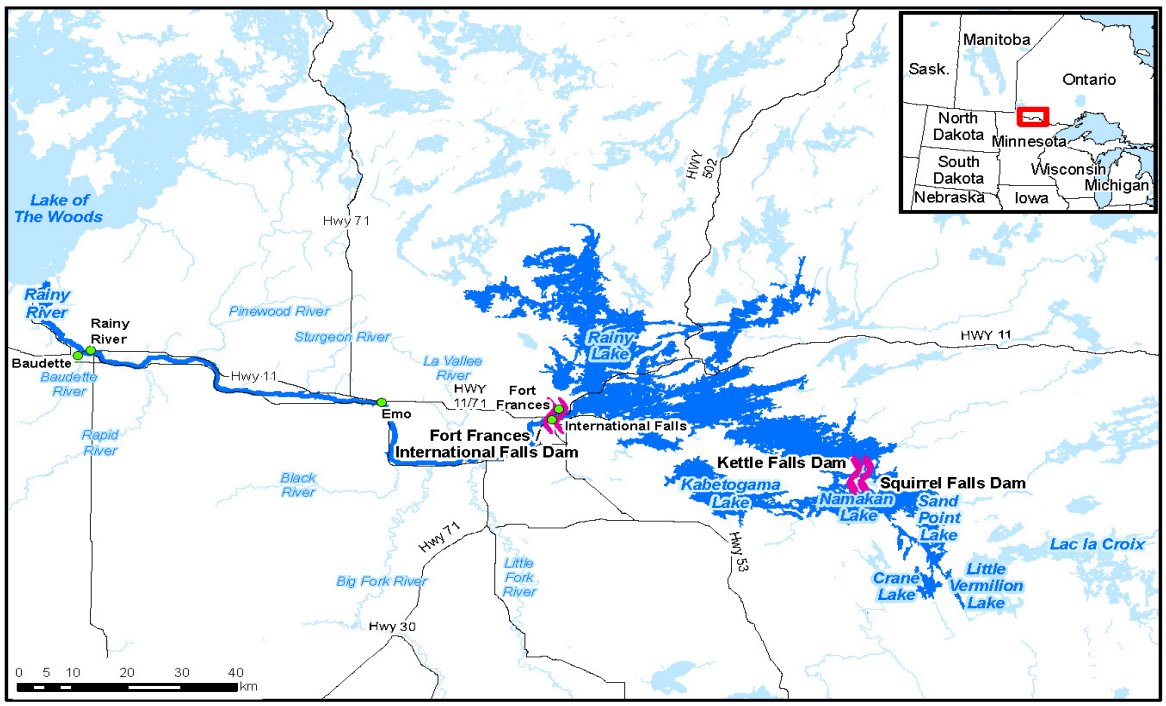
# 1 INTRODUCTION

On January 18, 2001 the International Joint Commission (IJC) issued its 2001 Consolidation of the "Order Prescribing Method of Regulating the Levels of Boundary Waters, replacing previous Supplementary Orders issued in 1949, 1957, 1970 and 2000 for Rainy and Namakan lakes. The Consolidated Order was effective on February 28, 2001 and contained a provision making it subject to review 15 years (2015) following adoption of the Commission's Supplementary Order of 5 January 2000, or as otherwise determined by the Commission. With respect to conducting any review of the Commission's Order, fundamental questions and concerns exist regarding information/data to be monitored and collected and by whom, and funding for the effort.

Early efforts by the IJC and resource agencies to identify needed monitoring programs resulted in two workshops of subject matter experts held in the basin in January 2000 and May 2001. A third workshop in 2002 further refined the monitoring priorities identified in 2000 and identified "best bets" for evaluating the 2000 rule curves. The focus of these early workshops was on ecological monitoring of the aquatic and riparian ecosystems of Rainy Lake and Namakan Reservoir, and did not include the Rainy River or an assessment of socio-economic impacts (Workgroup Study area examined for this report is shown in **Figure 1**). Existing agency efforts, monitoring programs, and funding grants have been helpful, but many information gaps continue to exist for which ready answers have not been available to date. Further complicating matters are a number of confounding variables including: extreme weather and hydrology; U.S. Federal Energy Regulatory Commission (FERC) lake level regulations affecting management in the 1990's; lack of monitoring funding or poor timing of funding availability on maintaining important time series data; invasive species; changes in fishery regulations and their effect on exploitation; and climate change.

**Figure 1 – Workgroup Study Area**



In a December 2006 memorandum to the IJC, the International Rainy Lake Board of Control (IRLBC) and the International Rainy River Water Pollution Board (IRRWPB), hereinafter referred to as the "Boards," noted the collaborative efforts and interest of the resource agencies to assess the effectiveness of the 2000 rule curves, but also noted the significant gaps in the process and specific concerns of stakeholder representatives in the basin. The memorandum sought direction and advice from the Commission on how to fill the gaps and work toward completing the rule curve change assessment in 2015.

In response, the Commission proposed development of a "Plan of Study" (POS) that the Commission would provide to both governments for their consideration to address the concerns raised in the Boards' December 2006 memorandum. The Commission established a six-member Workgroup to develop the POS and approved the "Terms of Reference" (TOR) and appointments for the Workgroup in October 2007. The Workgroup's mission was to report on and prioritize the monitoring and analyses required to lead to a scientifically defensible identification of the impacts on the biological and aquatic communities of the adoption of the 2000 Order by 2015 for Rainy and Namakan Lakes and Rainy River. Subsequently, the Workgroup provided the Commission with a work plan for completing its work and set about the task of fulfilling its terms of reference.

This report contains a background discussion of the events just prior to the adoption of the 2000 Order by the IJC and subsequent efforts to ensure that there is an adequate source of information to support future reviews, including the 2015 Review. This report provides responses to the various considerations put forth to the Workgroup in its TOR. It is a broad "plan of study" to fill gaps in current monitoring and to prepare for the 2015 review; it is not a compilation of individual study plans. In this context, project cost estimates provided by the Workgroup are rough estimates. The Workgroup expects that researchers who pursue studies to fill gaps in current monitoring will subsequently develop individual study plans (i.e. proposals) and more precise study costs for consideration by the Commission.

The details of the approach and process used by the Workgroup in its work are presented along with its findings. The findings of the Workgroup deal with the areas of: current agency monitoring studies with uncertain future funding, new priority studies, three options for pursuing new priority studies and the rule curve review decision making process. Five recommendations to the Commission are given with respect to: agency commitments of funding for long-term studies and monitoring programs, assessment by the paper Companies (with Board oversight ) of the effects on hydropower generation, options for new priority studies, coordination of the 2015 Review, and use of a "weight of the evidence" approach to decision-making during the review.

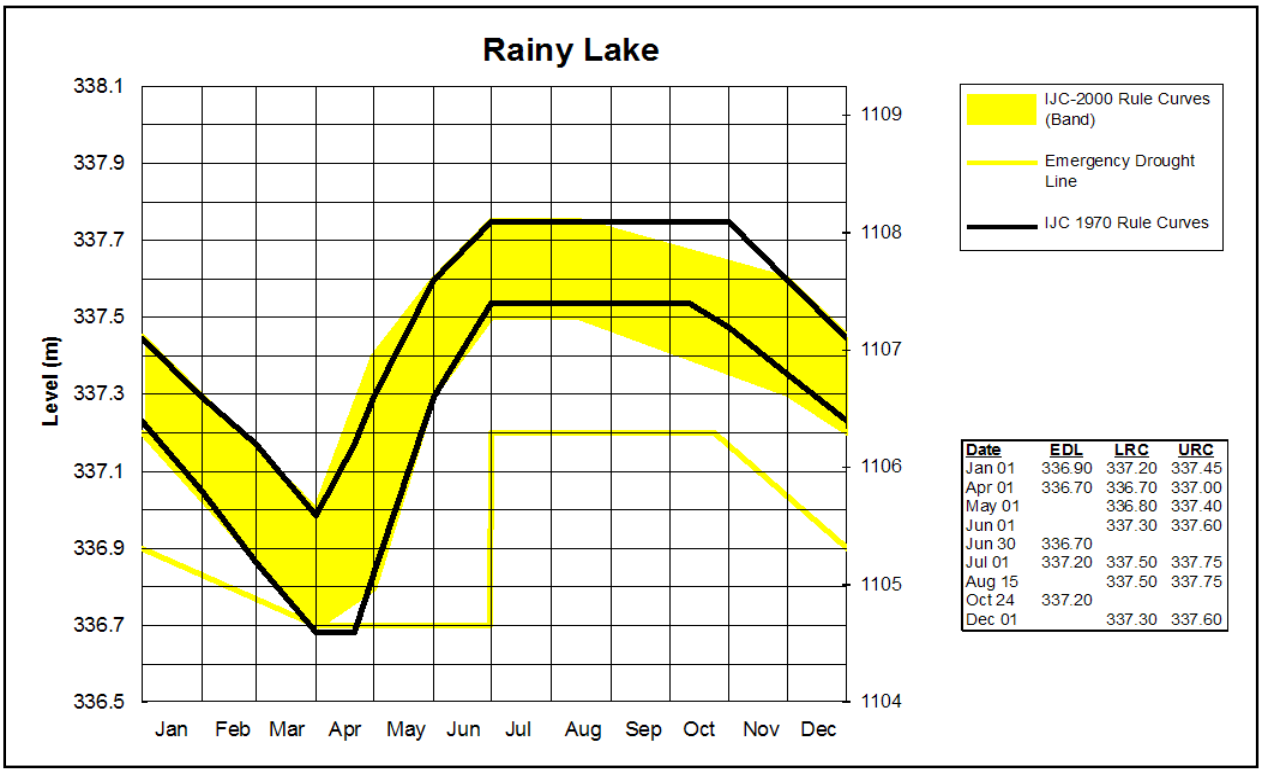
# 2 BACKGROUND

## 2.1 Adoption of the IJC 2000 Order for Rainy and Namakan Lakes

Following submission of the Final Report of the IRLBC entitled "Final Report, Review of the IJC Order for Rainy and Namakan Lakes" and dated October 26, 1999, the IJC issued its January 5, 2000 Supplementary Order for Rainy and Namakan lakes, modifying the earlier 1970 Rule

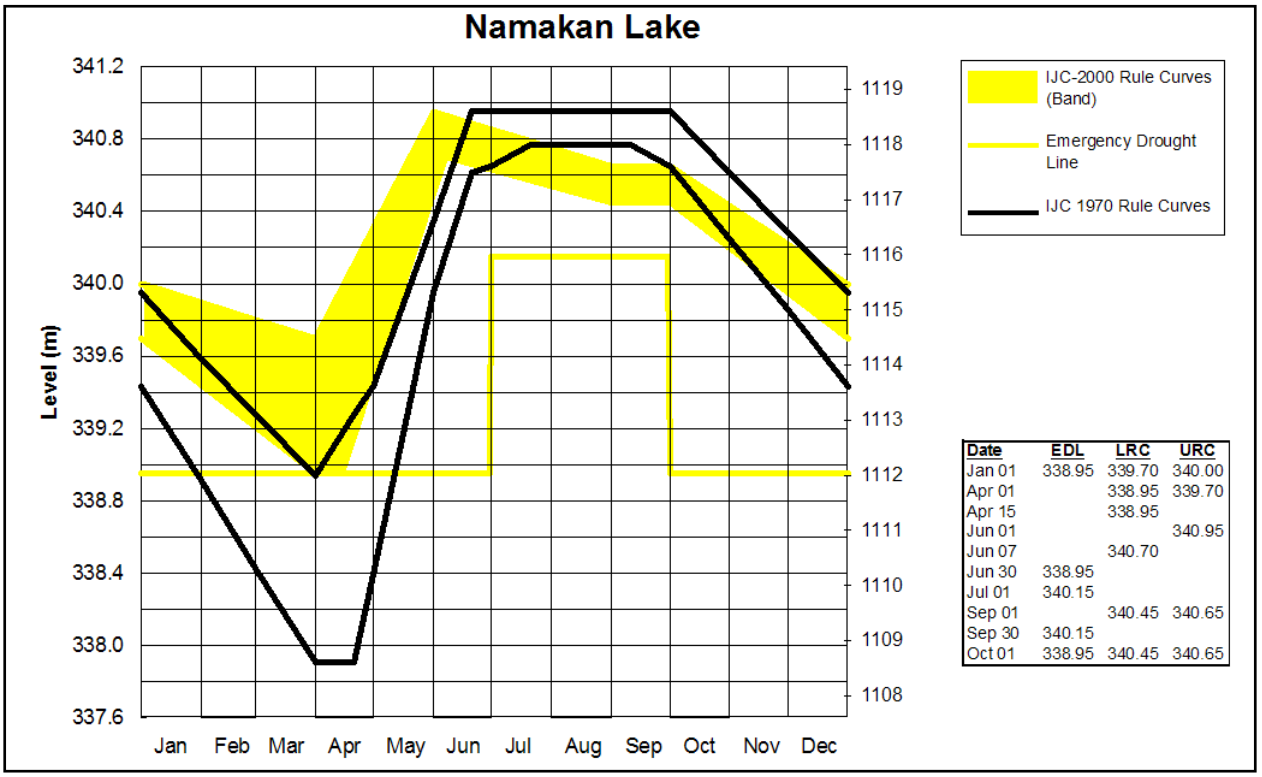
curves for both lakes. Comparisons of the 2000 Rule Curves and 1970 Rule Curves for Rainy Lake and Namakan Lake are shown in **Figures 2 and 3**, respectively.

**Figure 2: The 2000 Rule Curves for Rainy Lake Compared to the 1970 Rule Curves.**




| Date | EDL | LRC | URC |
|---|---|---|---|
| Jan 01 | 336.90 | 337.20 | 337.45 |
| Apr 01 | 336.70 | 336.70 | 337.00 |
| May 01 | | 336.80 | 337.40 |
| Jun 01 | | 337.30 | 337.60 |
| Jun 30 | 336.70 | | |
| Jul 01 | 337.20 | 337.50 | 337.75 |
| Aug 15 | | 337.50 | 337.75 |
| Oct 24 | 337.20 | | |
| Dec 01 | | 337.30 | 337.60 |

**Figure 3: The 2000 Rule Curves for Namakan Lake Compared to the 1970 Rule Curves.**




| Date | EDL | LRC | URC |
|---|---|---|---|
| Jan 01 | 338.95 | 339.70 | 340.00 |
| Apr 01 | | 338.95 | 339.70 |
| Apr 15 | | 338.95 | |
| Jun 01 | | | 340.95 |
| Jun 07 | | 340.70 | |
| Jun 30 | 338.95 | | |
| Jul 01 | 340.15 | | |
| Sep 01 | | 340.45 | 340.65 |
| Sep 30 | 340.15 | | |
| Oct 01 | 338.95 | 340.45 | 340.65 |

The new Order was based upon the recommendations presented in the Board's Final Report. On January 18, 2001 the Commission issued its consolidation of the "Order Prescribing Method of Regulating the Levels of Boundary Waters", dated 8 June, 1949, as amended by Supplementary Order dated 1 October, 1957, by Supplementary Order dated 29 July, 1970, and by Supplementary Order dated 5 January, 2000". The 2001 Order consolidated and replaced the Supplementary Orders of 1949, 1957, 1970 and 2000 as of February 28, 2001.

The IJC's new supplementary order allowed it to meet its responsibilities under the 1938 Convention for avoiding emergency conditions while providing a careful balance between upstream and downstream concerns relative to the environment, hydropower, flood risk, and navigation. The order also took into account improvements to water quality in the Rainy River that allowed lower discharges under low-flow conditions than were previously desirable. A major premise of the 2000 Rule Curves modification was that a move towards a more natural hydrograph would benefit the aquatic communities of Rainy Lake and Namakan Reservoir. To a lesser degree, the changes were also expected to provide more flow to the Rainy River during certain times of the year, which would benefit the aquatic riverine community.

## 2.2 Rule Curve Monitoring Requirements, Efforts, Concerns

The 2001 Consolidated Order contained the provision that "This order shall be subject to review 15 years following adoption of the Commission's Supplementary Order of 5 January 2000, or as otherwise determined by the Commission. The review shall, at a minimum, consider monitoring information collected by natural resource management agencies and others during the interim that may indicate the effect of the changes contained in the Supplementary Order of January 5, 2000." Fundamental questions and concerns, with respect to any review of the Commission's Order, have centered on what information/data should be collected, who will collect it and how the effort will be funded. These questions and concerns have been answered to some extent through existing agency monitoring programs and funding grants, but many information gaps continue to exist for which ready answers have not been available to date.

### 2.2.1 Early Efforts to Identify Needed Monitoring Programs

Subsequent to its issuance of the 2000 Order for Rainy and Namakan lakes, the IJC sponsored a bi-national workshop on ecological monitoring held in International Falls, MN on January 11-12, 2000. The impetus for the workshop came from the review provisions of the 2000 Order. The goals of the facilitated workshop in which 60 scientists and resource managers participated were to: (1) define the scope of the monitoring program, (2) develop monitoring protocols for fisheries and other major components of the aquatic communities, and (3) identify possible funding mechanisms for implementation of the monitoring protocols (Kallemeyn 2000). In May 2001, a second workshop of subject matter experts was held to help Voyageurs National Park plan a pilot study to investigate the effects of the 2000 Order on the aquatic vegetation communities in the affected lakes and reservoirs (Szymanski 2001).

In 2002, the Ontario Ministry of Natural Resources, Fort Frances District, sponsored a third workshop at which 20 participants were asked to (1) refine the monitoring priorities identified in

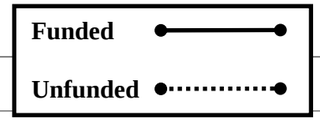
2000, and (2) identify what they considered the "best bets" for evaluating the 2000 rule curves. The focus was on ecological monitoring of the aquatic and riparian ecosystems of Rainy Lake and Namakan Reservoir, and did not include the Rainy River or an assessment of socio-economic impacts (Northern Bioscience 2002). The workshop results were used by Kallemeyn (2002) to select from the numerous questions and hypotheses that were developed in the 2000 workshop, those considered critical to evaluating the effectiveness, benefits, and/or problems of the 2000 rule curves.

### 2.2.2 Minnesota and Ontario Rule Curve Monitoring Committee

Another objective of the 2002 workshop was to provide guidance to the Rule Curve Monitoring Committee that had been recently formed by the Minnesota and Ontario natural resource agencies to oversee the development and implementation of the assessment program. Since its establishment, the Committee's member agencies have committed significant dollars and effort to plan and conduct studies and monitoring under existing agency mandates. **Table 1** provides a list of these studies and monitoring programs that have been or are planned to be conducted between 2000 and 2015. Many of these studies have been funded but a number remain to be funded. To date, all activities have been restricted to assessing the effects on Rainy Lake and Namakan Reservoir. Downstream effects and socio-economic impacts have not been addressed.

**Table 1: Existing and Planned Resource Agency Studies to Monitor Effects of IJC 2000 Rule Curves - Years 2000 to 2015 (Cont'd on Page 7)**

| Project | Portion of project | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Five part lake level research project (NPS) | Fish - see also fish monitoring below | | | | | | | | | | | | | | | | |
| | Invertebrates | | | | | | | | | | | | | | | | |
| | Loons | | | | | | | | | | | | | | | | |
| | Furbearers | | | | | | | | | | | | | | | | |
| | Wetland Vegetation | | | | | | | | | | | | | | | | |
| Rainy Lake and Namakan Reservoir Water Quality Spatial Characterization (USGS/NPS) | | | | | | | | | | | | | | | | | |
| Rainy Lake and Namakan Reservoir Water Quality Monitoring (USGS/NPS) | | | | | | | | | | | | | | | | | |
| Synthesis and Modeling (USGS/NPS) | | | | | | | | | | | | | | | | | |
| Remote Sensing for water quality; analyze the imagery from '86, '95, '04 and ~ 2014 for transparency, chlorophyll-a and TSI (MPCA) | | | | | | | | | | | | | | | | | |
| Lake Sturgeon Assessment (NPS/MNDNR/OMNR) | Rainy Lake | | | | | | | | | | | | | | | | |
| | Namakan Reservoir | | | | | | | | | | | | | | | | |
| Paleolimnology (USGS/NPS) | | | | | | | | | | | | | | | | | |
| Relationship of mercury concentration in Young-of-the-year yellow perch to hydrology (USGS/NPS) | | | | | | | | | | | | | | | | | |
| Long term fish monitoring – index netting, seining, and electrofishing (MNDNR/USGS/NPS) | Kabetogama | | | | | | | | | | | | | | | | |
| | Rainy | | | | | | | | | | | | | | | | |
| | Namakan | | | | | | | | | | | | | | | | |
| | Sand Point | | | | | | | | | | | | | | | | |
| | Crane | | | | | | | | | | | | | | | | |
| | Little Vermilion | | | | | | | | | | | | | | | | |
| | Lac La Croix | | | | | | | | | | | | | | | | |



| Project | Portion of project | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Walleye/N. Pike Monitoring Program (Fall Walleye Index Netting) (OMNR/USGS) | Rainy | | | | | | | | | | | | | | | | |
| | Namakan | | | | | | | | | | | | | | | | |
| | Sand Point | | | | | | | | | | | | | | | | |
| | Lac La Croix | | | | | | | | | | | | | | | | |
| Fish Community Index Netting (OMNR/MNDNR/USGS) | Rainy - South Arm only | | | | | | | | | | | | | | | | |
| | Namakan | | | | | | | | | | | | | | | | |
| | Sand Point | | | | | | | | | | | | | | | | |
| | Lac La Croix | | | | | | | | | | | | | | | | |
| Creel Survey (MNDNR) | Rainy Lake | | | | | | | | | | | | | | | | |
| | Namakan Reservoir | | | | | | | | | | | | | | | | |
| Creel Survey (OMNR) | Rainy Lake | | | | | | | | | | | | | | | | |
| | Namakan Reservoir | | | | | | | | | | | | | | | | |
| Sportfish Contaminant Monitoring (OMNR/OMOE/MNDNR) | Rainy | | | | | | | | | | | | | | | | |
| | Namakan | | | | | | | | | | | | | | | | |
| | Sand Point | | | | | | | | | | | | | | | | |
| | Lac La Croix | | | | | | | | | | | | | | | | |
| | Kabetogama | | | | | | | | | | | | | | | | |
| | Crane | | | | | | | | | | | | | | | | |

**Funded**

**Unfunded**

### 2.2.3 The Challenge of Demonstrating Cause and Effect

Data from natural ecosystems usually have high variability and are often affected by many complex factors. This makes it difficult to identify specific cause and effect relationships. There is a high potential that such relationships may be masked or made undetectable by one or more confounding factors. Examples of such confounding factors include: FERC lake level regulations affecting management in the 1990's; exceptionally high and low water events after 2000 that resulted from extreme weather (**Figures 4 and 5**); and the invasion of exotic species. Kitchell and Koshinsky (1996), in their review of water level regulations for Rainy and Namakan Lakes acknowledged that uncertainty and variability are natural components of these systems. However, they stressed that the presence of uncertainty is not a sound reason to delay corrective management actions that are based on the best available knowledge and intended to improve overall ecological conditions.

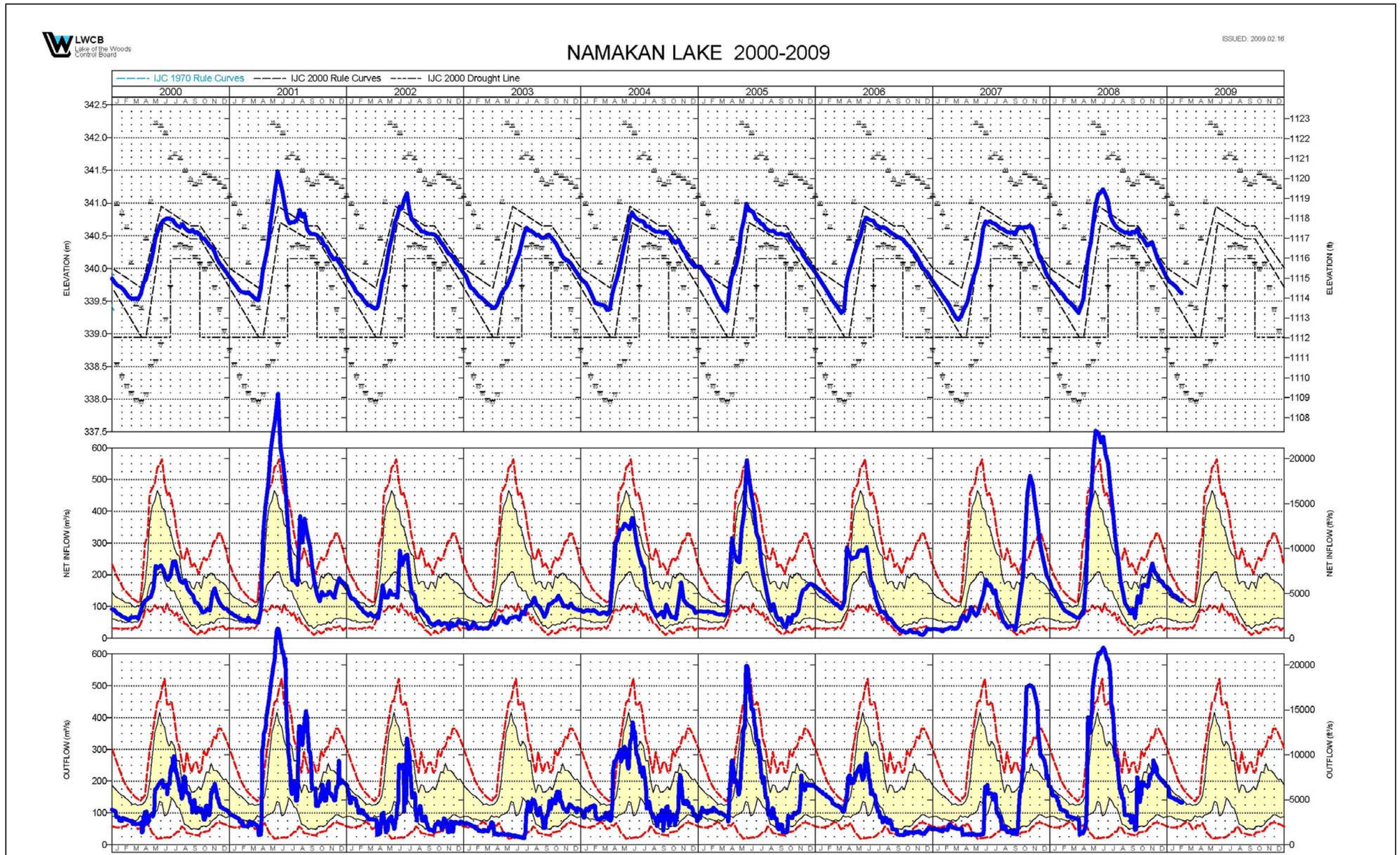
While the monitoring conducted on Rainy and Namakan has not and cannot remove inherent natural variability, it and studies of similar reservoirs have identified important relationships against which effects of the 2000 Rule Curve changes may be evaluated (Ploskey 1986, Wilcox and Meeker 1991, and Minns et al. 1996). Williams (1996) suggested that long-term data series, indicators of ecological state, and sport fish population parameters should be used to investigate cause and effect relationships.

Monitoring of aquatic ecosystems ranges from pure experiment at one extreme to long-term trend monitoring at the other. Experiments provide maximum control and are best suited to identify cause and effect relationships. Long-term trend monitoring is often least able to identify cause and effect relationships because of human-induced influences and natural background variability. Studies that evaluate management actions often lie in the middle of this range (Stow et al. 1998). While influenced by confounding factors, such evaluations provide useful information and may indeed be able to elucidate cause and effect.

Monitoring on the Rainy and Namakan Reservoirs has evolved since the 1980's. Initially, it was retrospective because cause and effect relationships were poorly understood or unknown, and historical ecological data were either scarce or unusable for management. As knowledge was gained, effort shifted to prospective monitoring and the development of data sets more useful in identifying cause-and effect relationships (e.g. aquatic vegetation, benthic organisms). This evolution is typical of many monitoring programs; i.e. they start with retrospective monitoring and gradually involve more prospective monitoring and research leading to models that elucidate linkages between physical and biological components of the system (Trexler and Loftus 2004). The same approach would seem to be applicable to assessing effects on socio-economic and cultural concerns. This approach is basically what the Workgroup is proposing for the Rainy and Namakan Reservoirs. Monitoring to date has occurred on the reservoirs and may be ready to now take a prospective approach, whereas monitoring on the Rainy River may have to be more retrospective due to the limited information that is available.

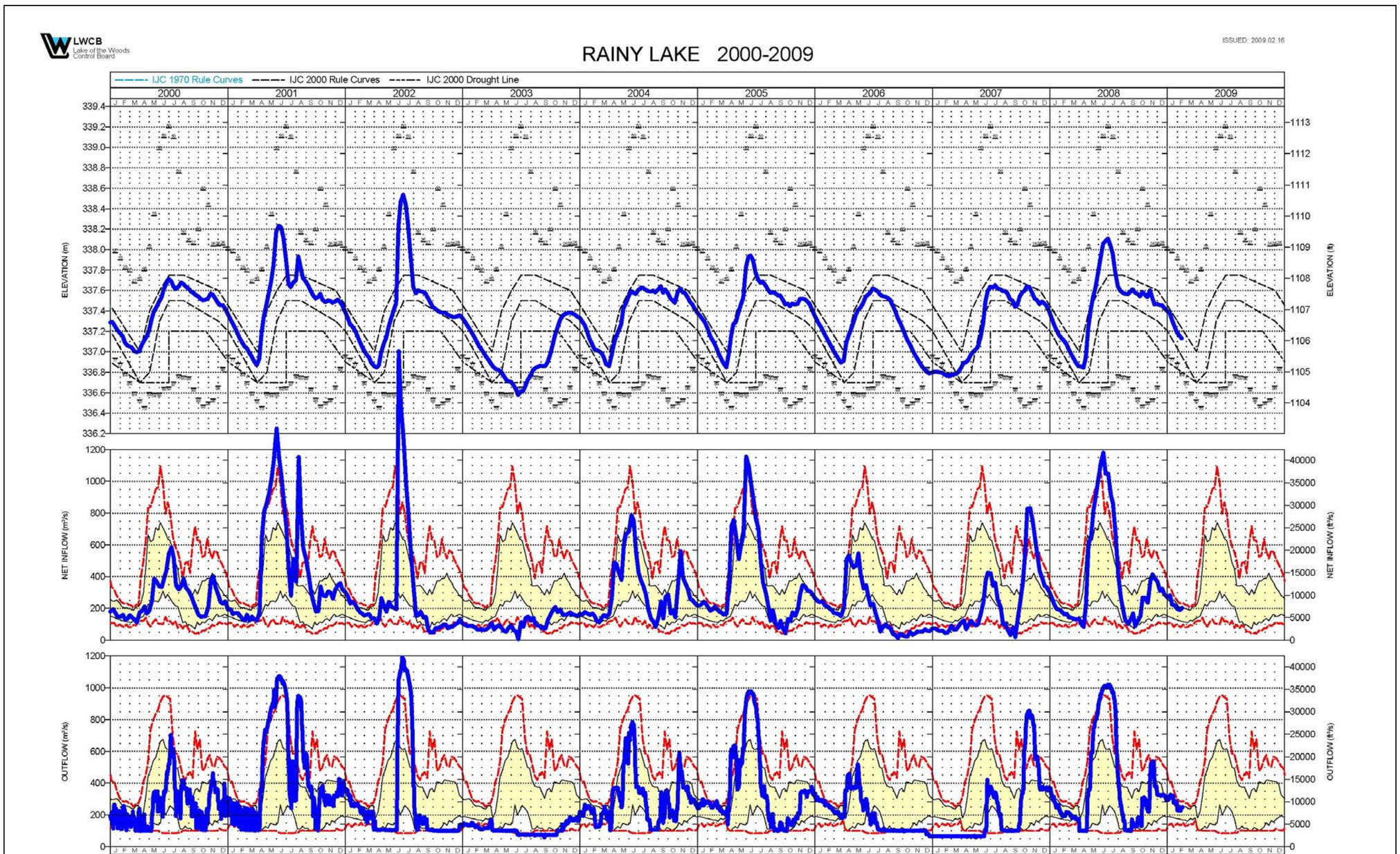
Unfortunately, maintenance of the level of natural resource monitoring that has occurred in the early years may not be feasible due to budgetary constraints and personnel changes. Failure to maintain important time series such as the data collected in the Minnesota Department of Natural Resources (MDNR) large lake program could have a significant negative effect on the ability to

**Figure 4 – Namakan Lake Regulation Under Its IJC 2000 Rule Curves, Showing Lake Elevation, Net Inflow and Outflow (Note Extreme Data Variability Since 2000)**




**Note: Blue Lines = Recorded Level / Flow; Yellow Band = 25 to 75 Percentile Flow Range; Red Lines = 10 and 90 Percentile Flows**

**Figure 5 – Rainy Lake Regulation Under Its IJC 2000 Rule Curves, Showing Lake Elevation, Net Inflow and Outflow (Note Extreme Data Variability Since 2000)**




**Note: Blue Lines = Recorded Level / Flow; Yellow Band = 25 to 75 Percentile Flow Range; Red Lines = 10 and 90 Percentile Flows**

assess change, particularly given the inherent natural variability that can exist in biological populations and communities. Other potential confounding factors include the effects of: invasive species such as non-native rainbow smelt, rusty crayfish and spiny water flea; changes in fishery regulations and their effect on exploitation; and climate change.

### 2.2.4 Monitoring and Reporting Concerns

In a December 8, 2006 memorandum to the IJC, the IRLBC and the IRRWPB explained in greater detail the issues that had evolved, as the two Boards saw them, related to monitoring and reviewing the effects of the 2000 Rainy and Namakan Lake Rule Curve changes on the natural, social and economic resources of the Rainy River and the Rainy-Namakan Basin. The Boards noted that monitoring and reporting concerns were discussed by the Boards three times in 2006; via teleconference, during August 2006 at basin meetings with natural resource agency representatives and the companies who operate the dams and with the IJC in Ottawa during the IJC's October semi-annual meeting. The memorandum went on to note that there has been considerable collaboration in monitoring among resource agencies (even without sufficient resources), that there is much interest in the basin to assess the 2000 rule curve effectiveness, but there are significant gaps in the process. Specific concerns from people who represent the stakeholders in the basin are:

- Natural resource agency funding for monitoring on the lake basins may decline.
- No process has been set up and implemented for assessing the impacts of the rule curve change on the social-economic resources of the Rainy River and the Rainy and Namakan Lake basins. Natural resource agencies strongly support the need to conduct such studies but are not responsible to engage in social-economic studies.
- Assessment of the effects of 2000 rule curve on the natural resources of the Rainy River currently is limited. The natural resource agencies do not have the money, time or staff to conduct additional natural resource studies on the Rainy River.
- The natural resource and social-economic work that needs to be done to fill the gaps is not something that the Rainy Boards can or are committed to do.
- Changes in resource staff in the basins and in membership of the Rainy Boards and the IJC over time likely will affect corporate memory making it difficult to maintain the continuum necessary to complete a quality review by 2015.
- There is no clear process for outlining; 1) who will collect the monitoring information and synthesize it into a final 2015 report, and 2) who will fill in the monitoring gaps identified and how will it be funded and accomplished.
- There is a need for the economic impacts of rule curve changes on hydroelectric generation to be assessed and documented.

The memorandum sought direction and advice from the Commission on how to fill the gaps and work toward completing the rule curve change assessment in 2015, as identified in the 2000 Order.

### 2.2.5 IJC Proposal to Develop Plan of Study for 2000 Rule Curve Assessment

In response to the Boards' December 8 memorandum, the Commission's letter of February 8, 2007 proposed development of a "Plan of Study" (POS) that the Commission would provide to

both governments for their consideration to address the concerns raised by the Boards. The Commission requested the help of the Boards in identifying potential candidates to serve on a six-member POS team to develop the POS. The POS would outline the monitoring and analysis required to lead to a scientifically defensible review of the impacts of the 2000 Order by 2015. The POS would:

- Consider within their overall efforts the various short-comings identified in the Boards' memorandum to the Commission;
- Provide an overview of the need for the monitoring and scientific assessment to establish the impacts associated with the adoption of the new rule curves;
- Identify the monitoring and analytical gaps that would infringe on the ability to perform such an assessment;
- Identify the agencies, groups or individuals who may be best placed to fill the gaps or have a role in doing so;
- Estimate the costs associated with the above.

In letters to the IJC, dated March 9, 2007 and July 3, 2007, the Boards submitted and confirmed the names of six potential POS team members to the Commission, three from each country (**Appendix A**). The three candidates from the United States were drawn from the U.S. Army Corps of Engineers (USACE), U.S. Geological Survey (USGS) and the MDNR. Of the three candidates from Canada, two were drawn from the Ontario Ministry of Natural Resources and one from the Department of Fisheries and Oceans Canada. One IRRWPB member and one IRLBC engineering advisor were among the six candidates.

# 3 PLAN OF STUDY DEVELOPMENT

On October 16, 2007 the IJC approved the terms of reference and appointments for the POS team, naming the group the "2000 Rule Curve Assessment Workgroup" or "Workgroup" for short. Subsequently, the Workgroup provided the Commission with a work plan for completing its work and set about the task of fulfilling its terms of reference.

The work plan (with later refinements) defined the approach and process that the Workgroup would use to accomplish its work, including a communication plan, Workgroup brainstorming, a gap analysis workshop of experts, evaluation of best bets, existing studies and other needs, development of options for filling gaps and development of an approach for undertaking the 2015 Review.

## 3.1 Terms of Reference for the 2000 Rule Curve Assessment Workgroup

Under the IJC Terms of Reference, the Workgroup was given the mission to report on and prioritize the monitoring and analyses required to lead to a scientifically defensible identification of the impacts on the biological and aquatic communities (both beneficial and adverse) of the adoption of the 2000 Order by 2015 for Rainy and Namakan Lakes and Rainy River.

In accomplishing and completing its work, the Workgroup was to keep the Commission informed of its progress and direction and submit to the Commission:

- Within one month of its formation, a document framing the general nature of the anticipated work plan with special emphasis on outlining how it plans to proceed and collaborate with the Rainy Boards;
- By April 30, 2008 a draft report; and
- By June 30, 2008, a final report (an electronic copy and 5 printed copies provided to each section of the Commission.)

The Final Report from the Workgroup was to contain two main aspects. The first was to:

- Consider the various monitoring programs needed to identify and assess, by 2015, the impacts of changes to Namakan Lake and Rainy Lake and River biological and aquatic communities associated with the implementation of the 2000 rule curves;
- Identify and prioritize short-comings or gaps in existing monitoring programs required to lead to a scientifically defensible review of monitoring information collected by natural resource management agencies and others that may indicate the effect of changes contained in the Supplementary Order of January 5, 2000 by 2015;
- Identify the agencies, organizations, groups or individuals who are undertaking monitoring programs that may be best placed to fill the identified gaps or would have a role in doing so, including identifying resources they currently provide or could provide to this effort; and
- Estimate the costs associated to overcome each identified gap or short-coming.

The second main aspect was to:

- Recommend an approach for review of the 2000 Order that may be initiated in 2015, including:
  - The articulation of all studies to be performed and level of detail anticipated for each study;
  - Recommendations as to the agencies or organizations capable of conducting aspects of each study, recognizing that studies are to be conducted by a bi-national team;
  - The identification of sources of, or means of obtaining, needed information;
  - The priority, duration and timing of each study, considering the inclusion of phases to assist in the organizational management of the overall review; and
  - An estimate of the human and financial resources, including expertise, required to conduct each individual study and a summary for the entire review.

## 3.2 Approach and Process

The Workgroup prepared and submitted its work plan to the Commission at the end of December 2007. The work plan identified the approach and process the Workgroup intended to use in accomplishing its work.

The Workgroup also suggested several changes to the original TOR. Through communication with Commission staff, the Workgroup confirmed an expansion of the scope and objectives of the TOR to include analyses of the impact of the 2000 rule curves on socio-economics, navigation and erosion. Additionally, the Workgroup requested of the Commission and received approval for extensions of the due dates of the draft and final reports to June 20, 2008 and August 29, 2008, respectively. The submission of this final report was further delayed until June 2009, pending revisions to the draft final report in response to comments received from IJC staff

in late August 2008 and final comments received from the IRLBC and resource agencies in mid-March 2009.

The approach was broken into three phases: (1) initial actions required; (2) methods to address the first main aspect of the TOR, namely how to identify and fill gaps in current monitoring efforts; and (3) methods to address the second main aspect of the TOR, namely recommending an approach for conducting the 2015 review.

### 3.2.1 Initial Actions

#### *Communications*

It was the original intent of the Workgroup to write a brief communications plan early in 2008 for review and approval by the Rainy Boards and Commission staff, so that internal and external communications about the Workgroup and its activities could be carefully planned and implemented before the Workgroup got heavily involved in its assignment. However, it became apparent in the early phases of the assignment that a written formal communications plan was not needed. The Workgroup utilized a simplified approach to communications, relying to a great extent upon the existing board and agency affiliations represented in the membership of the Workgroup. Hence, the Workgroup communicated in the following manner:

- Communicated regularly with members of the IRLBC and IRRWPB via the Workgroup members who were affiliated with the Boards. The Workgroup provided drafts of their progress and final reports to the Boards for their review and comment before the reports were sent to the Commission.
- Communicated regularly with the resource agencies via Workgroup members who were affiliated with the agencies. In addition, two employees of the MDNR served as advisors to the Workgroup on Rainy River fisheries and aquatic studies.
- Communicated with senior resource agency officials to ensure they were aware of the rule curve change, the monitoring efforts, the 2015 review, and the need for additional resources. The assistance of Commission staff was helpful in this communication.
- Shared the Work Plan and the Workgroup TOR with certain members of academic institutions to enable effective development of the POS (e.g. invitations to workshop(s), purpose, etc.).
- Provided information on the Workgroup to the public via the IRLBC in its reports and newsletters on the IRLBC website.

#### *Workgroup Brainstorming (Planning)*

Delivery of this POS was the result of Workgroup efforts to layout a strategic approach for undertaking the tasks established in the approved TOR. The Workgroup met six times, all but once by conference call. From October to December, 2007 the Workgroup formulated the approach for the review, focusing on clarifying the objectives, scope of the review, the study area, and communications of the Workgroup. A Workgroup planning session was held on January 31, 2008 at Voyageurs National Park headquarters in International Falls, MN to: solidify the scope, needs, process and tasks; develop a communications plan; and develop a preliminary Gantt chart. Planning for a Workshop of experts was initiated.

At this time the Workgroup also explored the state of understanding for downstream resources and gained familiarity with research for this area. Key to that understanding was a presentation on a HEC-RAS hydraulic model developed by the USACE for the Rainy River. Also at this time the Workgroup reviewed a summation of monitoring studies within the basin. Conference calls on February 21 and March 3, 2008, were used for planning the expert workshop. An important decision was the addition of facilitator Erika Rivers of the MDNR for both planning and implementation of the workshop. The Workgroup conducted a post-workshop conference call on March 27, 2008.

### 3.2.2 Methods to Address First Main Aspect of TOR (Identifying and Filling Monitoring Gaps)

The methods used to identify and fill gaps in the current monitoring efforts were:

- A workshop of experts to conduct a gap analysis of monitoring programs on the reservoirs and Rainy River, and to identify and prioritize the "best bet" studies needed to fill the gaps, and;
- Workgroup evaluation of the "best bets" to collate priority studies into options for the Commission's consideration.

#### *Gap Analysis Workshop of Experts*

The Workgroup held a workshop of 30 academic and agency experts on March 10 and 11, 2008, at La Place Rendezvous on the shores of Rainy Lake in Fort Frances, Ontario (Darby et al. 2008, **Appendix D**). The intent of the workshop was to conduct a gap analysis of existing monitoring projects that are investigating effects of the 2000 rule curve changes on Rainy Lake and Namakan Reservoir. Participants were also asked to consider gaps relating to socio-economics and effects on the Rainy River downstream. Specific workshop tasks were: to conduct a status check of previous and ongoing studies; to identify and prioritize critical information gaps; to identify "best-bet studies" to fill critical gaps; and to suggest researchers, methods and timelines for the best-bet studies. The working group defined "best-bet studies" as research efforts that would most likely measure meaningful system changes from the 2000 rule curves.

Presentations were provided on:

- History of water level management in the Rainy Basin;
- Status check of ongoing studies and other previously identified monitoring categories and components for Rainy Lake, Namakan Reservoir, and the Rainy River;
- List of reports relevant to assessing effects of the 2000 rule curves on the Rainy River;
- Hydrological studies and the HEC-RAS model for the Rainy River;
- Potential effects of flow modifications to the Rainy River based upon impact assessment studies on other river systems; and
- Fisheries and aquatic ecosystem studies to date on the Rainy River.

During the workshop, the participants identified "best bet" studies and organized them into a table that included suggested timelines to undertake the studies. The "best bet" studies for the reservoirs during the workshop are shown in **Table 2**. Those for the Rainy River are shown in **Table 3**.

**Table 2: Best Bet Studies Identified for Rainy Lake and Namakan Reservoir at the 2008 Gap Analysis Workshop, Including Suggested Timelines to Undertake the Studies**

| Categories And Best-Bet Studies To Fill Gaps | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| **Hydrology and Water Quality:** | | | | | | | | |
| Develop a spatially explicit hydrodynamic model for all reservoirs. | X | X | X | X | X | | | |
| **Aquatic Vegetation:** | | | | | | | | |
| Replicate Meeker & Harris (In Press) Study. | | | | | X | X | | |
| **Benthic Macro-invertebrates:** | | | | | | | | |
| Relate changes in benthic community to rule curve change. | | | | X | X | | | |
| Relate changes in benthos to changes in aquatic vegetation. | | | | X | X | | | |
| **Birds, Herpetiles and Furbearers:** | | | | | | | | |
| How has Hg in bald eagles & loons been affected? | X | X | | | | | | |
| How has over-winter survival of herpetiles been affected? | X | X | X | | | | | |
| **Fish:** | | | | | | | | |
| Has Pike reproductive & nursery habitat been affected? | X | X | X | X | X | X | X | |
| **Cultural Resources:** | | | | | | | | |
| Measure erosion impact on a small # of known sites. | X | X | X | X | X | X | X | |
| **Economic Interests:** | | | | | | | | |
| Confirm impact on hydropower generation. | | X | | | | | | |
| Economic survey of impact on tourism resorts. | | X | | | | X | | |
| Survey of property damages due to flooding and ice. | | X | X | | | | | |

**Table 3: Best Bet Studies Identified for Rainy River at the 2008 Gap Analysis Workshop, Including Suggested Timelines to Undertake the Studies**

| Categories And Best-Bet Studies To Fill Gaps | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| **Hydrology and Water Quality:** | | | | | | | | |
| Model natural hydrology (HEC-RAS Model) vs. rule curves. | X | X | | | | | | |
| How do sediment deposit and transport vary longitudinally? | X | X | X | X | | | | |
| What is the relative contribution of curve change in the context of the watershed and natural variability? | X | X | X | X | X | X | X | X |
| Survey sites of high erosion risk, map in GIS and model effects of rule curve change. | X | | X | | X | | X | |
| **Aquatic Vegetation: (No recommendation)** | | | | | | | | |
| **Benthic Macro-invertebrates:** | | | | | | | | |
| Identify & measure critical habitats; model changes at cross-sections. | X | X | X | X | | | | |
| Measure benthic community composition over time and look for effects (include EEM monitoring data). | | X | X | X | X | X | | |
| Measure Unionid (mussel) diversity and abundance – compare to pre-change data. | | X | X | | | | | |
| **Birds, Herpetiles and Furbearers: (No recommendation)** | | | | | | | | |
| **Fish:** | | | | | | | | |
| Measure critical spawning and nursery habitats & assess how they have been affected. | X | X | X | X | X | X | X | |
| Measure changes in fish abundance (Sturgeon, Walleye & Log Perch) and relate to rule curve change. | X | X | | | | X | X | |
| Measure changes in fish community health (e.g. Index of Biotic Integrity) and relate to rule curve change. | X | X | | | | X | X | |
| **Cultural Resources:** | | | | | | | | |
| Survey archaeological sites, map in GIS & do hydrological modeling of effects. | X | X | X | | | | | |
| Identify benchmark archaeological sites & measure changes; relate to rule curve change. | X | X | X | X | X | X | X | |
| Literature search to compile known sites & model impacts. | X | | | | | | | |
| **Economic Interests:** | | | | | | | | |
| Water Treatment, Hatchery Data, Erosion and Tourism - examine for impacts. | X | X | X | X | X | X | X | |

The workshop participants suggested some "key guiding principles" for the IJC decision-making framework during the 2015 review. The guiding principles were:

- Natural variability and confounding factors (e.g., extreme weather or changes in fishing regulations) may preclude the identification of significant differences in sampling data and the determination of cause and effect relationships.
- Data analyses should include assessment of the effect of extreme weather events and climate change on the behaviour of monitoring data. It may be possible to discern these effects by comparing post-2000 weather and hydrologic data to the historical record. In addition, forecasting models should be used in pro-active and reactive manners.
- The primary source of information for the 2015 review should be data and reports resulting from monitoring studies undertaken pursuant to the 2001 IJC Consolidated Order and the 2000 Rule Curve Plan of Study.
- Secondary sources of information may be studies that indirectly relate to the review, such as: environmental assessments of proposed developments; periodic resource inventories undertaken as normal business of the federal, state and provincial natural resource agencies; and studies undertaken by academic institutions and industries.
- Other sources of information that should be considered during the review are the scientific literature, previous reports (e.g., International Rainy Lake Board of Control, 1999; Rainy Lake and Namakan Reservoir International Water Level Steering Committee, 1993) and proposals relating to the 2000 rule curve change, stakeholder input and public consultation results.
- In some cases a cost-benefit analysis may be possible and warranted.
- It may be advisable to have an independent third party review of all evidence to assist the Commission in its review and decision. It may be appropriate for the third-party review to identify options for the Commission to consider.
- The IJC should make its review decision based upon an evaluation of all quantitative, qualitative and expert-opinion evidence, with the intent of striking a fair and reasonable balance among all interests and needs in the basin. This "weight of the evidence" approach will require a conclusion flowing from a statement of judgement.

The Workgroup used the workshop proceedings as essential information and a guide in writing its POS. The Workgroup evaluated the workshop "best bets", existing long-term monitoring projects, and additional needs, to select priority indicators for inclusion in options for the Commission's consideration.

### *Workgroup Evaluation of Best Bets, Existing Studies, and Other Needs*

The Workgroup recognized that the list of "best bets" produced by the workshop participants might outstrip the capabilities of the researchers and funding agencies. Consequently, the Workgroup considered products from the 2008 and previous workshops, the existing and anticipated future resource agency monitoring projects, and other needs, to identify a list of "priority studies" that could be packaged into options for the Commission's consideration (**Appendix B, Table 11**). In so doing, the Workgroup intended to identify its preferred option to the Commission.

The Workgroup identified "**priority studies**" by screening and scoring the workshop best bets and other necessary studies using nine decision criteria adapted from Coughlan and Armour

(1992), Rice and Rochet (2005), and Fisheries and Oceans Canada (2008). A scale of 1 to 5 was employed to rank each best bet under each of the nine criteria. A value of 1 was considered poor, 2 fair, 3 good, 4 very good and 5 excellent. For cost, a value of 1 indicated that the cost of a project or study would exceed $400K, 2 represented $201-400K, 3 $101-200K, 4 $51-100K, and 5 less than $50K. The nine decision criteria used by the Work Group to evaluate and prioritize best bet studies consisted of the following:

1. **Cost** – Best bet study relies on tools that vary from widely available and inexpensive (excellent) to complex and costly (poor). Best bet can be addressed within the context of an assessment or monitoring program (high), or it requires an intensive spatial or temporal design only practical for a research program (low).
2. **Technical feasibility** – Has the best bet methodology been scientifically validated already (excellent), or partially validated? Can it be validated? Has validation been completed?
3. **Measurable** – Can the best bet be measured and if so, with what precision? High natural variability, both temporal and spatial, in biological populations and communities, and historical reliance on monitoring programs that were not designed to evaluate effects of water management, make this a significant issue in evaluation of the rule curves.
4. **Sensitive and Responsive** –Does the best bet measure a parameter(s) that is expected to have high or low sensitivity to the rule curve changes, and if so will this become obvious in a relatively short time period or will it only happen in decadal scales or longer? This is pertinent given that the overall evaluation period for the 2000 rule curves is only 15 years and by the time any additional work can be developed there will probably only be five years or less for further evaluation. Thus, changes that might be detectable within one to three years would be rated high while system responses on decadal changes or longer would be rated low.
5. **Cause and Effect Due to Rule Curve Change** – Is the best bet capable of distinguishing changes resulting from the 2000 rule curve from those caused by other factors such as peaking, fisheries management, climate change, and of course the fact that since the 2000 Order was established there have been several years of water levels both above and below the rule curves? Relative to the other factors, a best bet would be rated excellent or very good if it is unresponsive, good if it responds in known ways or is thought to be unresponsive, and fair or poor if its response is partly understood or unknown.
6. **Pre-change Data Available** - The availability of pre-rule curve change data is obviously critical with the ranking for this potentially going from a 5 for actual data from studies conducted on Rainy Lake and Namakan Reservoir or the Rainy River to lower rankings for comparable information from studies conducted on other systems.
7. **Political and Social Values** – Is there high or low public awareness of the issue the best bet will address and if so, is the public likely to feel it should be a major decision-making factor in the evaluation of the 2000 rule curves (excellent or very good ) or would they be largely indifferent (poor)? Based on the issues that contributed significantly to the rule curve changes, this is extremely important.
8. **Theoretical Basis** – If the concept in the best bet is readily reconciled with established theory it would be ranked excellent or very good; e.g. studies elsewhere and pre-rule curve change studies indicate that northern pike reproduction should benefit from an earlier spring rise in water levels. If the concept is not inconsistent with, but is not accounted for by ecological theory it would be ranked fair, while it would be ranked fair or poor if it is difficult to reconcile with ecological theory.

9. **Pragmatic and Relevant –** The Work Group's practical judgment of a best bet's interconnection and bearing upon the overall assessment of the 2000 rule curve changes.

***Development of Options for Filling the Gaps***

In developing options, the Workgroup made the following assumptions:

- The Commission may prefer to examine two or three options rather than receive recommendations from the Workgroup that have limited flexibility. Such options need to be pragmatic and feasible. For example, an option may be physically possible, but the project cost has to be realistic.
- Studies by the resource agencies that have been essential components of the monitoring program and may be in jeopardy due to uncertain funding, are included in the options.
- The companies will be asked to do a detailed analysis of the effect of the rule curve change on hydropower costs, but it may be necessary to align expectations of the companies, the Rainy Boards and the Commission.
- Professional review of individual study designs may be required before the studies are funded and undertaken.

The Workgroup organized the "**priority studies**" resulting from its evaluation into the following hierarchy of options:

- **Option 1: Core Studies** - lowest cost option that includes only those priority studies essential to a balanced review in 2015 (core studies).
- **Option 2: Core Studies Plus** - medium cost option of core and additional high scoring studies that will support a thorough review;
- **Option 3: All Priority Studies** - highest cost option includes all priority studies leading to a comprehensive and highly defensible review.

The Workgroup recognized the most significant challenge to a successful review in 2015 will be the difficulty of obtaining sufficient resources to implement a selected option.

### 3.2.3 Methods to Address Second Main Aspect of TOR (2015 Rule Curve Review)

Regarding the second aspect of the TOR, the Workgroup integrated the guiding principles from the workshop with its own and resource agency experience to identify a reasonable approach and mechanism for the review. The Workgroup believes the most appropriate method for conducting the review consists of a comparison of conditions under the 2000 rule curve to conditions under the 1970 rule curve to ascertain whether, on balance, there has been a net benefit to the various interests in the basin.

Given the variability of data derived from natural systems, the presence of continental and global influences in the watershed (e.g. atmospheric deposition of mercury, climate change, etc.), and changing economic conditions, some studies may be confounded by unrelated factors, and effects of the rule curve change may in some cases be unclear. In order to guard against this possibility, and to ensure that doubt about the review outcome is minimized, the Workgroup believes the review should take a "weight of the evidence" approach to decision-making.

The Workgroup believes that a reasonable method for weighing the evidence arising from the monitoring studies is to employ a simple matrix that uses study outcomes as positive, negative or neutral indicators in comparison to assist in making a decision. Independent expertise could be called upon to interpret study outcomes and populate the matrix accordingly. Each outcome would contribute evidence (influence) to the matrix. The matrix would summarize the evidence for all studies so that the combined outcome can be meaningfully "weighed" by an independent panel of experts and by the Commission.

Various matrices could be used, but a simple transparent matrix which is easily understood by the public would be preferred. The summary assessment should be undertaken by subject category and by individual study for each water body (e.g. Rainy Lake, Namakan Reservoir or Rainy River). Agency monitoring results could be similarly represented or incorporated directly into the matrix.

***Assumptions***

- The 2015 review process will be as open and transparent as possible and will be conducted in a manner that is, and is perceived to be, impartial and objective.
- The review will require independent (out-of-basin) scientific expertise, primarily in water resource management and the environmental sciences.
- The necessary resources will be made available to support a panel of independent professional experts.
- The Rainy Boards will be available as a source of information.
- The resource agencies and the companies (dam operators) will be willing contributors to the review.

***Considerations***

The Workgroup developed its recommendations for conducting the 2015 review by considering the following:

- Distilling and understanding the complex effects of the 2000 rule curve change from the hydrologic, environmental and socio-economic perspectives will be a daunting task. The monitoring studies may sometimes not produce clear and decisive results. For example, the variability of natural systems may sometimes confound the researchers' ability to measure significant differences or to determine "cause and effect" relationships.
- There is an important need to achieve an appropriate balance among the hydrologic, environmental and socio-economic needs that is fair and reasonable and will avoid cross-border disputes and disputes among interests as much as possible, including reservoir and downstream interests.
- It will be important that the review carefully discern between effects of the 2000 rule curve change and effects of unrelated climatic, water management or economic events and decisions that may have occurred during the 2000 to 2015 time period.
- The independent panel of experts will not likely be able to pull together all information necessary for the review without the assistance of the resource agencies and the Rainy Boards.

- Continuation of the long-term monitoring programs being conducted by the resource agencies will be essential to the review. The resource agencies are likely to need financial assistance to maintain the monitoring programs to 2015.
- The Rule Curves were modified in 2000 on the premise that a move towards a more natural hydrograph would benefit the aquatic communities of Rainy Lake and Namakan Reservoir. To a lesser degree, the changes were also expected to provide more flow to the Rainy River during certain times of the year, which would benefit the aquatic riverine community. Though many will recognize the importance of improved conditions for loons and furbearers, fewer will appreciate improvements for benthic invertebrates. Members of the public will likely focus on whether the fishery has responded, either positively or negatively to the rule curve changes.
- The experience of the resource agencies and the Workgroup members was considered in identifying a reasonable approach and mechanism for the review.

# 4 FINDINGS

## 4.1 First Main Aspect of TOR (Identifying and Filling Monitoring Gaps)

### 4.1.1 Current Agency Monitoring Studies with Uncertain Funding in the Future

**Table 1** provided a list of resource agency studies that are either ongoing or have not been started, and are intended to be part of the monitoring program to 2015. From 2001 to 2007 the resource agencies have contributed significant financial resources to the monitoring effort. For example, the U.S. National Park Service has contributed about $1.8 million (includes project costs, seasonal staff but not permanent), the U.S. Army Corps of Engineers about $100,000 (includes projects, gauges and travel), the Minnesota DNR about $500,000, and the Ontario MNR about $400,000 (includes project costs, seasonal staff but not permanent). This represents significant leveraging toward IJC objectives without which monitoring conducted to date would not have been possible.

The resource agency representatives have indicated to the Commission at previous annual meetings in the basin that future funding for some of the monitoring studies is uncertain. The Workgroup believes that completion of the current studies and continuance of long-term agency monitoring programs should be the first order of business in preparing for the 2015 review. The Workgroup is quite concerned that these studies or programs may be dropped by the resource agencies for financial reasons. Such a decision would not be in the Commission's interest.

The Workgroup believes the Commission should seek a commitment from the resource agencies that they will complete the list of studies and programs in **Table 4** to provide essential baseline information for the 2015 review. If the resource agencies do not provide funding, then the Commission should add those studies to the list in its selected option.

**Table 4: Studies and Long-Term Monitoring Programs of the Resource Agencies on Rainy Lake, Namakan Reservoir and Rainy River for Which Future Funding is Uncertain.**

| Study/Program | Estimated Cost/Year (1000's USD) |
|---|---|
| Long-term water quality modeling (USNPS) | 50 |
| Loon population monitoring, including reproductive success (USNPS) | 40 |
| Annual large lake fisheries sampling program – Namakan and Sandpoint lakes (MDNR) | 26 |
| Annual fisheries sampling program – Rainy River (MDNR) | 15 |
| Long-term walleye index netting (OMNR) | 30 |
| Mercury sampling of young-of-the-year yellow perch (USNPS) | 10 |
| Coregonid/rainbow smelt monitoring (MDNR) | 10 |
| Beaver monitoring (USNPS) | 30 |
| Creel surveys (MDNR and OMNR combined) | 145 |

### 4.1.2 New Priority Studies

The Workgroup screened and scored the best bets from the 2008 workshop and four best bet studies from the 2000 workshop that are not yet undertaken (see **Appendix B** for priority scoring results), according to the method outlined in **Section 3.2.4**. In one instance during the screening process, the Workgroup used its judgment to replace a best bet from the 2008 workshop concerning development of a spatially explicit hydrodynamic model for all reservoirs. The Workgroup replaced it with a combination of a reservoir hydrologic model for Rainy Lake and the Namakan Chain of lakes and the Physical Habitat Simulation Model, PHABSIM, adapted to a reservoir environment for selected locations on the lakes. The resulting list of Workgroup Priority Studies is arranged in **Tables 5 and 6** for the reservoirs and Rainy River respectively. Information for each study such as research question, estimated cost and recommended researchers, can be found in **Appendix C**.

**Table 5: Workgroup List of New "Priority Studies" for Rainy Lake and Namakan Reservoir**

| Category | New Priority Studies For The Reservoirs |
|---|---|
| **Cultural Resources** | • Measure impact of erosion; small # sites on reservoirs. |
| **Hydrology & Water Quality** | • Reservoirs - develop reservoir hydrologic model and reservoir PHABSIM habitat model.<br>• Detailed littoral bathymetry for selected locations to assist other monitoring studies such as aquatic vegetation, benthos, northern pike.*<br>• Assess effects of land use changes in the watershed on water quantity and quality relative to effects of the rule curve change* |
| **Birds, Herpetiles & Furbearers** | • How has the 2000 curve affected mercury in Loons?<br>• Map & evaluate distribution of habitat for marsh nesting birds & herpetofauna.* |
| **Fish** | • Has 2000 curve changed pike reproductive & nursery habitat?<br>• Has pike reproductive success improved?<br>• Measure critical spawning habitat for walleye on Namakan Lake; assess how it has been affected by rule curve change.*<br>• Assess influence of fixed-station vs. randomized sampling design on rule curve evaluation results for index-netting.* |
| **Aquatic Vegetation** | • Replicate Meeker & Harris Study (In Press). |
| **Benthic Macro-Invertebrates** | • Measure changes in benthic community in relation to curves.<br>• Relate changes in benthos to changes in aquatic vegetation. |
| **Economic Interests** | • Confirm rule curve change impact on hydropower generation.<br>• Economic survey of impact on tourism resorts on reservoirs.<br>• Survey of property damages due to flooding and ice. |

*: studies recommended by the 2000 and 2002 workshops but not yet undertaken.

**Table 6: Workgroup List of New "Priority Studies" for the Rainy River**

| Category | New Priority Studies For The Rainy River |
|---|---|
| **Cultural Resources** | • What are the specific impacts? Survey, GIS Mapping & hydrological modeling.<br>• Assess effects on cultural resources at benchmark sites on Rainy R. |
| **Hydrology & Water Quality** | • Model RR natural hydrology (HEC-RAS Model) vs. Rule Curves |
| **Fish** | • Measure critical spawning and nursery habitats & how affected.<br>• Measure changes in fish community (biotic diversity re: effects). |
| **Benthic Macro-Invertebrates** | • Identify & measure critical habitats; model changes at X Sections.<br>• Measure unionid diversity & abundance in Rainy R. re: effects. |
| **Economic Interests** | • Water Treatment & Hatchery Data - examine for impacts.<br>• Assess rule curve change impact on pattern of erosion on Rainy R.<br>• Economic survey of impact on tourism use of the river. |

### 4.1.3 Options for Pursuing New Priority Studies

The following are three options developed by the Workgroup for pursuing new priority studies. It is important to note that these options are organized to supplement the base cost of supporting some current agency monitoring studies for which funding is uncertain (**see Section 4.1**).

***Option 1: Core Studies***

Option 1, shown in **Table 7**, is a low cost option that includes core studies for a balanced review in 2015.

Pros:
- Most inexpensive option.
- These studies ranked highest for likelihood of discerning cause and effect relationships.
- Fundamental questions and needs of the review will be addressed on a range of topics.
- Achieves hydrologic modeling capability which is a foundation need for a wide range of studies now and in the future.
- Studies are suitable for contracting.

Cons:
- Substantial cost, given that option 1 costs may be in addition to supporting the cost of some current agency studies for which funding is in doubt.
- Significant coordination effort required.

**Table 7: Option 1 - Core Studies (Estimated Costs in 1,000's USD)**

| Priority Study | Est. Cost |
|---|---|
| Reservoirs - develop reservoir hydrologic model & reservoir PHABSIM habitat model | 300 |
| Model natural hydrology of Rainy River (HEC-RAS Model) vs. rule curves | 75 |
| Measure changes in benthic community in relation to curves, in the reservoirs | 100 |
| Aquatic vegetation (replicate Meeker and Harris, In Press) | 100 |
| Reservoirs – northern pike spawning habitat and reproductive success | 75 |
| Rainy River – critical spawning and nursery habitats | 300 |
| Hydropower (assumes assessment costs will be borne by companies) | 0 |
| Economic survey of impact of rule curves on tourist resorts on reservoirs | 75 |
| Relate rule curve changes to flooding and ice effects on reservoirs | 100 |
| **Total Cost** | **1,125** |

***Option 2: Core Studies and Additional High-Scoring Studies***

Option 2, shown in **Table 8**, is a medium cost option combining the Core Studies identified in Option 1 with additional high scoring studies identified by the Workgroup.

Pros:

- Includes and builds on the Core Studies of Option 1.
- Addresses the need to assess impact on significant cultural resources.
- Expands the spectrum of effects-monitoring to address significant downstream questions.
- Relatively inexpensive cost for the number of additional studies undertaken.
- Unionid (mussel) survey is compatible with long-term monitoring done on Rainy River by Abitibi-Bowater in Fort Frances.

Cons:

- Cost of the studies in Option 2 is accumulating to a substantial level, especially if it becomes necessary to support some agency studies for which funding is uncertain.
- Likelihood of discerning cause and effect relationships with the rule curve change is not as high for the additional high scoring studies as it is for the core studies.
- Does not elevate the review to the watershed level.

**Table 8: Option 2 - Additional Priority Studies in Conjunction with Core Studies (Estimated Costs in 1,000's USD)**

| Priority Study | Est. Cost |
|---|---|
| **Core Studies:** | |
| Reservoirs - develop reservoir hydrologic model & reservoir PHABSIM habitat model | 300 |
| Model natural hydrology of Rainy River (HEC-RAS Model) vs. rule curves | 75 |
| Measure changes in benthic community in relation to curves, in the reservoirs | 100 |
| Aquatic vegetation (replicate Meeker and Harris, In Press) | 100 |
| Reservoirs – northern pike spawning habitat and reproductive success | 75 |
| Rainy River – critical spawning and nursery habitats | 300 |
| Hydropower (assumes assessment costs will be borne by companies) | 0 |
| Economic survey of impact of rule curves on tourist resorts on reservoirs | 75 |
| Relate rule curve changes to flooding and ice effects on reservoirs | 100 |
| **Additional High Scoring Studies:** | |
| Detailed bathymetric mapping of the littoral zone of selected reservoir locations | 75 |
| Assess effects on cultural resources at a small number of sites on the reservoirs | 75 |
| Assess effects on cultural resources at benchmark sites on the Rainy River | 75 |
| Assess effects on reservoir habitats for marsh-nesting birds/herps at selected sites | 200 |
| Identify critical river benthic habitats at X-sections; model effects of curve change | 75 |
| Measure Unionid (mussel) diversity and abundance in the Rainy River re: effects | 25 |
| Measure changes in fish community health (Index Biotic Diversity) re: effects | 25 |
| Measure critical spawning habitat for walleye on Namakan Reservoir re: effects | 75 |
| Examine municipal water treatment and hatchery data for Rainy River re: effects | 25 |
| **Total Cost** | **1,775** |

### *Option 3: All Priority Studies*

Option 3, shown in **Table 9** is a high cost option, which includes all "priority studies". It should lead to a comprehensive and highly defensible review. This option includes the studies referenced in Options 1 and 2, plus remaining priority studies identified by the Workgroup.

**Table 9: Option 3 - All Priority Studies (Estimated Costs in 1,000's USD)**

| Priority Study | Est. Cost |
|---|---|
| **Core Studies:** | |
| Reservoirs - develop reservoir hydrologic model & reservoir PHABSIM habitat model | 300 |
| Model natural hydrology of Rainy River (HEC-RAS Model) vs. rule curves | 75 |
| Measure changes in benthic community in relation to curves, in the reservoirs | 100 |
| Aquatic vegetation (replicate Meeker and Harris, In Press) | 100 |
| Reservoirs – northern pike spawning habitat and reproductive success | 75 |
| Rainy River – critical spawning and nursery habitats | 300 |
| Hydropower (assumes assessment costs will be borne by companies) | 0 |
| Economic survey of impact of rule curves on tourist resorts on reservoirs | 75 |
| Relate rule curve changes to flooding and ice effects - reservoirs and Rainy River | 100 |
| **Additional High Scoring Studies:** | |
| Detailed bathymetric mapping of the littoral zone of selected reservoir locations | 75 |
| Assess effects on cultural resources at a small number of sites on the reservoirs | 75 |
| Assess effects on cultural resources at benchmark sites on the Rainy River | 75 |
| Assess effects on reservoir habitats for marsh-nesting birds/herps at selected sites | 200 |
| Identify critical river benthic habitats at X-sections; model effects of curve change | 75 |
| Measure Unionid (mussel) diversity and abundance in the Rainy River re: effects | 25 |
| Measure changes in fish community health (Index Biotic Diversity) re: effects | 25 |
| Measure critical spawning habitat for walleye on Namakan Reservoir re: effects | 75 |
| Examine water treatment and hatchery data for Rainy River re: effects | 25 |
| **Remaining Priority Studies:** | |
| Assess watershed for land use & anthropogenic effects on water quantity and quality | 200 |
| Assess effects on river cultural resources – surveys and hydrological modeling | 150 |
| Assess fixed vs. random fish netting designs to enhance statistical analyses re: effects | 75 |
| Assess effects of rule curve change on pattern of erosion on Rainy River | 150 |
| Assess effects of rule curve change on mercury concentrations in Common Loons | 25 |
| Economic survey of effect of the rule curve change on tourism use of the river | 50 |
| **Total Cost** | **2,425** |

Pros:

- Completion of all studies in Options 1 through 3 provides a comprehensive and integrated monitoring package that should support a highly defensible review.
- Ability to understand effects of the rule curve change in a watershed and ecosystem context is greater than with Options 1 or 2.

Cons:

- Cumulative cost of some support for agency studies plus the cost of options 1, 2 and 3 is high.
- Some studies may not be readily perceived as relevant to the rule curve review (e.g. statistical comparison of fish netting designs).

### 4.1.4 Prioritization of Studies Within the Options

The Workgroup developed the above options using the scoring results shown in **Table 11** (**Appendix B**), moderated by the need to include representative studies across subject categories. The Workgroup organized the priority studies into three distinct packages at different funding levels by selecting a core group of priority studies (Option 1) and adding additional high scoring studies to that Core group to form Options 2 and 3. The Workgroup designed the options in anticipation of needs of the 2015 review, and future needs of the Commission, based on the 2008 scientific, socio-economic and political context.

Given rapid changes in the economic and political environment, it is difficult for the Workgroup to anticipate the future budgetary and priority context for the studies. It is possible that in future the Commission may not consider the above options appropriate, or there may be a need to shorten or modify the list of studies within a given option. Such modifications may be made using the information contained in this POS.

The "Total Score" shown on the right of **Table 11** (**Appendix B**) represents the relative importance of individual studies to the 2015 Review across all subject categories. Consequently, there may be more than one study with the same or similar scores. This is because the Workgroup did not attempt to make value judgments regarding whether one subject category was more important than another (e.g. economic versus fish). Nonetheless, the scores can be used as a general guide to the relative importance of a study to the 2015 review.

If the Commission wishes to shorten or modify a list of studies within a given option, it may compare the total score for each study in **Table 11**, to the timelines in **Tables 2 and 3**, and the descriptions and costs in **Appendix C**.

## 4.2 Second Main Aspect of TOR (2015 Rule Curve Review)

The 2001 IJC Consolidated Order for Rainy Lake and other Boundary Waters in the Rainy Lake Watershed states that the IJC`s 2000 objective is to continue to avoid emergency conditions associated with high and low water by instituting revised rule curves and other requirements which provide a careful balance between upstream and downstream concerns and among various interests, including hydropower, flood risk, boating and environmental concerns.

The Workgroup`s mission, as stated in its TOR is to report on and prioritize the monitoring and analyses required to lead to a scientifically defensible identification of the impacts on the biological and aquatic communities (both beneficial and adverse) of the adoption of the 2000 Order by 2015 for Rainy and Namakan Lakes and Rainy River. The Commission subsequently agreed to the inclusion of socio-economic impact assessment in the mission.

The TOR also required the Workgroup to recommend an approach for conducting the review of the 2000 Order, to be initiated in 2015, including the articulation of all studies to be performed and the level of detail anticipated for each study. Based upon results of the 2008 Workshop and the identification of options for filling gaps in the current monitoring, the Workgroup does not believe it is necessary to commence a replicate set of studies in 2015, as implied by the TOR. Instead, the Workgroup believes it will be sufficient to engage an international panel of professional experts to review study reports for the basin and the scientific literature, apply their professional expertise and experience, and employ a decision-matrix to ascertain whether, on balance, there has been a net benefit to the various interests in the basin.

The Workgroup also believes the review needs to determine if the 2000 rule curves have indeed provided a "careful balance" among the varied interests, in today's context. This will be a daunting task that will require independent (out-of-basin) scientific expertise, primarily in water resource management and the environmental sciences. The independent panel should include experts in water resource and environmental management, perhaps two from the U.S. and two from Canada. The Rainy Boards should be available to the panel for information as required. The panel of experts should report to the Commission.

The panel's work may take two to three months and may cost in the range of $100-200k, but given volatility and uncertainty of the economy, and the 2015 horizon, a precise estimate of the panel cost is not possible at this time.

Given the variability of data derived from natural systems, the presence of continental and global influences in the watershed (e.g. atmospheric deposition of mercury, climate change, etc.), and changing economic conditions, some studies may be confounded by unrelated factors, and effects of the rule curve change may in some cases be unclear. In order to guard against this possibility, and to ensure that doubt about the review outcome is minimized, the Workgroup believes the review should take a "weight of the evidence" approach to decision-making.

The Workgroup believes that a reasonable method for weighing the evidence arising from the monitoring studies is to employ a simple matrix that uses study outcomes as positive, negative or neutral indicators to assist in making a decision. The panel of independent professional experts could interpret the study outcomes and populate the matrix accordingly. Each study outcome would contribute evidence (influence) to the matrix. The matrix would summarize the evidence for all studies so that the combined outcome can be meaningfully "weighed" by the panel.

There are various matrices that could be used, but a simple transparent matrix easily understood by the public would be preferred. A very basic example for Namakan Reservoir is provided for illustration in **Table 10** and represents a summation of more detailed and integrated analyses. The summary assessment should be undertaken by subject category and by individual study for

each water body (e.g. Rainy Lake, Namakan Reservoir or Rainy River). Agency monitoring results could be similarly represented or incorporated directly into the matrix.

**Table 10: Example of a Simple Matrix That Could be Used to Assess Summary Effects of Priority Studies for Evaluating the 2000 Rule Curve for Namakan Reservoir**

| **Subject Category** Priority Study | **Rating of Potential Net Effects** | | | | | | | | **Comment, Rationale** |
|---|---|---|---|---|---|---|---|---|---|
| | **-H** | **-M** | **-L** | **Nil** | **Unk** | **+L** | **+M** | **+H** | |
| **Cultural Resources:** | | | | | | | | | |
| Measure erosion at small # sites | | | | | | | | | |
| **Hydrology & Water Quality:** | | | | | | | | | |
| Develop hydrologic/habitat models | | | | | | | | | |
| Map littoral bathymetry | | | | | | | | | |
| Watershed land use changes | | | | | | | | | |
| **Birds, Herpetiles, Furbearers:** | | | | | | | | | |
| Mercury in Common Loons | | | | | | | | | |
| Map marsh habitat – birds & herps | | | | | | | | | |
| **Fish:** | | | | | | | | | |
| Pike spawn habitat & reproduction | | | | | | | | | |
| Walleye spawning habitat | | | | | | | | | |
| Fixed vs. random sampling designs | | | | | | | | | |
| **Aquatic Vegetation:** | | | | | | | | | |
| Replicate Meeker & Harris Study | | | | | | | | | |
| **Benthic Macro-Invertebrates:** | | | | | | | | | |
| Changes in benthic community | | | | | | | | | |
| **Economic Interests:** | | | | | | | | | |
| Effects on hydropower generation | | | | | | | | | |
| Effects on tourism resorts | | | | | | | | | |
| Flood & ice damage to properties | | | | | | | | | |

# 5 RECOMMENDATIONS

The Workgroup concurs with the Commission, that as per page 7 of the 2001 Consolidated Order, the objective of the review should be to determine if the 2000 rule curves, in comparison to the 1970 curves, have more or less effectively avoided emergency conditions associated with high and low water while providing a careful balance among the various interests including: upstream and downstream concerns, hydropower needs, flood risk, boating, and needs of the biological and aquatic communities. At a minimum, per the 2000 Supplementary Order, the review should consider monitoring information collected by natural resource management agencies and others during the interim. The Workgroup recognizes that the Consolidated Order does not require funding of required studies by the Commission or the Federal Governments. However, the Plan of Study is presented as a forecast of study and funding needs so that funding assistance can be sought from federal, provincial and state governments to make an acceptable review possible.

The Workgroup offers the following five recommendations regarding the 2015 review for consideration by the Commission.

1. The Workgroup recommends the Commission seek clarification from the resource management agencies as to which long-term studies and monitoring programs (**Table 4**) they commit to complete, to provide essential baseline information for the 2015 review. The Commission should endeavor to obtain funding for those studies (in **Table 4**) that the resource agencies can not continue to support.
2. The Workgroup recommends the Commission, via the Rainy Boards, develop an understanding with the Companies that the Companies will undertake assessment of the effects on hydropower generation, with Board oversight.
3. The Workgroup recommends the Commission endeavor to obtain funding for Option 2.
4. The Workgroup recommends the review be conducted by an independent panel of water resource and environmental experts that reports directly to the Commission.
5. The Workgroup recommends the Commission use a "weight of the evidence" approach to decision-making during the review. In this context, a decision matrix may be used as a tool to summarize study results and effects, and to aid decision-making.

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## APPENDIX A - 2000 RULE CURVE ASSESSMENT WORKGROUP

| Canadian Section | US Section |
|---|---|
| Bill Darby, OMNR (Co-chair) | Larry Kallemeyn, Retired USGS (Co-chair) |
| Karen Smokorowski, DFO | Kevin Peterson, MN DNR |
| John Van den Broeck, OMNR | Ed Eaton, Corps of Engineers |

## APPENDIX B - WORKGROUP SCORING RESULTS FOR BEST BET STUDIES

This appendix contains the Workgroup's screened and scored results for the best bet studies from the 2008 workshop and four best bet studies identified in the 2000 workshop but not yet undertaken. These results are shown in **Table 11**.

**Table 11: Workgroup Screened and Scored Results for the Best Bet Studies from the 2008 Workshop and Four Best Bet Studies Identified in the 2000 Workshop but Not Yet Undertaken**

| EVALUATION CRITERION, WEIGHT FACTOR & SCORE - (Note: 1 = poor; 2 = fair; 3 = good; 4 = very good; 5 = excellent). | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CATEGORIES AND BEST BET STUDIES TO FILL GAPS (Note: Black Font = Reservoir Studies; Blue Font = River Studies.)** | **1: COST (to 2015)** | **2. TECHNICAL FEASIBILITY** | **3: MEASURABLE** | **4: SENSITIVE & RESPONSIVE** | **5. CAN DISCERN CAUSE & EFFECT DUE TO CURVE** | **6. PRE-CHANGE DATA AVAILABLE** | **7. POLITICAL & SOCIAL MERIT** | **8. MERIT ON A THEORETICAL BASIS** | **9. PRAGMATIC & RELEVANT** | **TOTAL SCORE** | **COMMENTS** |
| **Cultural Resources:** | | | | | | | | | | | |
| Measure erosional impact on small # sites on reservoirs. | 4 | 4 | 4 | 3 | 3 | 4 | 5 | 4 | 4 | 35 | |
| Cadillac: What are the specific impacts? Survey, GIS Mapping & hydrological modelling | 3 | 4 | 4 | 2 | 2 | 3 | 5 | 4 | 3 | 30 | |
| Chev/VW: Use known benchmark arch. sites & measure changes | 4 | 4 | 4 | 1 | 1 | 3 | 4 | 4 | 2 | 27 | |
| Bicycle - Literature search to compile known sites and model hydrolgic impacts on them. | 5 | 5 | 1 | 1 | 1 | 2 | 3 | 3 | 1 | 22 | |
| | | | | | | | | | | | |
| **Hydrology and Water Quality:** | | | | | | | | | | | |
| Reservoirs - Develop reservoir hydrologic model and reservoir PHABSIM habitat model. | 3 | 4 | 3 | 4 | 5 | 2 | 5 | 5 | 5 | 36 | Platform for other studies |
| Develop detailed bathymetric map of the littoral zone* | 2 | 5 | 5 | 3 | 3 | 2 | 2 | 4 | 3 | 29 | |
| Effects of watershed land use changes on water quality* | 1 | 4 | 3 | 4 | 2 | 3 | 3 | 5 | 3 | 28 | |
| Model natural hydrology of RR (HEC-RAS Model) vs. Rule Curves | 4 | 5 | 3 | 4 | 4 | 3 | 5 | 5 | 3 | 36 | |
| How do sediment deposition and transport vary longitudinally on RR? | 3 | 4 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 17 | Not very relevant to study purpose |
| Relate rule curve & watershed landscape changes to sediment transport in RR? | 1 | 4 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 15 | Not very relevant to study purpose |
| | | | | | | | | | | | |
| **Birds, Herps & Furbearers:** | | | | | | | | | | | |
| How has 2000 curve affected Hg in Loons? | 5 | 4 | 4 | 4 | 1 | 4 | 3 | 3 | 3 | 31 | Supports perch study on a different trophic level. |
| How has overwinter survival of herps been affected by change? | 5 | 5 | 5 | 3 | 1 | 1 | 4 | 4 | 2 | 30 | |
| Map and evaluate distibution of marsh habitats for birds and herpetofauna* | 2 | 4 | 5 | 4 | 4 | 3 | 2 | 4 | 3 | 31 | |
| | | | | | | | | | | | |
| **Fish:** | | | | | | | | | | | |
| Has Pike reproductive & nursery habitat changed due to curve? Has recruitment improved? | 4 | 4 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 36 | |
| Assess influence of fixed station vs. randomized sampling index netting design re: curves* | 4 | 5 | 5 | 3 | 2 | 1 | 3 | 5 | 3 | 31 | |
| Measure critical spawning and nursery habitats & how affected. | 2 | 4 | 4 | 5 | 2 | 3 | 4 | 4 | 3 | 31 | |
| Measure changes in fish abundance - Sturgeon, Wa & Log Perch. | 2 | 3 | 4 | 2 | 1 | 1 | 5 | 3 | 2 | 23 | |
| Measure changes in fish community health (Index Biotic Integrity) | 5 | 4 | 4 | 3 | 2 | 1 | 3 | 4 | 2 | 28 | Would be more valuable if a longer data set was available. |
| | | | | | | | | | | | |
| **Aquatic Vegetation:** | | | | | | | | | | | |
| Replicate Meeker & Harris Study - focus on areas of change. | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 5 | 4 | 35 | |
| | | | | | | | | | | | |
| **Benthic Macroinvertebrates:** | | | | | | | | | | | |
| Measure changes in benthic community in relation to curves. | 4 | 4 | 4 | 4 | 3 | 3 | 1 | 5 | 3 | 31 | |
| Relate changes in benthos to changes in aquatic vegetation. | 3 | 4 | 4 | 4 | 3 | 3 | 2 | 5 | 3 | 31 | |
| Identify & measure critical habitats; model changes at X Sections. | 4 | 5 | 4 | 4 | 2 | 1 | 1 | 5 | 3 | 29 | |
| Measure benthic community composition over time and look for effects | 3 | 5 | 5 | 4 | 2 | 2 | 1 | 5 | 3 | 30 | |
| Measure Unionid (mussel) diversity and abundance. | 5 | 5 | 5 | 4 | 2 | 1 | 1 | 5 | 3 | 31 | |
| | | | | | | | | | | | |
| **Economic Issues:** | | | | | | | | | | | |
| Confirm impact of rule curve change on hydropower generation. | 3 | 5 | 5 | 5 | 3 | 4 | 5 | 5 | 4 | 39 | |
| Economic survey of impact on tourism resorts on reservoirs. | 4 | 4 | 4 | 2 | 3 | 2 | 4 | 3 | 3 | 29 | |
| Survey of property damages due to flooding and ice. | 2 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 | 38 | |
| Water Treatment & Hatchery Data - examine for impacts | 5 | 5 | 5 | 3 | 2 | 4 | 5 | 5 | 4 | 38 | |
| Assess impact of rule curve change on pattern of erosion on Rainy River. | 3 | 4 | 4 | 2 | 2 | 1 | 3 | 4 | 3 | 26 | |

*: Best bet studies identified in the 2000 workshop that have not yet been completed.

## APPENDIX C - NEW STUDIES INCLUDED IN DEVELOPMENT OF OPTIONS

This appendix contains a listing of new priority studies (**Section 4.2**) from which selections were made and incorporated in the three recommended option groups (**Section 4.3**). These new priority studies are categorized in this appendix under two broad headings, "Rainy Lake and Namakan Reservoir" and "Rainy River". Studies for Rainy Lake and Namakan Reservoir cover the categories of cultural resources, hydrology and water quality, birds, herpetiles, and furbearers, fish, aquatic vegetation, benthic macro-invertebrates and economic interests. Studies for Rainy River cover the same categories with the exception of birds, herpetiles, and furbearers and aquatic vegetation.

### RAINY LAKE AND NAMAKAN RESERVOIR

#### Category – Cultural Resources:

***Study – Determine if the 2000 rule curves have had a measurable impact on erosion at a small number of known archeological sites on the reservoirs.***

Key Research Question: How have cultural resources been affected by the 2000 rule curves? Reconnaissance inventories of archeological resources in Voyageurs National Park in the 1970s and 80s found that all of the prehistoric and most historic sites occurred along the shorelines of Rainy Lake and Namakan Reservoir. Approximately 75% of the prehistoric sites were found to have been adversely affected by erosion from wave action since the creation of the reservoirs. Even sites located above the maximum lake levels were impacted by the fluctuating water levels. Intense wave action during the period when lake levels are at their summer peaks was particularly destructive to archeological sites since it caused undercutting and bank slumping. The only sites that had escaped damage were those located behind and protected by bedrock shoreline.

Recommended Method: To determine if the hypothesis that the summer drawdowns included in the 2000 rule curves have reduced the destruction of archeological resources is correct, erosion rates and damage to cultural resources should be monitored at archeological sites previously identified by the National Park Service. The best time to conduct such assessments is early in the spring, immediately after ice out, when water levels are lowest. This assessment will require, in addition to water level data, information on soil types and site exposure to prevailing winds and wave action. Comparison with previous NPS observations and evidence of erosion in the archaeological (soil) profile can be used to assess whether the hypothesized changes have occurred.

Suggested Researchers: Jeff Richner, NPS-Midwest Archaeological Center; Bill Ross, Thunder Bay; Edgar Oerichbauer, Koochiching County Museum; and Stacey Jack, Pwi-Di-Goo-Zing Advisory Services, Fort Frances.

Cost: $75K

#### Category - Hydrology and Water Quality:

***Study – Develop reservoir hydrologic model and reservoir PHABSIM habitat model for Rainy Lake and the Namakan Chain of lakes.***

Key Research Question: Have hydrodynamics of the reservoirs changed due to the 2000 rule curve changes? Determine how hydrodynamics and circulatory flows have changed historically

and how changes may have affected nutrient interfaces, and aquatic and terrestrial (riparian) habitats. This key research question and study recommendation offered by the experts at the 2008 workshop was considered by the Workgroup and felt to be too complex and costly relative to the usefulness of the information it would yield. The Workgroup believes that a simpler approach utilizing reservoir hydrologic modeling coupled with habitat simulation modeling to evaluate changes to Habitat Suitability Indices (HSI's) for key indicator species is a more useful and cost-effective approach. The key research question in this case is: How have changes in lake level timing, frequency and duration changed HSI's for key indicator species.
Recommended Method: Experts at the 2008 workshop recommended development of a spatially explicit hydrodynamic model that incorporates the different metrics (all components of lake level studies). They felt this model would be helpful as a research and educational tool because of its ability to visually display relationships and changes. The Workgroup has significant reservations with respect to sustaining the information collection needed to integrate all the metrics and develop/ensure a good hydrodynamic model to determine the changes the rule curve has created? In addition, the Workgroup believes the cost of developing a 2-dimensional or 3-dimensional hydrodynamic model for all the lakes would be prohibitive in relationship to the usefulness of the information such a model would provide on changes in the metrics measured. Instead, the Workgroup believes a more meaningful and cost-effective approach is to develop a reservoir hydrologic model for the lakes and perform simulations to develop key lake level timing, elevation-frequency and elevation-duration relationships that would interface with the Physical Habitat Simulation Model, PHABSIM, adapted for use in a reservoir environment to look at changes to Habitat Suitability Indices (HSI's) for key indicator species. The reservoir hydrologic model would be developed for Rainy Lake and the Namakan Chain of lakes, while the PHABSIM model would focus on selected locations of interest for key indicator species in both lakes.
Suggested Researchers: U.S. Army Corps of Engineers, Environment Canada
Estimated Cost: $300K

***Study – Develop detailed bathymetric maps of the littoral zone for selected locations to assist other monitoring studies designed to assess the effect of the 2000 rule curves on aquatic vegetation, benthos, northern pike, and walleye.***
Research Need: More detailed maps of the littoral zones of Rainy Lake and Namakan Reservoir are needed since this is the depth zone most directly affected by the rule curve changes. Water level regulation affects littoral geomorphology, vegetation, benthos, and fish fauna. On current, bathymetric maps for Rainy Lake and Namakan Reservoir only 1.52 m and 3.05 m depth contours are shown for the littoral zone. Finer scales of bathymetric measurements are needed to assess the effects of the rule curves on habitat availability and quality (e.g. spawning shoals, substrates, nesting areas, etc.)
Recommended Method: Due to the size and complexity of the reservoir basins, bathymetric mapping will need to be focused on selected locations representing the variety of habitats that are present in the reservoirs. Contour intervals no greater than 0.3 m should be established using standard bathymetric surveying techniques.
Suggested Researchers: MNDNR Ecological Services, USGS
Estimated Cost: $75K

***Study – Assess effects of land use changes in the watershed on water quality relative to the effects of the 2000 rule curve changes.***

Research Question: Will land use changes in the watershed and other anthropogenic effects overshadow effects related to the 2000 rule curves? Despite 25% of the Rainy Lake drainage being occupied by parks and wilderness areas, Rainy Lake and Namakan Reservoir like other boreal waters and landscapes, are also being exposed to stressors such as logging, climate change, atmospheric deposition and biological uptake of mercury, and human wastewater discharges. Paleolimnological analysis of diatoms in sediment cores from Namakan Lake and Lac La Croix have shown that European settlement (particularly logging), damming, and hydro-management all impacted Namakan Lake (Serieyssol et al. 2009). At logging, diatom assemblages shifted away from pre-settlement communities. This also occurred in a non-regulated control lake, Lac La Croix. Nevertheless, damming and water-level manipulations on Namakan Lake clearly created physical (increased sedimentation), ecological (decreased species richness and greater inter-sample variability) and water quality (increased TP and conductivity) changes. None of these changes took place in the control lake, Lac La Croix. However, a potential signal of impacts from post-1970s climate change can be identified in both Namakan Lake and Lac La Croix based on diatom community response. Recreational home development within the watershed, particularly in areas adjoining Rainy Lake and Namakan Reservoir, could disturb riparian areas and increase nutrient inputs. Determining the influence of these additional stressors will be difficult since important interactions occur between some of them. Because of this, they cannot be treated in isolation

Recommended Method: Assess the effects of landscape level changes by combining results from remote sensing, existing climatological and hydrological monitoring networks, historical records, limnological surveys, and paleolimnological analysis of sediment cores. A priority should be the development of a centralized database, including the existing models for the watershed, that can be used for analyses and evaluation of different scenarios.

Suggested Researchers: M. Edlund, St. Croix Research Laboratory, A. Patterson, OMOE, J. Snyder, GIS Specialist, Voyageurs National Park

Estimated Cost: $200K

**Category – Birds, Herpetiles, and Furbearers:**

***Study – How have the 2000 rule curves affected mercury concentrations in common loons?***

Research Question: Is the observed relationship between reservoir water levels and mercury concentrations in young of the year yellow perch (YOY) (Sorensen et al. 2005), a primary prey species for loons, also apparent in mercury concentrations in common loons? Results from a three-year study of 14 lakes in northeastern Minnesota found that mercury levels in YOY yellow perch were strongly correlated with annual water level fluctuations with higher mercury concentrations in yellow perch in years with larger fluctuations. It was hypothesized that this was due to increased inundation of organic substrates and resulting inflow from wetland areas. This would suggest that the reduced drawdown on Namakan Reservoir from the 2000 rule curve might, via reduced mercury levels in YOY perch, reduce levels in piscivorous fish and birds, such as the common loon.

Recommended Method: Available pre- and post-rule curve change data for mercury concentrations in yellow perch and common loon can be compared and related to hydrologic data from the same periods. Additional sampling of common loons should be done for comparison with the data from the ongoing sampling and evaluation of mercury in yellow perch.

Suggested Researchers: J. Sorensen, University of Minnesota-Duluth; K. Kenow, USGS-Upper Midwest Environmental Sciences Center
Estimated Cost: $25K

***Study – Map and evaluate the distribution of habitats for marsh nesting birds and herpetiles.***
Research Question**:** What effect have the 2000 rule curve changes had on habitat for marsh nesting birds and herpetiles? It was hypothesized that the 2000 rule curves, through restoration of a more natural hydrologic regime, particularly on Namakan Reservoir, would provide a more natural and structurally diverse macrophyte community that would provide more diverse habitats for aquatic fauna (Wilcox and Meeker 1992).
Recommended Method: The response variable for this would be the quantity/distribution of selected vegetation communities, possibly in selected study areas. Much of the analysis could be done with GIS interpretation of pre- and post rule curve change aerial photos and the use of the Voyageurs National Park's vegetation map (Hop et al. 2001). Those results could then be related to bird and herpetile species diversity and abundance. There is some pre-rule curve change information on relative abundance of some bird species but nothing for herpetiles.
Suggested Researchers: J. Snyder, GIS Specialist, Voyageurs National Park; K. Hop and W. Sadinski, USGS-Upper Midwest Environmental Sciences Center
Estimated Cost: $75K

**Category - Fish**

***Study – Determine if northern pike spawning and nursery habitat and reproductive success has changed due to the 2000 rule curves?***
Research Question: Has the earlier spring rise/summer drawdown in Namakan Reservoir translated into improved spawning and nursery habitat and improved reproductive success for northern pike? The 2000 rule curve, by providing a summer drawdown and an earlier spring rise was expected to expand the range of elevations covered by emergent aquatic vegetation that would be available as spawning habitat, thus improving spawning conditions for northern pike. It would also increase the amount of food and nursery habitat. The latter has been found to be as important if not more important than the availability of spawning habitat in determining northern pike production.

From 2004 to 2006, light traps were used to examine spatial and temporal variation in catches of northern pike fry in potential nursery areas affected by water level regulation in Rainy and Namakan lakes (Pierce et al. 2007). Additional sampling in 2007-08 demonstrated that despite significant variation in the light trap catches, the method holds great potential for assessing the relationship between habitat availability and pike production (R. Pierce, MNDNR, personal communication).
Recommended Method: Sampling for northern pike fry should be conducted each spring on Rainy and Kabetogama lakes using light traps. Light trap results should be compared with results from long term summer seining programs, fall small mesh trap netting, and the MNDNR's long term gillnetting program to assess whether the hydrological changes resulting from the 2000 rule curves have improved pike reproductive success. Pre- and post-rule curve assessment of potential northern pike spawning habitat could be done for known spawning areas using existing aerial photos and by on the ground surveys.
Suggested Researchers: R. Pierce, MNDNR
Estimated Cost: $75K

***Study – Measure critical spawning habitat for walleye on Namakan Reservoir and assess how it has been affected by the rule curve change.***

Research Question: What effect has the 2000 rule curve had on walleye spawning habitat in Namakan Reservoir? It was hypothesized the earlier spring rise in Namakan Reservoir would improve walleye spawning conditions by flooding the spawning beds earlier, while the summer drawdown would rejuvenate lower level gravel and rock spawning substrates by allowing them to be wave washed. Walleye year-class strength estimates from post-2000 MNDNR gillnetting surveys, however, suggest that this may not be happening, particularly in Kabetogama Lake. The assessment of spawning habitat would only be one aspect of a program trying to ascertain what is contributing to reduced walleye recruitment.

Recommended Method: The assessment of walleye spawning habitat should focus on spawning areas identified as part of a walleye tagging study conducted from 1984 to 1986 on Kabetogama Lake. (Kallemeyn 1990). The quantity and quality of gravel and rock spawning substrates should be determined along with their elevational distribution. With this information it will be possible to assess whether these substrates have been flooded at the necessary time by the 2000 rule curves. It should also allow an assessment of whether the drawdown associated with the 2000 rule curve is successfully removing the fine materials and periphyton build-up from the preferred substrates.

Suggested Researchers: MNDNR Fisheries and Ecological Services

Estimated Cost: $75K

***Study – Assess influence of fixed station vs. randomized sampling design on rule curve evaluation results for index netting.***

Research Question: Does the fixed station sampling used in the MNDNR annual netting program provide an accurate enough estimate of the population status of walleye and northern pike to discern the effects of water level management? The MNDNR's Large Lake Assessment program utilizes several sampling methods, but its primary aspect is an annual standardized gillnet survey with the nets being set at the same locations and time each year. These gillnet surveys, which have been conducted annually since 1983 on Rainy, Kabetogama, Namakan, and Sand Point lakes, provide indices of abundance and population parameter related data. Similar sampling is done on Crane and Little Vermilion lakes but only every third and fifth year, respectively. Similar gillnet surveys are conducted by the OMNR in their portions of the border lakes, but not as regularly or in as systematic a manner. Unfortunately, the non-probability fixed station sampling designs limit statistical inferences to the sites sampled and restrict other potential uses of the data (Wilde and Fisher 1996). However, comparing netting results from the fixed stations with those from randomly chosen sites over a number of years could enhance utilization of this large, gillnet survey database. Fish collected in these surveys could also be used to assess changes in growth and condition, both of which could be important indicators of environmental changes resulting from the water management changes.

Recommended Method: Conduct an alternative index netting program based on simple-random sampling design to determine the statistical validity of the fixed station sampling program. Comparison of these results with those from the MNDNR's program over a number of years could enhance utilization of this large, gillnet survey database which dates back to well before the 2000 rule curve change.

Suggested researchers: Section of Fisheries, MNDNR

Estimated Cost: $75K

**Category – Aquatic Vegetation:**

***Study – Determine the long term effects of the 2000 rule curves on the aquatic vegetation communities in Rainy Lake and Namakan Reservoir.***

Key Research Question: What will be the long-term response of the aquatic vegetation communities in Rainy Lake and Namakan Reservoir to the 2000 rule curve changes? The changes in the amplitude and frequency of the water level fluctuations may alter the extent of vegetative cover as well as species and structural diversity. Changes in the plant communities could significantly affect many components of the aquatic ecosystem, including primary and secondary production, thereby influencing food chains, as well as habitats and/or nursery areas for fish, mammals, birds, and invertebrates (Burton 1985). Changes in wild rice abundance, in addition to having biotic effects, may also have economic and cultural repercussions for the First Nation communities.

Wilcox and Meeker (1991) found that in comparison to unregulated Lac La Croix, aquatic plant species diversity and structural form were reduced by the altered hydrology in Rainy Lake and Namakan Reservoir. Because of the relatively minor changes in the 2000 Rainy Lake rule curve, they hypothesized there would be little change in the plant communities on Rainy. Significant changes were projected for Namakan Reservoir, however. Wilcox and Meeker (1991) hypothesized that in Zone 3 (0 –0.25 m below full pool) species that were limited by the sustained flooding under the 1970 rule curve would increase due to the summer drawdown. This may happen by colonization or expansion of contiguous populations. In Zone 2 (0.25-2.0 m below full pool), species richness and stem density of wild rice was expected to increase. Changes in Zone 1 (2.0-3.1 m below full pool) would include increases in submerged and floating obligate aquatics and decrease in mat-forming species. As a consequence, species richness may decline.

To determine if these hypotheses held true, monitoring of plant communities in Namakan Reservoir, Rainy Lake, and Lac La Croix was done in 2001 and 2002 and from 2004 to 2006 with the resulting data being compared with the aquatic vegetation data from 1987 (pre-rule curve change) (Meeker and Harris (In Press). As predicted for Namakan Reservoir, shrubs and other plant species intolerant of prolonged flooding increased in Zone 3. In Zone 2 there was twice the vegetative cover in 2004 and 2006 than in 1987 and 2002. This change appeared to have been caused by some perennial aquatic plants from the tall submergent category responding positively to the rule curve changes. In Zone 1, which was typically dewatered under the 1970 rule curve, the relative importance of mat-forming aquatics decreased while erect or floating aquatics increased.

Although no significant changes were predicted for Rainy Lake because of the minor change in the rule curve, comparisons of pre- and post-rule curve vegetation data showed changes similar to those observed in Namakan Reservoir. The most obvious changes occurred in Zone 1 where there were significant increases in aquatic plant cover. On unregulated Lac La Croix, where there has been a steady contraction in the mean high water level, woody plant taxa along the shoreline has as predicted increased. However in Zones 2 and 1, aquatic cover decreased, unlike in Rainy Lake and Namakan Reservoir.

Recommended Method: Replication of the Meeker and Harris (In Press) methodology in 2011-12 and 2012-13 will extend the robust baseline for aquatic vegetation that has been developed,

and will provide a gauge to measure changes that have occurred over time. Aquatic vegetation should be sampled thoroughly to better define the relationship between the vegetation and water level management. Lac La Croix should continue to be used as a non-regulated control site. .
Suggested Researchers: J. Meeker (Northland College) and A. Harris (Northern Bioscience), USGS-Northern Prairie Wildlife Research Center.
Estimated Cost: $100K

**Category – Benthic Macro-invertebrates:**

***Study – Measure changes in benthic macro-invertebrate communities in relation to the 2000 rule curve changes.***
Key Research Question: What will be the long-term response of the benthic macro-invertebrate communities in Rainy Lake and Namakan Reservoir to the 2000 rule curve changes? Because benthic invertebrates are an integral component of aquatic food webs, disturbances such as water level fluctuations that cause changes in community composition or abundance may alter whole-lake production and trophic efficiency (Vadeboncoeur et al. 2002). The large winter draw-downs that occurred on Namakan Reservoir (2.3 m) under the 1970 rule curves had a negative impact on macro-invertebrates in the littoral zone (Kraft 1988). Mean diversity and equitability values and species richness of invertebrates at depths of 1 and 2 m in Namakan Reservoir were significantly lower than in Rainy Lake in which the average over-winter drawdown was 0.8 m (Kraft 1988). It was concluded that invertebrates were especially vulnerable to desiccation and/or freezing in winter-exposed habitats in the shallows of Namakan Reservoir,

In 2003-05 McEwen and Butler (2008) conducted a before-after control-impact comparison with Kraft's (1988) study to assess what effect the 2000 rule curves, particularly the reduction in the winter drawdown, may have had on the macro-invertebrate communities in the soft sediments. The 2000 rule curves reduced the magnitude of the winter (November 1 – April) drawdown on Namakan Reservoir by about one meter while leaving the Rainy drawdown unchanged. McEwen and Butler (2008) revisited the same sites used in the Kraft (1988) investigation, beginning three years after the rule curve change went into effect. They found lower densities of invertebrates in Namakan Reservoir sites relative to the Rainy Lake sites, with a shift from small to larger bodied invertebrates. Changes were most notable in Namakan Reservoir at 1m and 2m depths. Based on their results, they argued that the observed changes likely resulted from cooler water and lower production under the new regime, coupled with a more stable environment with respect to physical processes involving wave energy and fluctuation.

Further sampling is needed, however, since it is possible that insufficient time has elapsed to produce a more significant response by the benthic community (McEwen and Butler 2008). Additional changes in benthos populations, plus interactions among these organisms and the rest of the lake ecosystem, are likely to occur that will result in greater community changes over time. To obtain a more complete picture of the possible effects of the water level changes associated with the 2000 rule curves will require sampling additional habitats since invertebrates exhibit distinct habitat preferences. For the other habitats, however, comparisons of results from Namakan Reservoir and Rainy Lake with those from naturally regulated reference lakes will be required to determine if the one-meter reduction in the over-winter drawdown on Namakan Reservoir has resulted in the restoration of a more diverse littoral community.

Recommended Method: Replicate methodology used by McEwen and Butler (2008) in 2003-05, but supplement with additional sampling to determine if changes in the aquatic vegetation are contributing to changes in the macro-invertebrate communities. As has been done with aquatic vegetation, use Lac La Croix as a control site to gain a better understanding of the effects of water level fluctuations on macro-invertebrate communities.
Suggested Researchers: M. Butler, North Dakota State University; L. Ferrington, University of Minnesota.
Estimated Cost: $100K

**Category – Economic Interests:**

***Study – Confirm impact of rule curve change on hydropower generation.***
Key Research Question: What have been the actual economic impacts of the 2000 rule curves on hydropower generation at International Falls-Fort Frances dam?
Recommended Method: The companies who operate the dams should be responsible for the initial economic analysis, with the Independent Panel of Experts and the IJC providing oversight and review. The analysis needs to differentiate the effects of the rule curves from those based solely on dam management and market conditions.
Suggested Researchers: Abitibi-Consolidated Hydro Limited Partnership and Boise Paper Solutions.
Estimated Cost: $75K (assume this will be borne by the Companies).

***Study – Economic survey to determine the effect of the 2000 rule curves on resorts on Rainy Lake and Namakan Reservoir.***
Key Research Question: What have been the actual economic impacts of the 2000 rule curves on resorts based on Rainy Lake and Namakan Reservoir? It was hypothesized that the 2000 rule curve for Namakan Reservoir would not only benefit the biological system but would also have a positive economic effect on resorts on the reservoir. The benefits would accrue from the earlier spring rise, which would increase the seasonal availability of docks and boat launches and improve navigation, and the summer drawdown, which would reduce the frequency of damage to docks and shorelines from above normal precipitation, particularly during fall equinox storms. Effects on the resorts on Rainy Lake were projected to be much smaller due to the relatively minor changes in the rule curve.
Recommended Method: An economic survey of the impact of the rule curves on tourism resorts on both Namakan Reservoir and Rainy Lake should be conducted. The survey should be designed so that the results reflect the impacts over several years, rather than just one year that may reflect an extreme hydrologic condition. The survey must focus on discerning the incremental impact of the 2000 rule curves versus the 1970 rule curves, rather than just the absolute impact of the 2000 rule curves. Extension of the hydrologic modelling work accomplished for the 1999 IJC Rule Curve Study for Rainy Lake and Namakan Lake, through 2008, will be useful to determine comparative lake elevation differences under the two rule curve sets. Field surveys using these differences can then be applied at each resort and combined to estimate the overall economic impact to tourism. Because of the differences in the projected hydrological and associated economic effects, survey results from the two systems should be compared to identify other factors that may have influenced the resort economy.

Suggested Researchers: Cooperative Environmental Studies Unit, University of Minnesota; L. Hunt, Center for Northern Forest Ecosystem Research, Lakehead University.
Estimated Cost: $75K

***Study – Assessment of the impacts of the 2000 rule curves on property damages due to flooding and ice.***

Key Research Question: Have the 2000 rule curves resulted in more or less property damage on Rainy Lake and Namakan Reservoir? Prior to the 2000 rule curve implementation, work was conducted to assess the relative change in flood risk that might result from alternative rule curves if compared to the 1970 rule curves (IRLBC 1999). This assessment defined the elevation frequency and elevation-duration curves for Rainy and Namakan lakes, and the discharge-frequency curves for the Rainy Lake outflow. Results from the hydrologic model REGUSE for the period 1958-1996 showed that all the alternatives generally produced a small increase in flood levels on Rainy and Namakan lakes for all event frequencies. Simulated water levels from the REGUSE results were then used to assess potential flood damages. Again, all the alternatives, including one similar to the 2000 rule curves, resulted in increased flood damages with damages occurring in about 20% of the years in the 1958-1996 period. The overall conclusion was that compared to the existing condition the alternatives resulted in relatively small increases in flood levels and Rainy River discharges and did not significantly increase flood risk.
Recommended Method: An economic survey of the impact of the rule curves on flood and ice damage in damage-prone areas should be conducted. The survey should be designed so that the results reflect the impacts over several years, rather than just one year that may reflect an extreme hydrologic condition. The survey must focus on discerning the incremental impact of the 2000 rule curves versus the 1970 rule curves, rather than just the absolute impact of the 2000 rule curves. Extension of the hydrologic modelling work accomplished for the 1999 IJC Rule Curve Study for Rainy Lake and Namakan Lake, through 2008, will be useful to determine comparative lake elevation differences under the two rule curve sets. Field surveys using these differences can then be applied to the damage-prone locations and combined to estimate the overall economic impact on flood and ice damage.
Suggested Researchers: USACE
Estimated Cost: $100K

## RAINY RIVER

**Category – Cultural Resources:**

***Study – Assess effects of water management, particularly the 2000 rule curves on river cultural resources – surveys and hydrological modeling.***
Key Research Question: What specific cultural resources are being affected by the rule curve, and how? "Cultural resources" refers to pre-contact, contact and modern cultures. Archaeological studies in the Rainy River region have found evidence of human settlement dating back nearly 11,000 years. Cultural sites from subsequent Indian cultures have also been identified. Most notable of these are the Grand Mound near the mouth of the Bigfork River in Minnesota and the Kay-Nah-Chi-Wah-Nung or Manitou Mounds in Ontario. The Rainy River, which was first visited by Europeans in the late 1600s, was also an integral part of the Voyageur's Highway during the Fur Trade era in the 1700 and 1800s. The river continued to serve as a transportation corridor during the settlement period, with both people and goods including timber being moved on it. Despite this well recognized historical use, no comprehensive surveys have been done along the entire reach below Fort-Frances/International Falls. Such a survey will be necessary if a thorough job of assessing the effects of water management and in particular the 2000 rule curves on the cultural resources is to be done..
Recommended Method: An ethnographic, archaeological field survey and inventory. This should include lab studies and a literature survey, summarizing information in a GIS database. The data should tie into the GIS and cross-sectional database associated with the USACE hydrological model.
Suggested Researchers: Bill Ross, Thunder Bay; Edgar Oerichbauer, Koochiching County Museum; and Stacey Jack, Pwi-Di-Goo-Zing Advisory Services, Fort Frances.
Estimated Cost: $150K

***Study – How are specific cultural resources being affected by the 2000 rule curves?***
Key Research Question: What effect if any are the 2000 rule curves having on known archaeological sites along the Rainy River. As is the case on the reservoirs, archaeological sites along the river have been subject to erosion as a result of water management activities. Corrective actions such as shore stabilization have taken place at some locations but others remain subject to erosion.
Recommended Method: At a group of known archaeological sites, monitor erosion rates and assess impacts on cultural resources. Compare these data to evidence of erosion in the archaeological (soil) profile. Where ever possible, the data should be tied into the cross-sectional data associated with the USACE hydrological model.
Suggested Researchers: Bill Ross, Thunder Bay; Edgar Oerichbauer, Koochiching County Museum; and Stacey Jack, Pwi-Di-Goo-Zing Advisory Services, Fort Frances..
Estimated Cost : $75K

**Category – Hydrology and Water Quality:**

***Study – Model natural hydrology of the Rainy River (HEC-RAS Model) vs. rule curves.***
Research Question: How have the 2000 rule curves affected the natural hydrology of the Rainy River? Because hydrologic regimes directly affect the composition, structure, and function of

aquatic ecosystems, an understanding of the degree to which the human altered regime differs from natural or preferred conditions is essential.
Recommended Method: Use long-term data and the USACE's HEC-RAS model to develop an estimate of the Rainy River's natural or pre-dam hydrograph. Compare model results with conditions that have been recorded since the 2000 rule curves went into effect. An integral part of this study will be the differentiation of hydrological flow patterns that may result from the rule curve changes from those occurring to benefit hydropower production or some other management program.
Suggested Researchers: Ed Eaton, USACE; Heinz Stefan, University of Minnesota-St. Anthony Falls Laboratory; U.S. Geological Survey; R. Walden, Environment Canada
Estimated Cost: $75K

**Category – Fish:**

***Study – Measure critical fish spawning and nursery habitats and determine how they may be affected by the 2000 rule curves***.
Research Question: Where are critical spawning and nursery habitats in the upper river and how are they affected by water fluctuations and in particular, the 2000 rule curve changes? Hydrologic regimes play a major role in determining the biotic composition, structure and function of aquatic ecosystems (Richter et al. 1996). Dam-related alterations in hydrologic regimes have been shown to adversely affect fish recruitment and benthic fauna (Hynes 1970). Fluctuating ramping rates have been shown to affect food web structure and function in a regulated boreal river (Marty et al. 2008).

O'Shea (2005) identified biologically significant flows and the potential impacts of flow alterations in the lower Rainy River. The study focused on the Manitou and Long Sault rapids, the two primary riffle areas in the lower river. These riffle areas have been identified as important fish spawning and food production areas. Bathymetric and river stage versus discharge data were collected that could be used to assess aquatic habitat conditions at various discharges and that could be used to model hydraulic conditions. Relationships between habitat and discharge for walleye, lake sturgeon and log perch were used to identify in-stream flow prescriptions and to assess the effects of operating the Fort Frances/International Falls dam in peaking mode. Impacts of the altered flows on the natural flow regime were not assessed because stream flow data from prior to the dam did not exist.

A study similar to O'Shea's (2005) needs to be conducted in the upper river, where water flows and levels are likely to be more responsive to releases from the dam at International Falls-Fort Frances. Once the habitat discharge relationships are developed, alternative hydrographs could be compared to the estimated natural or pre-dam hydrograph. A model that estimates the outflows under the 2000 rule curves or alternative curves could then be used to assess the effects on spawning habitat of walleye, lake sturgeon, and log perch.
Recommended Method: This study will require identifying spawning areas of walleye, lake sturgeon, and log perch by field observation, and the measurement of spawning habitat characteristics at different flows and levels. Once this information is obtained, the USACE hydrologic model and GIS can be used to relate flows to available habitat. This information can then be used to assess the possible effects of the 2000 rule curves.

Suggested Researchers: D. O'Shea, MNDNR Ecological Services, MNDNR and OMNR Area Fishery Biologists, USGS-Upper Midwest Environmental Sciences Center
Estimated Cost: $300K

***Study – Measure changes in fish community health (Index of Biotic Integrity) in relation to effects of the 2000 rule curve change.***

Research Question: Has the fish community of Rainy River been healthy since the 2000 rule curve change? All assessments of the Rainy River fish community have occurred since 1909 when the dam at Fort Frances/International Falls was completed. Since then flows in the Rainy River have primarily been controlled by the outflow from Rainy Lake since the Little Fork and Big Fork Rivers, the principle tributaries to the Rainy River, contribute only about 13.7% of discharge recorded at the USGS gage at Manitou Rapids on the Rainy River (Eibler and Anderson 2004). During this period, the fish community has been subjected to manipulations of the historic hydrograph, exploitation by both sport and commercial fisheries, the addition of exotic species, and industrial pollution. Results of a recent paleolimnological study suggests that they like the other components of the Border Waters ecosystem are most likely being exposed to the effects of climate change (Serieyssol et al. 2009).

Prior to 1980, fish sampling on the river was limited. While Eddy et al. (1972) identified 61 fish species as being indigenous to the Rainy River basin, a Minnesota Department of Conservation survey of the fish community of the Rainy River in 1962 found 44 fish species. Two Minnesota Department of Natural Resources surveys in the 1980s yielded 31 and 18 species. Surveys in the 1990s and early 2000s generally focused on the lower river, from the mouth of the river at Wheeler's Pont to Long Sault Rapids (Topp 1997, Stewig 2004).

The first assessment of the fish community in the river from Long Sault Rapids upstream to the dam was done in 2002-03 (Eibler and Anderson 2004). Sampling with trap nets, experimental gillnets, large mesh gillnets, and electrofishing produced 42 fish species. The electrofishing catch data were analyzed using a modified version of the index of biotic integrity (IBI) developed by Lyons et al. (2001) for large (non-wadeable), warmwater streams of the mid-west. This IBI examines 10 metrics and scores them according to how they compare to regional expectations for minimally degraded sites. Scores of 80 – 100 are considered excellent, 60- 79 good, 40 – 59 fair, 20 – 39 poor, and less than 20 very poor (Lyons et al. 2001). IBI scores for 11, one-mile long stations on the upper river ranged from 50 to 80 with scores for nine stations in the good range.

Habitat alterations such as the changes in the timing and magnitude in flows resulting from the 2000 rule curves may invoke four types of fish community response: (1) total fish biomass and production changes, (2) alterations in fish assemblage composition (species richness, the distribution of biomass, and production by species), (3) alterations in the distribution of some or all elements of the fish assemblage in time and/or space, and (4) a response in the non-fish biotic elements of the target ecosystem (Minns et al. 1996). In combination, these four responses generate 16 possible response patterns, and there are eight if the non-fish response is discarded. Given this complexity and the variety of biotic and abiotic factors that may contribute to them, it would appear that the multi-metric approach encompassed in an IBI would be an effective tool for discerning the possible impacts of the 2000 rule curves (Simon 1999).

Recommended Method: Conduct fisheries community surveys and assess indicators of health such as the Index of Biological Integrity, reproductive parameters, growth rates, body and physiological condition, contaminants, etc. Focus on the upper river separately from the lower due to the backwater effect of Lake of the Woods. Also focus on species considered to be resident rather than those that might be migrants from Lake of the Woods.
Suggested Researchers: Minnesota and Ontario Natural Resource Agencies
Estimated Cost: $25K

**Category – Benthic Macro-invertebrates:**

***Study – Identify and measure critical benthic habitats; model changes at cross sections used in the USACE model to assess how the benthic macro-invertebrates may be affected by the 2000 rule curves***.
Research Question: What effects have the 2000 rule curve changes had on the benthic habitats and associated macro-invertebrate communities in the Rainy River? Hydrologic regimes play a major role in determining the biotic composition, structure and function of aquatic ecosystems (Richter et al. 1996). Dam-related alterations in hydrologic regimes have been shown to adversely affect benthic fauna , which historically have served as good indicators of a variety of environmental conditions (Hynes 1970, Rosenberg and Resh 1993). Fluctuating ramping rates have been shown to affect food web structure and function in a regulated boreal river, with macro-invertebrates being more responsive than fish (Marty et al. 2008).

O'Shea (2005) identified biologically significant flows and the potential impacts of flow alterations in the lower Rainy River. The study focused on the Manitou and Long Sault rapids, the two primary riffle areas in the lower river. These riffle areas have been identified as important fish spawning and food production areas. Bathymetric and river stage versus discharge data were collected that could be used to assess aquatic habitat conditions at various discharges and that could be used to model hydraulic conditions. Relationships between habitat and discharge for two invertebrates, the Fat Mucket and Fluted Shell mussels, were used to identify in-stream flow prescriptions and to assess the effects of operating the Fort Frances/International Falls dam in peaking mode. Impacts of the altered flows on the natural flow regime were not assessed because stream flow data from prior to the dam did not exist.

A study like O'Shea's (2005) needs to be conducted in the upper river, where water flows and levels are likely to be more responsive to releases from the dam at International Falls-Fort Frances. Once the habitat discharge relationships are developed, alternative hydrographs could be compared to the estimated natural or pre-dam hydrograph. A model that estimates the outflows under the 2000 rule curves or alternative curves could then be used to assess the effects on the two mussel species and other significant invertebrate species.
Recommended Method: This study, which should be restricted to the area above the Long Sault Rapids to avoid the backwater effect of Lake of the Woods, should examine habitats at both fine and coarse scales. Sampling of both habitats and macro-invertebrates should be done at three of the Abitibi's Environmental Effects Monitoring sites and along the cross-section transects used in the USACE hydrology model. Once this information is obtained, the USACE hydrologic model and GIS can be used to relate flows to available habitat. This information can then be used to assess the possible effects of the 2000 rule curves.

Suggested Researchers: USGS-Upper Mid-west Environmental Sciences Center; M. Butler, North Dakota State University; Environment Canada, Department of Fisheries and Oceans
Estimated Cost: $100K

**Category – Economic Interests:**

***Study – Examine domestic water treatment and fish hatchery data to see if they have been impacted by the 2000 rule curves.***
Research Question: Has implementation of the 2000 rule curves affected the use of water from the Rainy River for domestic purposes or fish hatchery operations? Fort Frances and International Falls intakes for domestic water are located in the reach of the Rainy River that lies above the dam between the two cities. Neither has expressed a concern about the effects of the 2000 rule curves on their operations. Emo, ON is the only community that lies downstream of the dam that relies entirely on the Rainy River for municipal needs. In recent years, its intake was moved closer to shore in deeper water but there are still concerns about the effects of water levels, sediment build up, and in the winter, ice build up. The Rainy River First Nation uses both river and well water in its fish hatchery where the emphasis is on the culture of lake sturgeon, which is classified as a Species of Special Concern in both Ontario and Minnesota.
Recommended Method: Conduct trend analyses of data for water withdrawals for domestic use and fish hatchery operations to assess whether either quality or quantity have been affected by the 2000 rule curves. Additionally, interview plant operators to obtain historical input on factors that may have contributed to variability in withdrawals
Suggested Researchers: Environment Canada, OMOE, Rainy River First Nation.
Estimated Cost: $25K

***Study – Assess impact of the 2000 rule curves on patterns of erosion on the Rainy River.***
Research Question: Have the changes in the timing and magnitude in releases from the International Falls-Fort Frances dam because of the 2000 rule curves affected erosion patterns along the Rainy River? O'Shea (2005) observed only a few, localized areas of erosion, but his observations were limited to the areas of the Rainy River near Manitou and Long Sault Rapids. He did indicate that there were general reports of more severe bank erosion in the areas downstream of Clementson, which is downstream of the two rapid areas. O'Shea (2005) recommended that stream bank erosion be investigated since it is fundamental to the health of the river.

No reach-wide survey of erosion has been completed so before an assessment of the effect of the rule curves can be done it will be necessary to identify reaches of river bank that are either naturally or artificially armoured , un-armoured but stable, or un-armoured and moderately or severely eroding. Fortunately, this background information may also be used in the assessment of the effects of the 2000 rule curves on cultural resources.
Recommended Method: Assessment of the possible effects of the 2000 rule curves on erosion along the Rainy River will require differentiation of the rule curve effects from those resulting from extreme climatic conditions, land use changes in the watershed, as well as dam management based on economic and other non-related factors. To do this, historical precipitation patterns and hydrological conditions need to be compared with those experienced since 2000 to determine their relative effect on erosion along the Rainy River. Changes in land use in the watershed and more active erosion sites along the river can be measured using aerial

photos from both pre- and post-rule curve change. Monitoring of actual bank erosion should be done at transects used in the USACE hydrology model. That linkage will facilitate using the hydrological model to evaluate the impact of the 2000 rule curves on erosion patterns.
Suggested Researchers: USACE, Environment Canada
Estimated Cost: $150K

***Study – Economic survey of impacts on tourism lodging facilities on Rainy River.***
Key Research Question: What have been the actual economic impacts of the 2000 rule curves on resorts based on or using the Rainy River? The Lake of the Woods/Rainy River fishery provides significant economic and social contributions, both to the local residents and the thousands of tourists that visit the area each year. In Minnesota, angling (tourism) generates the largest economic return to Lake of the Woods County, and is a major contributor to the economy of Roseau County. The angling and commercial fisheries in Ontario are also an important part of the local resource based economy. Local First Nations people continue to depend on the fishery as a source of food.

Although the majority of these fishing activities occur on Lake of the Woods, there are significant spring fisheries for walleye and lake sturgeon on the Rainy River (Eibler and Anderson 2004). Summer and fall fisheries also occur in which a variety of species are harvested. A significant portion of the participants in these fisheries are non-locals, many of whom stay in resorts and utilize local businesses. Thus, it is conceivable that changes in river flows and levels resulting from the 2000 rule curves could have a significant economic effect if they altered fish availability and accessibility to the river for the anglers.
Recommended Method: An economic survey of the impact of the rule curves on tourism resorts should be conducted. The survey should be designed so that the results reflect the impacts over several years, rather than just one year that may reflect an extreme hydrologic condition. The survey must focus on discerning the incremental impact of the 2000 rule curves versus the 1970 rule curves, rather than just the absolute impact of the 2000 rule curves. Utilization of the existing Rainy River HEC-RAS hydraulic model (developed by the USACE for the IJC under the International Watersheds Initiative) to model Rainy River water surface profiles for selected years will be useful to determine comparative river level differences under the two rule curve sets. Field surveys using these differences can then be applied at each resort and combined to estimate the overall economic impact to tourism. Portions of the survey could be conducted in collaboration with the creel surveys that are conducted on a regular basis by the Minnesota Department of Natural Resources.
Suggested Researchers: Cooperative Environmental Studies Unit, University of Minnesota; L. Hunt, Center for Northern Forest Ecosystem Research, OMNR, Lakehead University.
Estimated Cost: $50K

## APPENDIX D - WORKSHOP PROCEEDINGS

Attached in its entirety in this Appendix is the report on the "PROCEEDINGS OF THE MARCH 10-11, 2008, WORKSHOP: GAP ANALYSIS OF EFFECTS MONITORING FOR THE 2000 RULE CURVES RAINY LAKE, NAMAKAN RESERVOIR AND RAINY RIVER, A REPORT OF THE 2000 RULE CURVE ASSESSMENT WORKGROUP OF THE INTERNATIONAL JOINT COMMISSION, September 12, 2008".

# PROCEEDINGS OF THE
# MARCH 10-11, 2008, WORKSHOP:
# GAP ANALYSIS OF EFFECTS MONITORING
# FOR THE 2000 RULE CURVES
# RAINY LAKE, NAMAKAN RESERVOIR AND RAINY RIVER

**A REPORT OF THE 2000 RULE CURVE ASSESSMENT WORKGROUP**
**OF THE INTERNATIONAL JOINT COMMISSION**
**September 12, 2008**

(NOTE: This report may be referenced as: W.R. Darby, L. Kallemeyn, E. Eaton, K. Peterson, K. Smokorowski and J. Van den Broeck. 2008. Proceedings of the March 10-11, 2008, workshop: gap analysis of effects monitoring for the 2000 rule curves - Rainy Lake, Namakan Reservoir and Rainy River. Unpublished report prepared for the International Joint Commission by the 2000 Rule Curve Assessment Workgroup, 28 pp.)

# 1. EXECUTIVE SUMMARY

The 2000 Rule Curve Gap Analysis Workshop was held on March 10 and 11, 2008, at La Place Rendezvous on the shores of Rainy Lake in Fort Frances, Ontario. The workshop was organized by a Workgroup of the International Joint Commission, called the "2000 Rule Curve Assessment Workgroup." The intent of the workshop was to conduct a gap analysis of ongoing monitoring projects that were examining the effects of water level rule curve changes for Rainy Lake and Namakan Reservoir that the International Joint Commission had ordered in 2000, and subsequently in a Consolidated Order in 2001. Specific workshop tasks were: to conduct a status check of previous and ongoing studies; to identify and prioritize critical information gaps; to identify "best-bet studies" to fill critical gaps; and to suggest researchers, methods and timelines for the best-bet studies. The workgroup defined "best-bet studies" as research efforts that would most likely measure meaningful system changes from the 2000 rule curves.

Presentations were provided on:

- History of water level management in the Rainy Basin;
- Status check of ongoing studies and other previously identified monitoring categories and components for Rainy Lake, Namakan Reservoir, and the Rainy River;
- List of reports relevant to assessing effects of the 2000 rule curves on the Rainy River;
- Hydrological studies and the HEC-RAS model for the Rainy River;
- Potential effects of flow modifications to the Rainy River based upon impact assessment studies on other river systems; and
- Fisheries and aquatic ecosystem studies to date on the Rainy River.

Best Bet Studies identified for the reservoirs were:

- Develop a spatially explicit hydrologic model for the reservoirs.
- Replicate the recent Meeker and Harris (In Press) study on aquatic vegetation prior to 2015.
- Relate changes in benthic community to the 2000 rule curve change.
- Relate changes in benthos to changes in aquatic vegetation.
- Ascertain whether the 2000 rule curve affected mercury content in bald eagles & common loons.
- Ascertain whether over-winter herpetile survival has been affected by the 2000 rule curve change.
- Determine if pike spawning & nursery habitat changed due to 2000 rule curve.
- Measure erosion impacts on a small number of known archaeological sites.
- Confirm the economic impact of the 2000 rule curve change on hydropower generation.
- Survey the economic impact of the rule curve change on tourism resorts.
- Survey property damages due to flooding and ice resulting from the 2000 rule curve change.

Best-Bet Studies for the Rainy River included:

- Model natural hydrology (HEC-RAS Model) vs. rule curves.
- Examine longitudinal sediment deposit and transport variations with and without the change.
- How do impacts of the 2000 rule curve change on the hydrology of Rainy River compare to natural variability in the flow regime?
- Survey sites of high erosion risk, map in GIS and model effects of rule curve change on erosion.
- Identify & measure critical benthic invertebrate habitats and model changes at river cross-sections.

- Measure benthic community composition over time and look for effects.
- Measure Unionid (mussel) diversity and abundance and compare to pre-change data.
- Measure critical fish spawning and nursery habitats & assess how they have been affected.
- Measure changes in fish abundance (sturgeon, walleye & log perch) and relate to the rule curve change.
- Measure changes in fish community health (e.g. Index of Biotic Integrity) and relate to rule curve change.
- Survey the river for archaeological sites, map in GIS & model hydrologic impacts on the sites, and/or identify benchmark archaeological sites & measure changes; relate to 2000 rule curve change.
- Conduct a literature search for records of archaeological sites & model hydrologic impacts on them.
- Examine Municipal water treatment & hatchery data and examine for water quantity and quality impacts resulting from the 2000 rule curve change.

The workshop participants suggested some "key guiding principles" for the IJC decision-making framework during the 2015 review. The guiding principles were:

- Natural variability and confounding factors (e.g., extreme weather or changes in fishing regulations) may preclude the identification of significant differences in sampling data and the determination of cause and effect relationships.
- Data analyses should include assessment of the effect of extreme weather events and climate change on the behaviour of monitoring data. It may be possible to discern these effects by comparing post-2000 weather and hydrologic data to the historical record. In addition, forecasting models should be used in pro-active and reactive manners.
- The primary source of information for the 2015 review should be data and reports resulting from monitoring studies undertaken pursuant to the 2001 IJC Consolidated Order and the 2000 Rule Curve Plan of Study.
- Secondary sources of information may be studies that indirectly relate to the review, such as: environmental assessments of proposed developments; periodic resource inventories undertaken as normal business of the federal, state and provincial natural resource agencies; and studies undertaken by academic institutions and industries.
- Other sources of information that should be considered during the review are the scientific literature, previous reports (e.g. International Rainy Lake Board of Control,1999; Rainy Lake and Namakan Reservoir Water Level International Steering Committee, 1993) and proposals relating to the 2000 rule curve change, stakeholder input and public consultation results.
- In some cases a cost-benefit analysis may be possible and warranted.
- It may be advisable to have an independent third party review of all evidence to assist the Commission in its review and decision. It may be appropriate for the third-party review to identify options for the Commission to consider.
- The IJC should make its review decision based upon an evaluation of all quantitative, qualitative and expert-opinion evidence, with the intent of striking a fair and reasonable balance among all interests and needs in the basin. This "weight of the evidence" approach will require a conclusion flowing from a statement of judgement.

The Work Group will use these workshop proceedings as essential information and as a guide in writing its plan of study for filling critical information gaps prior to the 2015 review of the rule curves. The Work Group will compare existing monitoring studies with the critical gaps and "best bets" to develop options for the Commission's review.

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# 5. INTRODUCTION

The 2000 Rule Curve Gap Analysis Workshop was held on March 10 and 11, 2008, at La Place Rendezvous on the shores of Rainy Lake in Fort Frances, Ontario. The intent of the workshop was to conduct a gap analysis of ongoing monitoring projects that were examining the effects of water level rule curve changes for Rainy Lake and Namakan Reservoir that the International Joint Commission had ordered in 2000, and subsequently in a Consolidated Order in 2001.

The workshop was organized by a Workgroup of the International Joint Commission, called the "2000 Rule Curve Assessment Workgroup". The members of the Workgroup, and attendance at the workshop, are listed in Appendix 1 (Section 17.1).

The Workgroup's purpose in holding the workshop was: (1) to develop a monitoring and evaluation strategy to assess effects of the 2000 IJC rule curves on the biological and aquatic communities of Rainy River; (2) to conduct a status check and identify critical gaps of ongoing rule curve studies on Rainy Lake and Namakan Reservoir; and (3) to consider the need for socio-economic impact studies.

Results of the workshop also helped the Workgroup develop a science-based decision framework for the IJC to arrive at a socially and ecologically sustainable decision during the 2015 review of the rule curves.

Specific workshop tasks were to:

1. Conduct a status check of previous and ongoing studies;
2. Identify and prioritize critical information gaps;
3. Identify "best-bet studies" to fill critical gaps;
4. Suggest researchers, methods and timelines for the best-bet studies.

# 6. BACKGROUND

## 6.1 The Study Area

The Study Area comprises Rainy Lake, Namakan Reservoir, and the Rainy River, located within the Rainy Watershed, which straddles the border between the United States and Canada (Figure 1).

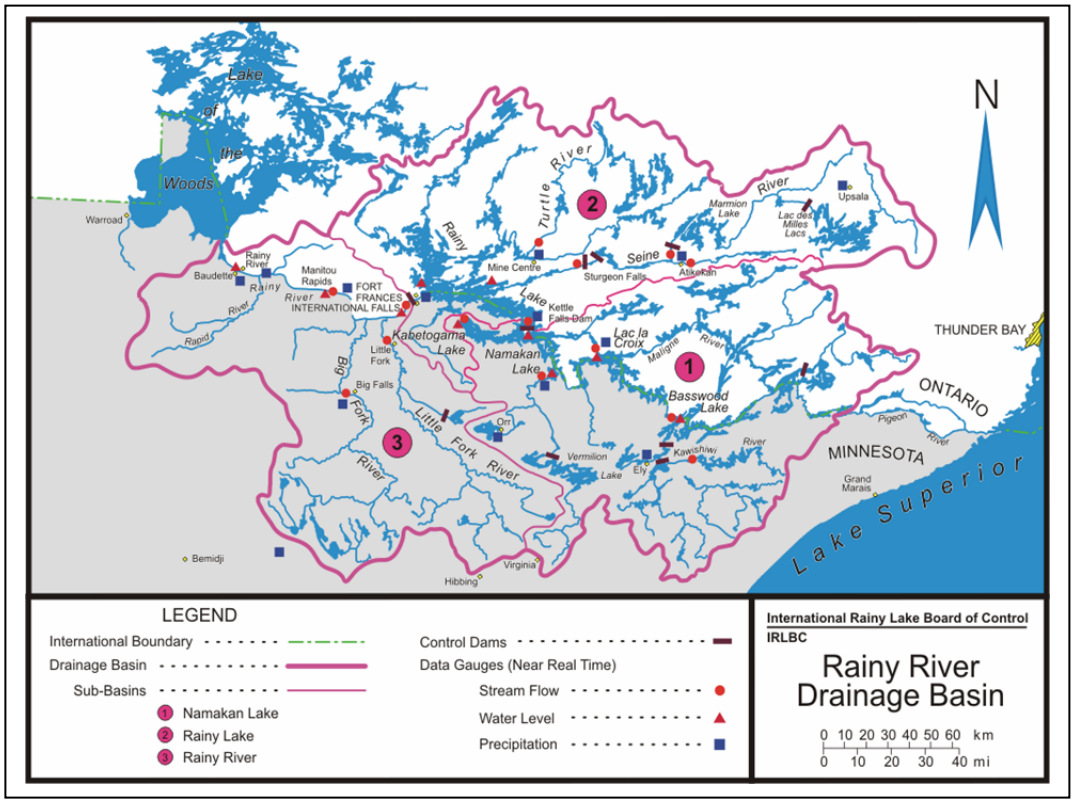



**Figure 1: The Rainy Lake and Rainy River Watershed along the U.S. and Canadian border.**

## 6.2 The 2000 Rule Curves

During the late 1990s, the IJC considered a proposal by an ad-hoc group of American and Canadian citizens (Rainy-Namakan Water Level International Steering Committee, 1993) to revise the 1970 rule curves to be more ecologically friendly. The Commission requested its International Rainy Lake Board of Control to review and report on the matter (IRLBC,1999); it also held public hearings in the basin on the proposal.

On January 5, 2000, the IJC issued a Supplementary Order that revised the 1970 upper and lower rule curves for both lakes, and required that the dam owner/operators, then Boise Cascade LLC in the United States and Abitibi-Consolidated Corporation of Canada ("the Companies"), normally target the middle portion of the rule curve band subject to other direction from the International Rainy Lake Board of Control, and revised the prescribed minimum outflows.

The new curves (Figures 2 and 3) were designed to provide a careful balance between upstream and downstream concerns and among various interests, including environmental concerns, hydropower, flood risk, and boating. The 2000 Supplementary Order took into account that improvements made in previous decades to the water quality of Rainy River allowed lower discharge limits to be established for use during low-flow conditions.

The Commission understood that monitoring programs would be implemented by the resource management agencies to enable the impacts of the 2000 rule curves on the biological and aquatic communities to be identified, and to provide an adequate source of information for future review.

In January, 2001, the IJC streamlined and simplified its various Orders by issuing a Consolidated Order for Rainy Lake and Namakan Reservoir, confirming how the dam operators were to follow the 2000 rule curves and directions related to them. The Consolidated Order was to be subject to review in 2015, or as otherwise determined by the Commission. The review was, at minimum, to consider monitoring information collected by natural resource management agencies and others during the interim that may indicate the effect of the changes contained in the Supplementary Order of January 5, 2000.

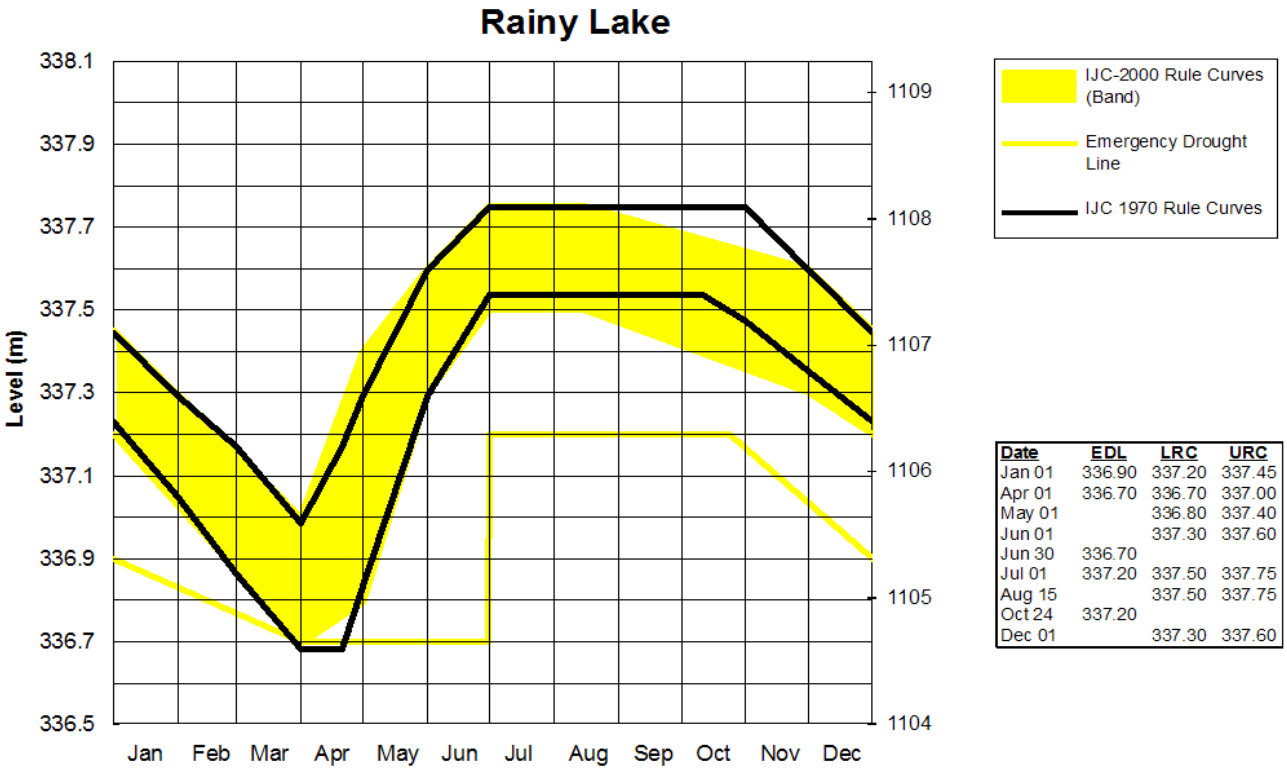
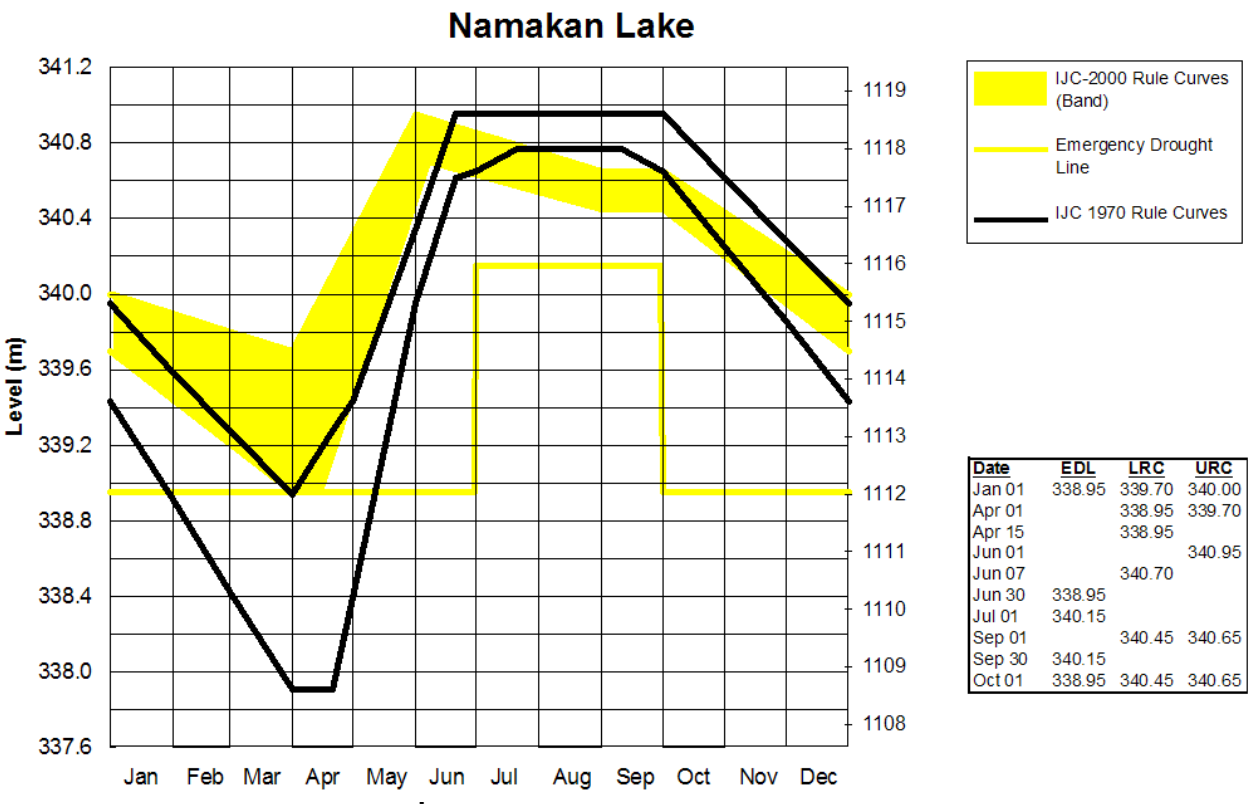



**Figure 2: The 2000 Rule Curve (Band) for Rainy Lake compared to the 1970 Rule Curve.**




| Date | EDL | LRC | URC |
|---|---|---|---|
| Jan 01 | 338.95 | 339.70 | 340.00 |
| Apr 01 | | 338.95 | 339.70 |
| Apr 15 | | 338.95 | |
| Jun 01 | | | 340.95 |
| Jun 07 | | 340.70 | |
| Jun 30 | 338.95 | | |
| Jul 01 | 340.15 | | |
| Sep 01 | | 340.45 | 340.65 |
| Sep 30 | 340.15 | | |
| Oct 01 | 338.95 | 340.45 | 340.65 |

Subsequent to the issuance of the January 5, 2000 Order for Rainy and Namakan lakes, the IJC sponsored a bi-national workshop on ecological monitoring held in International Falls, MN on January 11-12, 2000. The impetus for the workshop came from the Board's recommendation B6 in its Final Report, "Review of the IJC Order for Rainy and Namakan Lakes" (IRLBC, 1999). That recommendation called for monitoring programs implemented by the resource management agencies in accordance with the recommendations of the fisheries and environmental resources experts to enable the impacts of new rule curves on the biological and aquatic communities to be identified, and to provide an adequate source of information for future reviews. The workshop was seen as a first step toward that goal and focused on: (1) defining the scope of a monitoring program, (2) developing monitoring protocols and (3) identifying possible funding mechanisms (Kallemeyn, 2000). A second workshop was held in May 2001 to initiate a pilot study on wetland vegetation monitoring (Szymanski, 2001).

### 6.4 The 2002 Workshop

In February 2002, the Ontario Ministry of Natural Resources Fort Frances District sponsored a workshop to refine the monitoring priorities identified by Kallemeyn (2000) and provide guidance to a newly established monitoring Workgroup. The workshop focus was on ecological monitoring of the aquatic and riparian ecosystems of Rainy Lake and Namakan Reservoir, and did not look at Rainy River; nor did the workshop examine the assessment of socio-economic impacts (Northern Bioscience, 2002).

# 7. 2008 WORKSHOP ORGANIZATION

## 7.1 Overview Presentations

Day One of the 2008 workshop focused on Rainy Lake and Namakan Reservoir and began with presentations by five invited speakers (see Appendix, Section 17.2):

1. Workshop Co-Chair **Bill Darby** introduced the Workgroup members, IJC Board Members, and Facilitator Erika Rivers. Darby explained that the Workgroup was formed by the IJC to develop a Plan of Study to fill critical gaps and develop a decision-making framework for the 2015 IJC review.

2. Facilitator **Erika Rivers** summarized the purpose and intent of the workshop and had the participants introduce themselves, summarizing their position and area of expertise.

3. **Ed Eaton** presented a "Brief History of Water Level Management in the Rainy Basin".

4. **Larry Kallemeyn** summarized the monitoring categories and needs for the Rainy and Namakan Reservoirs that were identified in the 2000 and 2002 workshops. He reviewed the status of studies that have already been completed to address the biological and aquatic information needs, which studies are ongoing, and which are planned. Kallemeyn summarized this list in table format. Some promising aquatic vegetation work has been ongoing since 2001, and a final report is coming out soon. This study needs to be replicated once before 2015. Studies on benthos, shore-nesting birds, furbearers and fish have been done or are ongoing. The northern pike fry abundance studies are yielding some interesting results (Pierce et al., 2007), as are mercury studies in young of the year yellow perch (Sorensen et. al., 2005). The perch studies are showing that the more water levels fluctuate, the higher mercury concentrations in young of the year perch climb.

5. **John Van den Broeck** presented a list of existing reports that is relevant to assessing effects of the 2000 rule curves on the Rainy River.

Day Two of the workshop focused on the Rainy River and began with presentations by three invited speakers:

1. **Ed Eaton** reviewed some recent hydrology studies on the Rainy River, such as Rainy Lake Outflow-Duration Curves and Rainy River Elevation-Duration Curves at Fort Frances, Manitou Rapids, and the Town of Rainy River. Eaton also demonstrated the HEC-RAS hydrological model developed for the River by the U.S. Army Corps of Engineers with funding support from the IJC and technical work by the USGS and a private contractor.

2. **Karen Smokorowski** provided a presentation on potential effects of flow modifications to the Rainy River based upon impact assessment studies on other river systems.

3. **Kevin Peterson** summarized fisheries and aquatic ecosystem studies done on the Rainy River.

### 7.2 Identification of Critical Information Gaps

After the overview presentations each day, the workshop participants were assigned to break-out groups according to area of expertise: (1) hydrology and water quality; (2) aquatic vegetation; (3) benthic macro-invertebrates; (4) birds, herpetiles and furbearers; (5) fish; (6) cultural resources; and (7) economic interests. Each group was asked to first review the list of existing studies, the list of needs from previous workshops, and to identify "critical information gaps" in the monitoring done to date. These critical gaps were written on sheets of paper with markers, and posted on the wall in rows by monitoring subject category. Each group ordered their gaps by priority from left to right and marked the sheets with a priority number. Subsequently, the entire group participated in a "dotmocracy" exercise, wherein each participant was given six dots they could apply to the "gap" sheets of their choice by priority need from their perspective. The lists of gaps, priorities assigned by experts and priorities assigned by the whole group were recorded. Report backs from each group occurred during a large-group session.

### 7.3 Identification of Best Bet Studies

The same break-out groups were then asked to identify "best-bet" studies to fill the high priority information gaps on Rainy Lake and Namakan Reservoir. For purposes of this exercise, the Workgroup defined "best-bet studies" as research efforts that would be most able to measure system changes resulting from the 2000 rule curves. They were asked to identify clear research questions and hypotheses where possible, and to suggest appropriate researchers. Report backs and discussion occurred in a large-group follow-up session.

### 7.4 Key Guiding Principles for the 2015 Review

To wrap up the workshop, a brain-storming session was held in which the participants were asked to identify what they thought should be "key guiding principles" for the IJC decision-making framework during the 2015 review. They were also asked to assess how the "best-bet" studies/monitoring they had identified would fit into those guiding principles.

## 8. CRITICAL INFORMATION GAPS – THE RESERVOIRS

### 8.1 Hydrology and Water Quality

The break-out group for hydrology and water quality identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Need for a GIS-linked hydrodynamic model (high);
2. Information on the historical hydrodynamic context including human-caused influences, such as fire and paleo-developmental history (multiple core sampling) (high);
3. Need for continued monitoring of hydrology and water quality (high);
4. Inflow vs. outflow information, i.e. changes (medium);
5. Nutrient loading information, e.g. residence time (medium);
6. Study of basin complexity (medium);
7. Examination of the potential relevance of studies from the Canadian Department of Fisheries and Oceans Experimental Lakes Area near Kenora, Ontario (medium);
8. Outreach – need to share information with the public; want the public to know (low).

### 8.2 Aquatic Vegetation

Fortunately, work on aquatic vegetation communities was completed on Rainy Lake, Namakan Reservoir and Lac La Croix in 1987 before the 2000 rule curve change (Wilcox and Meeker, 1991). Post-2000 studies have measured aquatic vegetation at the landscape, community and population levels (Meeker and Harris 2004, In Press). Ikonos satellite imagery and aerial photos have been used to conduct landscape assessments. In addition, assessments have occurred on the abundance and patch size of wild rice, and the rates of spread of invasive species.

The only information gap for aquatic vegetation that was considered to be critical by workshop participants was the need to replicate the Meeker and Harris studies in 2011-12 and 2012-13 to measure changes that have occurred over time.

### 8.3 Benthic Macro-invertebrates

In conjunction with the aquatic vegetation studies, there is need to repeat the benthic macro-invertebrate transect surveys for two years (2011-12 and 2012-13). Invertebrates should be sampled thoroughly to tighten observed relationships. *Hexagenia* should be sampled for contaminants. A reference condition approach should be used for analysis (Ontario Benthos Biomonitoring Network).

### 8.4 Birds, Herpetiles and Furbearers

The break-out group for birds, herpetiles and furbearers identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Continue monitoring of common loon productivity (1);
2. Continue annual beaver lodge counts (3);
3. Effects of 2000 rule curve change on herpetiles (5);
4. Monitor beaver body condition (good pre-data) (4);
5. Contaminant analyses of bald eagles – pre & post data available (2);
6. Model available nesting habitat for colonial water birds - inexpensive and easy (low);
7. Model available habitat for muskrats - inexpensive but few animals, data poor (low);
8. Conduct annual muskrat house counts (6).

### 8.5 Fish

The break-out group for fish identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Map northern pike reproductive habitat, i.e. track changes (1);
2. Continue the monitoring of mercury levels in young of the year yellow perch (2);
3. Maintain long-term monitoring of fish communities, especially in relation to northern pike abundance. Include a stratified random design, e.g. North American netting standard (3);
4. Continue deep-water sampling for coregonids (low);
5. Continue creel surveys annually (4);
6. Sample young of the year northern pike with light traps (5).

### 8.6 Cultural Resources

The break-out group for cultural resources noted at the outset that there is no cross-border summary of baseline archaeological data for the reservoirs. The break-out group identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Compile information on all registered known archaeological sites on the reservoirs. In Minnesota the data are in the Office of the State Archaeologist with the Minnesota Historical Society. In Ontario, known sites are registered with the Ontario Ministry of Culture in Thunder Bay or Toronto (low);
2. Search the historical literature for unregistered site references. Conduct interviews with shoreline owners to identify unregistered archaeological sites (5);
3. Compile all known archaeological data (not all known sites are registered) (1);
4. Develop a method to compare the rule curve water level changes to known sites and assess their impact, e.g. pick 12 sites and measure site, bank and water elevations, and assess these elevations with respect to inundation and erosion (3);
5. Conduct archaeological investigations of the mouths of rivers entering the reservoirs, exits, rapids, beaches and points (4);
6. Conduct baseline archaeological surveys of all reservoir shorelines - none done to date (low);
7. Map all archaeological sites and put the information into a confidential geographic information system layer like the OMNR NRVIS system (2);
8. Develop a measure of the error margin for archaeological sites and data (6);
9. Consider the modern context of cultural heritage, e.g. 2000 rule curve effects on bald eagles, turtles, petroglyphs and pictographs (low).

### 8.7 Economic Interests

The economic break-out group identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Tourism – local economic impact study. Has there been an increase in business, e.g. occupancy rates of resorts on Lake Kabetogama in spring? (2);
2. Hydropower – Assess hydropower production losses due to the 2000 rule curve. Green power is now important (1);
3. Flood Damage - Need elevation data for flood-prone properties and property assessment data. In addition, has ice damage increased? (3);
4. Recreational Boating - Has the amount of recreational boating grown? Has there been a change in access issues? Has there been an increase in boat motor damage? (low);
5. Commercial Fishing – Has there been a change in estimated value of the commercial fishery since 2000, and if so, has that value been affected by the 2000 rule curve changes (i.e. whitefish spawning areas)? (4).

## 9. BEST-BET STUDIES – THE RESERVOIRS

### 9.1 Hydrology and Water Quality

Key Research Question: Have hydrodynamics of the reservoirs changed due to the 2000 rule curve changes? Determine how hydrodynamics and circulatory flows have changed historically, and how changes may have affected nutrient interfaces, and aquatic and terrestrial (riparian) habitats.
Recommended Method: Develop a spatially explicit hydrodynamic model that incorporates the different metrics (all components of lake-level studies). This model would be helpful as a research and educational tool because of its ability to visually display relationships and changes. An important consideration is, can we sustain the information collection needed to integrate all the metrics and develop/ensure a good hydrodynamic model to determine the changes the rule curve has created?
Suggested Researchers: This study would require a competent research leader, an hydrologist, a GIS analyst/modeller, and an historian.

### 9.2 Aquatic Vegetation

Key Research Question: The best bet for aquatic vegetation was considered to be replication of the Meeker and Harris (2004) study. This study should be replicated in 2011-12 and 2012-13 to measure changes that have occurred over time.
Recommended Method: Replication of Meeker and Harris methodology. Plants should be sampled thoroughly to tighten observed relationships.
Suggested Researchers: Meeker and Harris.

### 9.3 Benthic Macro-Invertebrates

Key Research Question: Has the benthic invertebrate community in Namakan Reservoir continued to change significantly in response to the 2000 rule curve change? Can changes in the invertebrate communities from 2004-05 to 2011-12 be attributed to changes in the plant communities? Note: continue to use Rainy as reference data.
Recommended Method: Repeat invertebrate methods; use more quantitative plant sampling methods.
Suggested Researchers: Researchers recommended are Len Ferrington for invertebrate taxonomy; Meeker & Harris for plant surveys; and Bruce Kilgore for data analyses.

### 9.4 Birds, Herpetiles and Furbearers

Key Research Question: How has implementation of the 2000 rule curve affected mercury concentrations in bald eagles and common loons?
Recommended Method: This study should complement the existing study of mercury concentrations in yellow perch, in that it would examine effects at a higher trophic level. Pre- and post-data are available; feeding habits are known; and decreased deposition can be controlled.
Suggested Researchers: None provided.

Key Research Question: How has over-winter survival of herpetiles on Namakan Reservoir been affected by the 2000 rule curve change? A challenge for this study is that no pre-2000 data appear to exist.

Recommended Method: Unknown, other than to collect abundance data for indicator species and determine if there are any changes in abundance data over time that may be related to a changed hydrologic regime. Confounding factors that may affect this study may be climate change and other sources of change from outside the basin.
Suggested Researchers: None provided.

### 9.5 Fish

Key Research Question: Has northern pike nursery habitat increased on the Namakan Reservoir since the 2000 rule curve change? Has it changed on Rainy Lake? Has northern pike reproduction/spawning success improved?
Recommended Method: Map northern pike spawning habitat using a geographic information system, and measure changes over time. Aerial photo interpretation can be used to identify historical distributions. A high-cost option would be to map both reservoirs in their entirety. A low-cost option would be to map selected sites/areas. Methods of measuring reproduction/spawning success that will have different cost implications are radio telemetry (high cost); electro fishing and index netting (low cost); and seining (low cost). Assess changes now and in the future, and integrate this study with the aquatic vegetation studies/data.
Suggested Researchers: Natural resource agencies (e.g. Minnesota Department of Natural Resources and Ontario Ministry of Natural Resources).

### 9.6 Cultural Resources

Key Research Question: Compare the impacts of fluctuating water levels on the long-term preservation of cultural resources in prehistoric and historic times to impacts since the 2000 rule curve change.
Recommended Method: Identify a small number of archaeological sites on Rainy Lake and Namakan Reservoir that are sensitive to fluctuating water levels, and monitor the erosion impacts over time. Compare these data to evidence of erosion in the archaeological (soil) profile.
Suggested Researchers: Bill Ross, Edgar Oerichbauer and Stacey Jack.

### 9.7 Economic Interests

Key Research Question: What have the actual economic impacts been on hydro-electric power generation due to the 2000 rule curve changes?
Recommended Method: Have the companies who operate the dams determined the effect on their costs?
Suggested Researchers: Abitibi-Consolidated Hydro and Boise Paper Solutions.

Key Research Question: Have the 2000 rule curve changes had a positive or negative effect on tourism on the reservoirs?
Recommended Method: Simple, statistically valid survey (e.g. questionnaire) of operators of main-base tourism resorts on Namakan Reservoir and Rainy Lake.
Suggested Researchers: None provided.

Key Research Question: Have the 2000 rule curves resulted in more or less property damage?
Recommended Method: Surveys of flood-prone properties.
Suggested Researchers: None provided.

## 10. CRITICAL INFORMATION GAPS – THE RAINY RIVER

### 10.1 Hydrology and Water Quality

The break-out group for hydrology and water quality identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Modelling the natural hydrograph (high - 1);
2. Transport and fate of sediments and nutrients – bed and channel loading and processes; includes reconstruction coring (high - 2);
3. Maintaining and gathering long-term flow data (high - 3);
4. Hydrology model incorporating backwater effects (medium);
5. Assessment of channel stability and floodplains (medium);
6. Historical and current floodplains (medium);
7. Maintaining and installing gauge stations (low).

### 10.2 Aquatic Vegetation

There was no break-out group for aquatic vegetation for Rainy River, because the flows in the Rainy River have historically and presently preclude significant establishment of aquatic vegetation except in back eddies, minor ox-bows and deltas of tributaries. It was anticipated that the fish break-out group would identify information gaps relating to aquatic vegetation as fish habitat (see Section 10.4). However, the benthic macro-invertebrate group identified a critical gap, namely the evaluation of impacts of the 2000 rule curve change on macrophytes (submerged, semi-emergent and emergent), although, the benthic group considered this a low priority in their overall evaluation of research priorities.

### 10.3 Benthic Macro-Invertebrates

The break-out group for benthic macro-invertebrates identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Mapping of critical habitats, flows and sediments and evaluation of the relationship between these factors and the distribution of macro-invertebrates (1);
2. Generate a computer model that can relate the distribution of invertebrates to bottom and sediment type, flow, thermal regime, hydrology, water chemistry, and other factors (2);
3. Conduct Unionid Surveys – Assess impacts of changing levels and flows on the species of concern (e.g. mussel beds vs. flows and water levels, odonate emergence) (3);
4. Continue the ongoing Environmental Effects Monitoring Study done by Abitibi-Bowater on Rainy River – this is important long-term data (medium);
5. Improve thermal data – modeling invertebrate populations of concern (low);
6. Replicate the O'Shea (2005) habitat study immediately below the Fort Frances-International Falls dam (low).

### 10.4 Birds, Herpetiles and Furbearers

There is very little detailed information on the distribution and abundance of birds, herpetiles and furbearers along the Rainy River. Thus, analysis of the impact of the 2000 rule curve changes would be very difficult to conduct even if a significant effort was made to begin collecting such distribution and abundance data in the future. Consequently, the participants believed this river category was not worth discussing at the workshop. For IJC purposes,

limited human and financial resources would be better focused on subject categories that have a better chance of discerning impacts.

### 10.5 Fish

The break-out group for fish identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Identify and map critical spawning and nursery habitats by guilds (1);
2. GIS habitat model with temperature layer, walleye layer, lake sturgeon layer, vegetation layer, etc. (2);
3. Need a water level and flow gauge installed 1/2 to 1 mile downstream of Fort Frances-International Falls dam. Include a temperature logger in the gauge (3);
4. Need to collect substrate data for the 288 cross-sections of Rainy River used in the U.S. Army Corps of Engineers hydraulic model (4);
5. Continue the monitoring of mercury in riverine fish. Evaluate mercury concentrations for a relationship to water levels and the 2000 rule curve changes (low);
6. Expand O'Shea's (2005) in-stream flow model to the tailrace at the Fort Frances-International Falls dam. (5).

### 10.6 Cultural Resources

The break-out group for cultural resources noted at the outset that there is no cross-border summary of baseline archaeological data for the Rainy River. The break-out group identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Basic archaeological survey of the Rainy River & literature search with compilation of the information collected in a geographic information system (2);
2. Identify and compile key known archaeological & cultural sites as benchmark sites (1);
3. Consider the modern context of cultural heritage, e.g. 2000 rule curve effects on bald eagles, turtles, petroglyphs and pictographs (low);
4. Identify the U.S. Army Corps of Engineers cross-sectional data of the Rainy River that is relevant to the benchmark archaeological sites (low);
5. Evaluate the impact of the1970 & 2000 rule curves on erosion of and public access to the benchmark archaeological sites. Also assess current usage of the sites (4);
6. Evaluate impacts of the 2000 rule curve change as they relate to current cultural activities, e.g., navigation to and use of archaeological sites (3).

### 10.7 Economic Interests

The break-out group for economic interests identified the following gaps in order of priority (large-group session dotmocracy priority rankings are shown in parentheses):

1. Erosion may be an issue if there are increased periods of flooding. Perhaps a comprehensive survey is required (3);
2. Water treatment – increased turbidity and organics in water intakes would lead to increased costs. Has this changed? (1);
3. Fish hatchery at Rainy River First Nations – Has there been an impact on the hatchery operation due to a change in spawning period that is water temperature related? (2);

4. Flood damage – is there increased flood damage from ice jams and floods that is due to the 2000 rule curve changes? Examination of this would require development of a contour map (4);
5. Recreation and Navigation – may need to create a navigation map for the river to offset low-water conditions related to the 2000 rule curve change. Are there impacts on road access to the river or on downstream ice roads? The primary impact on recreation will be determined by the status of the fishery (low).

Other additional thoughts of the economic break-out group that were not prioritized were:

- Have the 2000 rule curves changed the pattern of sediment transport and bed load?
- There is need for a better gauge network on the river to acquire adequate data.

## 11. BEST-BET STUDIES – THE RAINY RIVER

### 11.1 Hydrology and Water Quality

Key Research Question: What is the natural hydrograph of Rainy River? How have the 2000 rule curves altered the natural hydrology of Rainy River?
Recommended Method:

- Contingent on intensive long-term data;
- HEC-RAS model of natural hydrograph
- GIS watershed model
- IHA or other stats
- ADLP modelling (KL+H flow) – channel

Suggested Researchers: US Army Corps of Engineers - Ed Eaton & Heinz Stefan (St. Anthony Falls), and the U.S. Geological Survey.

Key Research Question: How do sediment deposition and transport vary longitudinally on the Rainy River at a decadal level of resolution (pre-logging, 1909, 1960, post-1970, 2000)?
Recommended Method: Paleo-riverine core sampling of sediments, and post-settlement alluvium coring.
Suggested Researchers: Karen Gran, Luan Reavie, Claire Bleser and Mark Edlund.

Key Research Question: What is the relative impact of the 2000 rule curves on Rainy River hydrology in a watershed context?
Recommended Methods: Need to use long-term data and perhaps high-resolution imagery. Examine sediment transport from the tributaries vs. rule curve influence. Examine the ameliorative effect of the backwater influence from Lake of the Woods. Watershed landscape changes need to be taken into account.
Suggested Researchers: This needs to be a joint U.S.-Canada effort.

Key Research Question: Have water temperature, dissolved oxygen and total phosphorus loading changed in Rainy River as a result of the 2000 rule curve changes?
Recommended Methods: Develop a method to discern, if possible, 2000 rule curve impacts on flows from other management impacts (e.g., peaking vs. natural variation, and tributary inputs below the Fort Frances-International Falls dam). Need to compile and analyze datasets for water temperature, dissolved oxygen, flows (gauge data), nutrient loading, sediment transportation and deposition, especially at and downstream from tributary mouths. Use the hydrologic model as a base with a GIS layer.
Suggested Researchers: None provided.

### 11.2 Aquatic Vegetation

Since there was no break-out group for aquatic vegetation for the Rainy River, there were no best-bet studies identified.

### 11.3 Benthic Macro-Invertebrates

Key Research Question: What impact has the 2000 rule curve change had on critical habitats for macro-invertebrates?
Recommended Method: Utilize Rainy River hydraulic model and habitat data to examine rule curve impacts. There is need to: examine habitat at fine and course scales; sample invertebrates along Environmental Effects Monitoring (EEM) gradients and representative transects of the hydraulic model database; and develop the corresponding model.

Concepts:

- gradient design – select 3 of 20 EEM sites
- only sample upper reach above Long Sault
- assess channels and select representative sites based on morphology

Assess Habitat:

- course scale
- fine scale - populate hydraulic model (only need x sections); explore side-scan sonar and multi-beam acoustics for field methods.
- photos
- brass ball
- video (Canadian Department of Fisheries and Oceans)

Consider Confounding Factors – Several of Them Exist

- water quality
- peaking
- influence of tributaries

Suggested Researchers: None provided.

### 11.4 Birds, Herpetiles and Furbearers

Since there was no break-out group for birds, herpetiles and furbearers for the Rainy River, there were no best-bet studies identified.

### 11.5 Fish

Key Research Question: Where are critical spawning and nursery habitats in the upper river and how are they affected by water fluctuations and the 2000 rule curve change? For example, are shallow fast-water species favoured in early spring? (low budget)
Recommended Method: Identify spawning locations by field observation. Conduct detailed habitat assessments at different flows. Use the river hydraulic model and GIS to relate flows to habitat.
Suggested Researchers: Ecological Resources Section of the Minnesota Department of Natural Resources – Ian Chisholm; area staff of the natural resource agencies.

Key Research Question: Are there more fish in the Rainy River since the 2000 rule curve change?

Recommended Method: Population abundance surveys of lake sturgeon, walleye and log perch.
Suggested Researchers: Staff of the natural resource agencies.

Key Research Question: Has the fish community of Rainy River been healthy since the 2000 rule curve change?
Recommended Method: Conduct fisheries community surveys and assess indicators of health such as the Index of Biological Integrity, reproductive parameters, growth rates, body and physiological condition, contaminants, etc. Focus on the upper river separately from the lower due to the backwater effect of Lake of the Woods.
Suggested Researchers: Natural resource agencies

### 11.6 Cultural Resources

Key Research Question – (high-cost version): What specific cultural resources are being affected by the rule curve, and how? Cultural resources refers to pre-contact, contact and modern cultures.
Recommended Method: An ethnographic, archaeological field survey and inventory. This should include lab studies and a literature survey, summarizing information in a GIS database. The data should tie into the GIS and cross-sectional database associated with the USACE hydrological model.
Suggested Researchers: Should include an archaeologist, an historian and an ethnographer, with demonstrated expertise and experience on Rainy Lake, Namakan Reservoir, or Lake of the Woods.

Key Research Question - (medium-cost version): How are known cultural resources being affected by the rule curve?
Recommended Method: Identify a series of known archaeological sites to serve as benchmarks; survey and record data on them and monitor changes over time. Measure impacts of erosion on them.
Suggested Researchers: Archaeologists with demonstrated expertise on Rainy Lake, Namakan Reservoir or Lake of the Woods.

Key Research Question (low-cost version): What known cultural resources are within the area affected by the rule curve?
Recommended Method: Search literature and existing registers to compile information on known sites. This option will result in no new data and still no benchmark data.
Suggested Researchers: Archaeologist with demonstrated expertise and experience in the region.

### 11.7 Economic Interests

Key Research Question: Trend analysis of data from water treatment and hatchery operations to assess if there are changes or major issues related to the 2000 rule curves.
Recommended Method: Evaluate data for variability and trends before and after 2000, and interview the operators.
Suggested Researchers: None provided.

Key Research Question: Have there been changes in the pattern of erosion on the river due to the 2000 rule curve changes?
Recommended Method:

- determine historical precipitation patterns vs. those experienced under 2000 rule curves;

- measure bank erosion at long-term monumental cross-sections in the river;
- link to the cross-sections that were used in the hydrological model;
- use the hydrological model to evaluate the impacts of 2000 rule curves on patterns of erosion;
- use aerial photos to assess effects of land use changes on run-off;
- identify factors that contribute to erosion and changes to tributary flows, e.g. human development, agriculture and logging, etc.;
- develop risk analysis method for prioritizing sites susceptible to erosion.

Suggested Researchers: None provided.

## 12. BEST-BET TIMELINES

After identifying the best-bet studies for filling critical information gaps, participants in the workshop discussed timing of those studies in relation to the 2015 IJC review of the 2000 rule curves. The result of this discussion was a Gantt Chart that outlined the years in which best bet studies should be conducted (Table 1).

Table 1: Recommended timing of best-bet studies in preparation for the 2015 IJC review of the 2000 rule curves.

| CATEGORIES AND BEST-BET STUDIES TO FILL GAPS[1] | YEARS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| **Hydrology and Water Quality:** | | | | | | | | |
| Develop a spatially explicit model for all components. | X | X | X | X | X | | | |
| *Model natural hydrology (HEC-RAS Model) vs. rule curves.* | X | X | | | | | | |
| *How do sediment deposit and transport vary longitudinally?* | X | X | X | X | | | | |
| *What is the relative contribution of curve change in watershed context?* | X | X | X | X | X | X | X | X |
| *Survey sites of high erosion risk, map in GIS and model effects of rule curve change.* | X | | X | | X | | X | |
| **Aquatic Vegetation:** | | | | | | | | |
| Replicate Meeker & Harris Study on areas of change. | | | | | X | X | | |
| **Benthic Macro-invertebrates:** | | | | | | | | |
| Relate changes in benthic community to rule curve change. | | | | X | X | | | |
| Relate changes in benthos to changes in aquatic vegetation. | | | | X | X | | | |
| *Identify & measure critical habitats; model changes at cross-sections.* | X | X | X | X | | | | |
| *Measure benthic community composition over time and look for effects (include EEM monitoring data).* | | X | X | X | X | X | | |
| *Measure Unionid (mussel) diversity and abundance - compare to pre-change data.* | | X | X | | | | | |
| **Birds, Herpetiles and Furbearers:** | | | | | | | | |
| How has 2000 curve affected Hg in bald eagles & loons? | X | X | | | | | | |
| How has over-winter survival of herpetiles been affected by the 2000 rule curve change? | X | X | X | | | | | |
| **Fish:** | | | | | | | | |
| Has Pike reproductive & nursery habitat changed due to 2000 rule curve? | X | X | X | X | X | X | X | |
| *Measure critical spawning and nursery habitats & assess how they have been affected.* | X | X | X | X | X | X | X | |
| *Measure changes in fish abundance (Sturgeon, Walleye & Log Perch) and relate to 2000 rule curve change.* | X | X | | | | X | X | |
| *Measure changes in fish community health (e.g. Index of Biotic Integrity) and relate to 2000 rule curve change.* | X | X | | | | X | X | |
| **Cultural Resources:** | | | | | | | | |
| Measure erosional impact on small # sites. | X | X | X | X | X | X | X | |
| *High $: Survey, GIS Mapping & hydrological modeling.* | X | X | X | | | | | |
| *Medium $: Identify benchmark archaeological sites & measure changes; relate to 2000 rule curve change.* | X | X | X | X | X | X | X | |
| *Low $: Literature search to compile known sites & model.* | X | | | | | | | |
| **Economic Interests:** | | | | | | | | |
| Confirm impact of 2000 rule curve change on hydropower generation. | | X | | | | | | |
| Economic survey of impact on tourism resorts on reservoirs. | | X | | | | X | | |
| Survey of property damages due to flooding and ice. | | X | X | | | | | |
| *Water Treatment & Hatchery Data - examine for impacts.* | X | X | X | X | X | X | X | |

1: Best bets in black text refer to Rainy Lake and Namakan Reservoir. Blue text in italics refers to Rainy River.

## 13. KEY GUIDING PRINCIPLES FOR THE 2015 IJC DECISION-MAKING FRAMEWORK

The workshop participants suggested some key guiding principles for the IJC decision-making framework during the 2015 review. They were also asked to consider how the research they proposed may fit into those guiding principles?

The participants identified the following principles:

- Natural variability and confounding factors (e.g., extreme weather or changes in fishing regulations) may preclude the identification of significant differences in sampling data and the determination of cause and effect relationships.
- Data analyses should include assessment of the effect of extreme weather events and climate change on the behaviour of monitoring data. It may be possible to discern these effects by comparing post-2000 weather and hydrologic data to the historical record. In addition, forecasting models should be used in pro-active and reactive manners.
- The primary source of information for the 2015 review should be data and reports resulting from monitoring studies undertaken pursuant to the 2001 IJC Consolidated Order and the 2000 Rule Curve Plan of Study.
- Secondary sources of information may be studies that indirectly relate to the review, such as: environmental assessments of proposed developments; periodic resource inventories undertaken as normal business of the federal, state and provincial natural resource agencies; and studies undertaken by academic institutions and industries.
- Other sources of information that should be considered during the review are the scientific literature, previous reports (e.g., International Rainy Lake Board of Control, 1999; Rainy Lake and Namakan Reservoir Water Level International Steering Committee, 1993) and proposals relating to the 2000 rule curve change, stakeholder input and public consultation results.
- In some cases, a cost-benefit analysis may be possible and warranted.
- It may be advisable to have an independent, third-party review of all evidence to assist the Commission in its review and decision. It may be appropriate for the third-party review to identify options for the Commission to consider.
- The IJC should make its review decision based upon an evaluation of all quantitative, qualitative and expert-opinion evidence, with the intent of striking a fair and reasonable balance among all interests and needs in the basin. This “weight of the evidence” approach will require a conclusion flowing from a statement of judgement.

## 14. USING THE PRODUCTS OF THIS WORKSHOP

The IJC 2000 Rule Curve Assessment Work Group will use these proceedings as essential information and a guide in writing its plan of study for filling critical information gaps prior to the 2015 review of the rule curves. The Work Group will compare existing monitoring studies with the critical gaps and “best bets” to develop options for the Commission’s review. These options may comprise high-, medium- and low-cost combinations of studies.

The options will address information gaps at different levels of intensity and resource requirements. Pros and cons will be identified for each option. This should provide the Commission with some latitude in identifying its preferred approach.

The Workgroup will consider the following in determining the options and/or best approaches for conducting the 2015 review:

- Minimum needs;

- Goals and objectives of the 2015 review;
- Methods and criteria for decision-making during the review (e.g., discrete choice analysis?);
- Identification of adverse and beneficial impacts;
- Who should conduct the review;
- Identification of pros/cons, risks and potential criticisms; and
- Methodology for making the review decision.

## 15. ACKNOWLEDGEMENTS

The Workgroup would like to express its gratitude and appreciation for the considerable efforts of agency staff that made the workshop happen in an efficient and effective manner, and that made these proceedings possible. In particular we would like to thank:

- Erika Rivers (Facilitator), Mike Larson and Dennis Topp (Advisors to the Workgroup) of the Minnesota Department of Natural Resources;
- Patti Collett and Sue Franko of the Ontario Ministry of Natural Resources.

We would also like to thank all the participants of the workshop (Section 17.1) who gave of their time and travelled long distances to contribute their expertise, knowledge and experience to making the products of the workshop useful and appropriate.

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## 17. APPENDICES

### 17.1 Members of the Workgroup, and Attendance at the Workshop

Table 2: Members of the 2000 IJC Rule Curve Assessment Workgroup.

| Name | Affiliation | Location |
|---|---|---|
| Larry Kallemeyn (U.S. Co-Chair) | U.S. Geological Survey (Retired) | International Falls, Minnesota |
| William R. Darby (Can. Co-Chair) | Ontario Ministry of Natural Resources | Fort Frances, Ontario |
| Kevin Peterson | Minnesota Department of Natural Resources | Ranier, Minnesota |
| John Van den Broeck | Ontario Ministry of Natural Resources | Fort Frances, Ontario |
| Karen Smokorowski | Fisheries and Oceans Canada | Sault Ste. Marie, Ontario |
| Ed Eaton | U.S. Army Corps of Engineers | St. Paul, Minnesota |

Table 3: Workshop Participants

| Name | Affiliation | Location |
|---|---|---|
| Jesse Anderson | Minnesota Pollution Control Agency | Duluth, Minnesota |
| Bob Anderson | Boise Paper Solutions | International Falls, Minnesota |
| Kim Armstrong | Ontario Ministry of Natural Resources | Thunder Bay, Ontario |
| Nolan Baratono | Minnesota Pollution Control Agency | International Falls, Minnesota |
| Chris Bazinet | Abitibi Consolidated Hydro LP | Fort Frances, Ontario |
| Claire Bleser | University of Minnesota | Saint Paul, Minnesota |
| Bill Darby | Ontario Ministry of Natural Resources | Fort Frances, Ontario |
| Jeff Eibler | Minnesota Department of Natural Resources | International Falls, Minnesota |
| Geoff Gillon | Rainy River Future Development Corporation | Fort Frances, Ontario |
| Kiley Hanson | Rainy River First Nation | Emo, Ontario |
| Mike Hirst | Lake of the Woods SWCD | Baudette, Minnesota |
| Stacey Jack | Pwi-Di-Goo-Zhing Advisory Services | Fort Frances, Ontario |
| Larry Kallemeyn | U.S. Geological Survey (retired) | International Falls, Minnesota |
| Richard Kiesling | U.S. Geological Survey | Moundsview, Minnesota |
| Mike Larson | Minnesota Department of Natural Resources (Ret'd) | Baudette, Minnesota |
| Ryan Maki | U.S. National Park Service | International Falls, Minnesota |
| Terry Marshall | Ontario Ministry of Natural Resources | Thunder Bay, Ontario |
| Gary Montz | Minnesota Department of Natural Resources | St. Paul, Minnesota |
| Edgar Oerichbauer | Koochiching County HS | International Falls, Minnesota |
| Kevin Peterson | Minnesota Department of Natural Resources | International Falls, Minnesota |
| Rod Pierce | Minnesota Department of Natural Resources | Grand Rapids, Minnesota |
| Cam Portt | C. Portt & Associates | Guelph, Ontario |
| Erika Rivers | Minnesota Department of Natural Resources | Grand Rapids, Minnesota |
| Gary Rogozinski | Abitibi/Bowater | Fort Frances, Ontario |
| Bill Ross | Retired Archaeologist | Thunder Bay, Ontario |
| Karen Smokorowski | Fisheries and Oceans Canada | Sault Ste. Marie, Ontario |
| Dennis Topp | Minnesota Department of Natural Resources | Baudette, Minnesota |
| John Van den Broeck | Ontario Ministry of Natural Resources | Fort Frances, Ontario |
| Tim Watson | Tourist Operator | Kabetogama, Minnesota |
| Steve Windels | US National Park Service | International Falls, Minnesota |

### 17.2 Workshop Presentations

The presentations provided at the workshop are briefly described below. Copies of the presentations may be obtained by contacting the District Manager, Ontario Ministry of Natural Resources, 922 Scott Street, Fort Frances, Ontario Canada, P9A 1J4.:

- Ed Eaton provided a brief history of water level management on the Rainy basin that summarized: the U.S./Canada Treaties, References and Conventions; the control dams; and the IJC, its Rainy Boards and Regulation Orders.

- Larry Kallemeyn provided a status check of ongoing studies and other previously identified monitoring categories and components for Rainy Lake, Namakan Reservoir, and the Rainy River.

- John Van den Broeck presented a list of reports relevant to assessing the effects of the 2000 rule curves on the Rainy River.

- Ed Eaton summarized hydrological studies done on Rainy River and demonstrated the HEC-RAS computer model for Rainy River.

- Karen Smokorowski summarized the potential effects of flow modifications to the Rainy River based upon impact assessment studies completed on other river systems.

- Kevin Peterson reviewed some of the fisheries and aquatic ecosystem studies done to date on Rainy River.