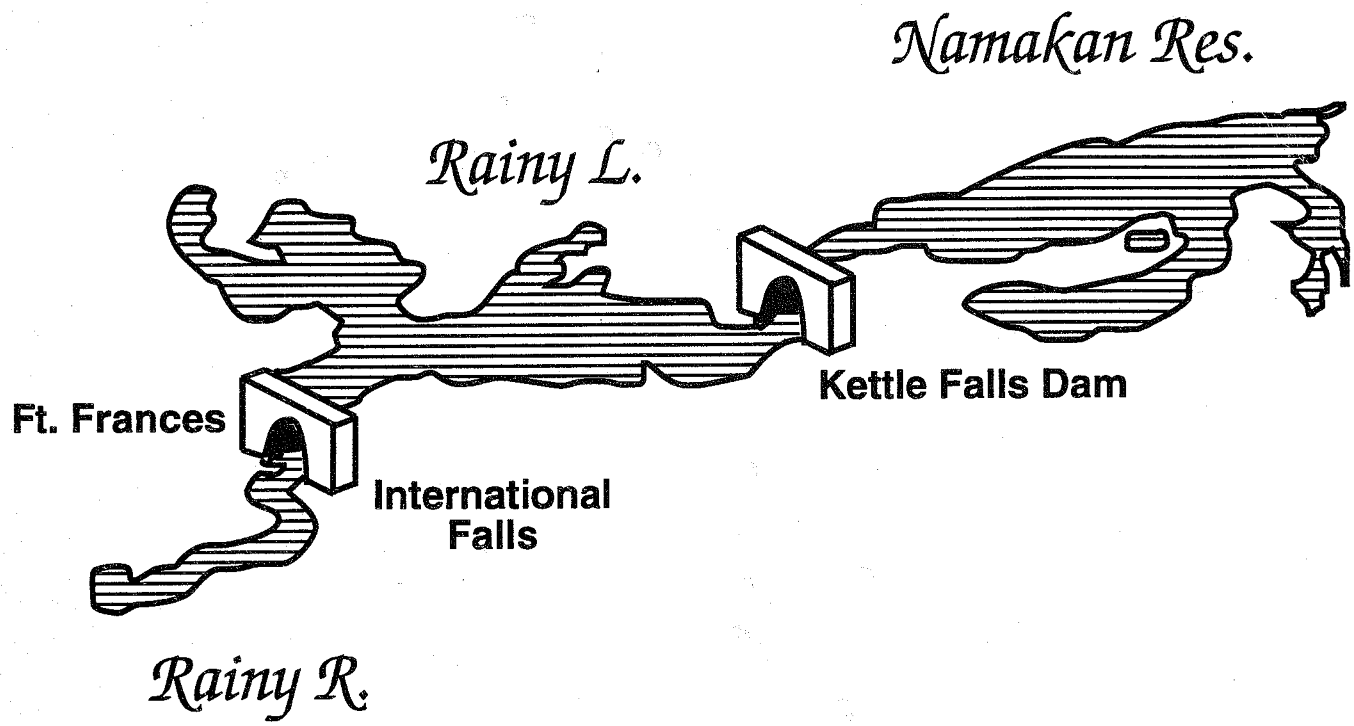
Paul Radomski

Rainy Lake & Namakan Reservoir Water Level International Steering Committee

FINAL REPORT AND RECOMMENDATIONS



NOVEMBER, 1993

ONTARIO, CANADA
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International Joint Commission

Ottawa, Ontario
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UNITED STATES OF AMERICA

Dear Commission Members:

From June 1991 to August 1993, we, the undersigned members of the Rainy Lake/Namakan Reservoir Water Level International Steering Committee, met to analyze the water level management system on the international border waters included in Rainy Lake and the Namakan Reservoir and to see if changes were needed. We concluded that changes to the existing water level management system are warranted, in fact they are necessary to restore the economic and environmental health of the area. Therefore, we are submitting this Final Report and Recommendations, the results of our two-year analysis, to you for your consideration and action.

Throughout the course of our deliberations we have conducted an open process with a high degree of public input and oversight. Government agency and public citizen representatives on our Steering Committee have reached consensus on how water levels should be managed on these reservoirs. We have sought to maximize the benefits of any change to as many interests as possible. We believe that we have achieved that objective.

This document represents our best effort to balance the interests and concerns of diverse and often conflicting users of these international water resources. Our recommendations call for modest but important changes to the water level management system. We expect and welcome further analysis of these recommendations by the IJC and others. We recognize the implications for Canadian and U.S. citizens, as well as the regional economy. We want any changes that are made to be based on the same thoroughness and objectivity that has guided our analysis.

Thank you in advance for your thoughtful attention to our Report and Recommendations.

Paul J. Radomski

Ben Clary

Tim Watson

RAINY LAKE/NAMAKAN RESERVOIR WATER LEVEL INTERNATIONAL STEERING COMMITTEE

FINAL REPORT AND RECOMMENDATIONS

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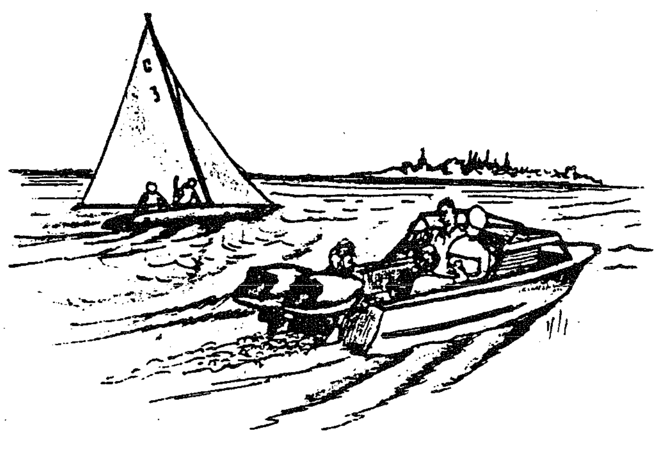
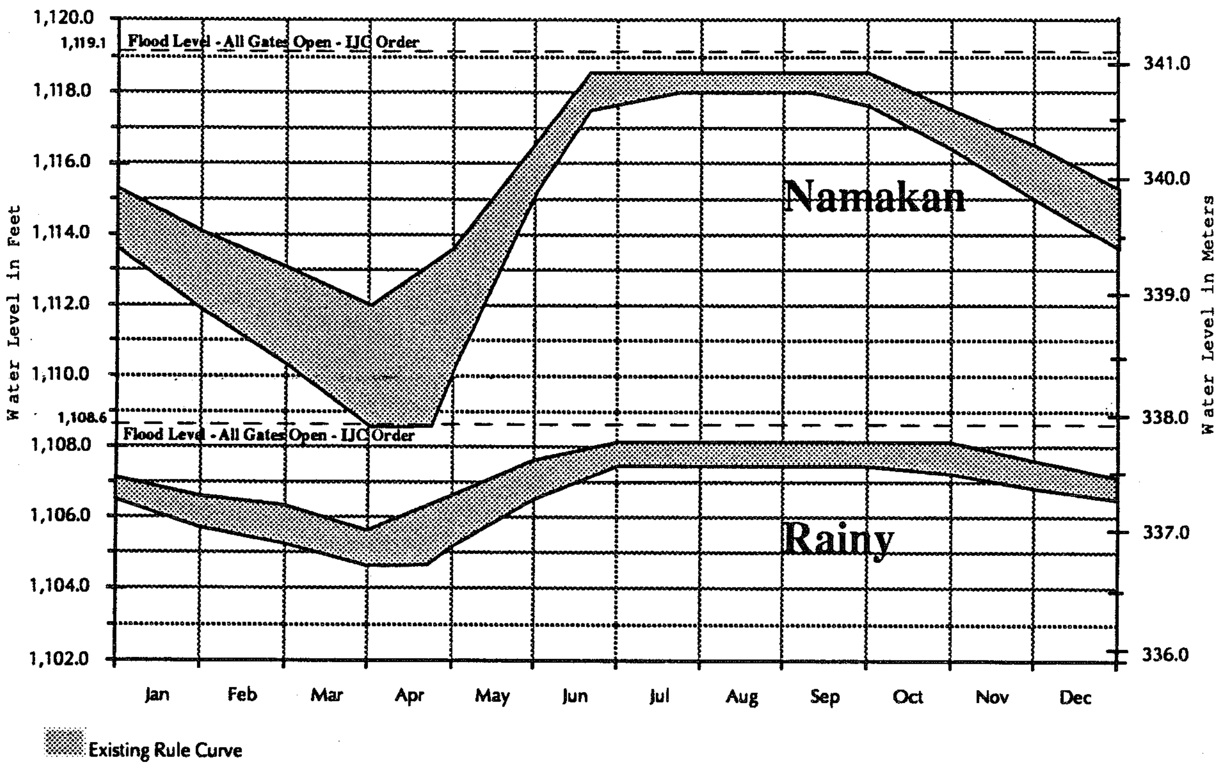
What is the *International Steering Committee*?

The *International Steering Committee* is a voluntary, nine-member group of private citizens, government officials from Canada and the United States, and a Boise Cascade representative. The *Steering Committee* formed in 1991 to analyze the existing water level management system on Rainy Lake and Namakan Reservoirs to see if changes were needed. The *Steering Committee* sought to build on the efforts of others who had recently studied the same system. From the start, the *Steering Committee* committed itself to a comprehensive process involving open dialogue and analysis, frequent and wide-ranging public consultation, and the exploration of a broad scope of concerns regarding use of the Rainy-Namakan watershed.



The *Steering Committee* began with the consideration of the existing water level management system--regulated within **rule curves** established by the International Joint Commission (IJC) and implemented by the Boise Cascade Corporation. Rule curves are the upper and lower water level elevations within which the dam operators must maintain the water levels of the reservoirs at any given time. The IJC has been regulating water level management on this system since 1940. The existing rule curves, one each for Rainy Lake and Namakan Reservoir, were established by IJC Order in 1970.



What things did the *Steering Committee* consider?

The *Steering Committee* realized early on that any changes to a water level management system that people have come to rely on for recreation and property protection cannot be changed drastically. Even though the *Steering Committee* considered some alternatives that involved introducing periodic extreme variations in water levels, those extreme modifications were eliminated after public consultation and debate within the group. Some of the key criteria the *Steering Committee* established to guide its consideration of management modifications included:

- the public does not want an unacceptable risk of flooding, but realizes that some floods are inevitable
- no changes will be proposed that exceed the existing IJC mandated extreme maximums and minimums
- maintain the existing IJC mandated discharge rules
- seek to maximize benefits to as many concerns as possible.

The *Steering Committee* sought a balance among the following concerns:

- navigation
- fish and wildlife
- hydrogeneration
- flooding
- shoreline property
- archaeological features
- aquatic vegetation
- public beaches
- native people's interests
- water quality
- water intake lines
- tourism
- up and downstream impacts

Does the existing water level management system need changing?

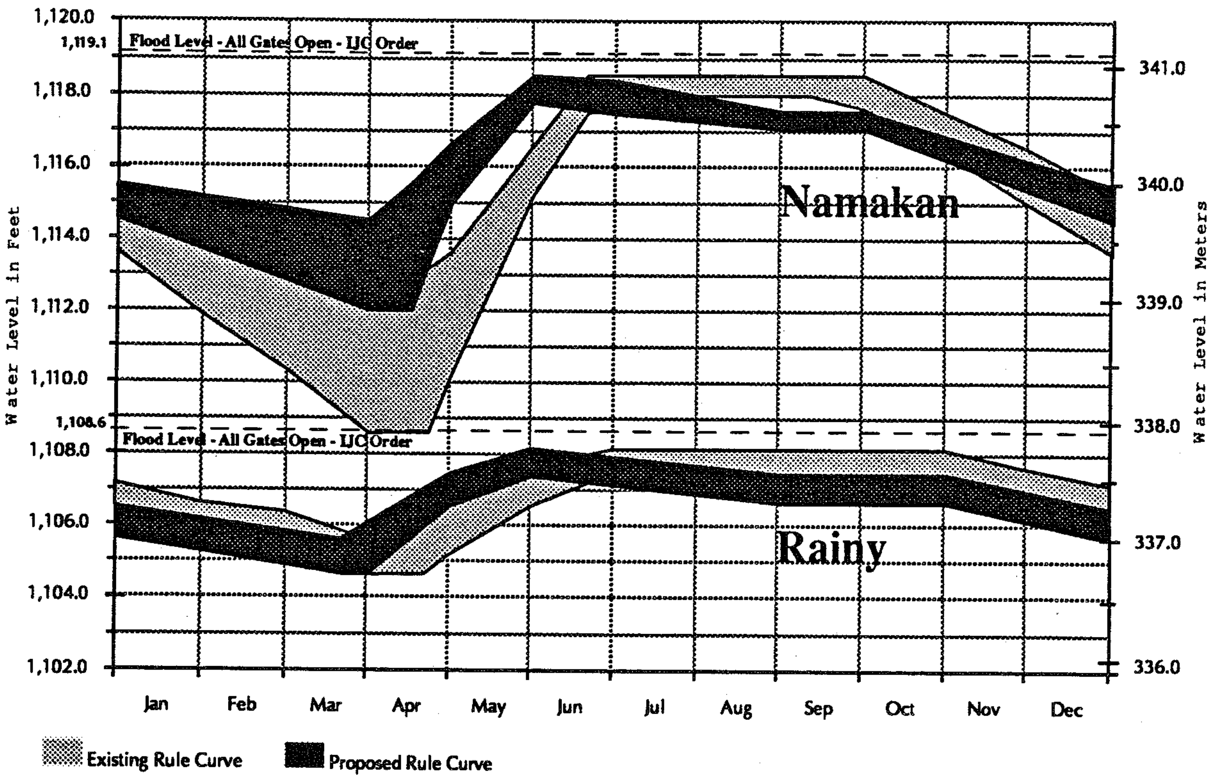
Many studies and reports compiled by the *Steering Committee* indicated that, while the existing rule curves provide advantages for the power generation and spring flood control, they have detrimental effects on fish and wildlife resources and navigation and contribute to the risk of fall high water events. On-going efforts to restore the walleye fishery in Rainy Lake from past overharvesting are significantly hindered by the adverse effects on spawning and rearing habitat from water level changes required by the present rule curve. Rising June water levels on both reservoirs flood vulnerable loon and grebe nests. On Namakan Reservoir, an extreme winter drawdown strands hibernating amphibians and furbearers and exposes incubating fish eggs to winter freezing. And the combination of inadequate spring water levels, high summer levels and extreme winter drawdown deny northern pike access to prime spawning habitat.

Resort operators on the Namakan Reservoir currently lose thousands of dollars worth of business during the weeks after the fishing opener in May waiting for water levels to rise to where boaters can access their docks. Native people on Lac La Croix, who rely on the Loon River for access to businesses and medical care, must wait until spring water levels rise enough to make the river navigable after winter ice-out. Late summer high water levels, while beneficial for hydrogeneration, leave shoreline property and archaeological resources susceptible to the damaging erosion of late summer and early autumn storms.

What does the *Steering Committee* think should be done?

The *Steering Committee* has two primary recommendations.

1. **The IJC should make modest changes in the existing rule curves**, as illustrated below, to help alleviate the existing navigation and environmental problems. These modifications include an earlier rise in spring water levels, stable or declining June water levels, a slight summer drawdown, and a reduction in the amount of overwinter drawdown on Namakan Reservoir.



2. To offset the potential for the proposed rule curve modifications to increase the frequency of spring flood events, **the IJC should enforce the provision of its 1970 Supplemental Order requiring the dam operators to anticipate inflows and maximize the discharge capabilities of the dams to prevent emergency water levels.** The *Steering Committee* believes that diligent use of the existing network of upstream lake level gauges and currently available hydrologic models can make this IJC mandate a reality and improve the accuracy and reliability of reservoir level control.

What would be the impacts of the *Steering Committee* proposals?

The *Steering Committee* expects the following impacts from its proposed rule curve modifications:

<u>BENEFITS</u>

- Improved spring navigation on Namakan Reservoir
- Better spring dock access on both reservoirs
- Improved fish and wildlife habitat
- 30 percent reduction in the number of high water events
- Improved walleye and northern pike spawning
- Improved conditions for whitefish and cisco
- Improved conditions for loon and grebe nesting

<u>SHORTCOMINGS</u>

- Seven percent reduction in hydroelectric generation
- Potential increase in spring ice damage to shoreline structures
- Potential fisheries habitat improvements limited by the need to protect water intake lines on Rainy Lake
- Potential doubling of the number of spring flood events on Rainy Lake [can be mitigated by the recommendation for improved inflow and lake level prediction].

How was the public involved and how did they respond?

The specifics for many of these concerns were obtained by direct input from members of the public. At every *Steering Committee* meeting an opportunity was provided for members of the public to express opinions, ask questions or raise a concern about the *Steering Committee's* work. Native people of the Lac La Croix First Nation were consulted at a special meeting of the *Steering Committee* at the Lac La Croix village. *Steering Committee* members met with special interest group representatives to discuss their reactions to tentative proposals. Rethinking and revisions frequently followed those sessions.

On three separate occasions spread out over the two-year process the *Steering Committee* sent out thousands of brochures and questionnaires to people in the area. Responses to these surveys showed that while many people were concerned about changes, most thought change was needed. Eighty-two percent of the responses obtained through the questionnaires and at public meetings support the *Steering Committee's* proposed rule curve changes. The 15 percent expressing opposition or reservations are mostly concerned about spring flooding and the potential for damage to shoreline structures. A small number were undecided.

Boise Cascade Corporation's response was strongly in support of maintaining the existing rule curves. The company commented that the best way to improve the lakes' fisheries is to modify fish harvests, not water levels.

What has the *Steering Committee* finally concluded?

The *Steering Committee* affirms that to achieve the broad improvements in the entire ecosystem -- fish, wildlife, vegetation and habitat -- the existing rule curves must be modified. Therefore, the *Steering Committee* has concluded that changes to the existing rule curves are warranted -- in fact, they are necessary -- to improve both the environment and economy to the area.

In all its deliberations and analyses, the *Steering Committee* has sought to balance benefits to <u>all</u> users of the lake and reservoir system. Consequently, recommendations and mitigation measures have been carefully formulated with that goal in mind. The *Steering Committee* believes that with its Final Recommendations it has achieved that goal.

How will these changes be made?

The *Steering Committee* proposal will be submitted to the IJC in the fall of 1993 as an application for their consideration. If the IJC concludes, based on its analysis, that the changes are warranted, as the *Steering Committee* has, they can order the companies operating the dams to implement the new rule curves.

The *Steering Committee* believes that its efforts and products demonstrate openness to public opinion, attempt to balance a wide variety of diverse and conflicting uses, and serve as a model for how complex resource management issues can be addressed in a highly effective and cooperative manner across international boundaries.

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RAINY LAKE / NAMAKAN RESERVOIR WATER LEVEL INTERNATIONAL STEERING COMMITTEE

FINAL REPORT AND RECOMMENDATIONS

November, 1993

VOLUME ONE

I. INTRODUCTION

Purpose

This report contains the final recommendations and a summary of the analysis conducted by the Rainy Lake - Namakan Reservoir Water Level International Steering Committee regarding the management of water levels in the Namakan Reservoir and Rainy Lake on the international border in northwestern Ontario and northeastern Minnesota. The Steering Committee is presenting this report to the International Joint Commission (IJC) of the United States and Canada for their evaluation and is seeking their approval of the recommendations.

Background

Recent studies on the environmental and navigation effects of water level management changes on Rainy and Namakan Reservoirs led to the formation of the Steering Committee. Reservoir water levels are controlled by the operation of dams at Kettle and Squirrel Falls for Namakan Reservoir and at International Falls-Fort Frances for Rainy Lake. The dams are operated by a subsidiary of the Boise Cascade Corporation to maintain water levels within limits prescribed by the IJC. Scientific studies of the response of the reservoirs' fish and wildlife resources to water level fluctuations suggested that the existing rule curves, the upper and lower limits within which the reservoir levels must be maintained throughout the year, have had significant adverse effects on the aquatic ecosystem. Furthermore, modifications to the rule curves could have rehabilitative benefits. In addition, members of the public had been appealing to government agencies for rule curve modifications. When Canadian and U.S. resource managers began to consider the implications of potential water level changes to benefit fish and wildlife, they realized that lakeshore residents and other lake users could also be affected by those changes.

With the urging of concerned members of the public, the managers decided to convene a group of citizens and government officials, who along with Boise Cascade, represented the major interests of all users of the reservoir system. This group, the Steering Committee, could analyze the problems, explore possible solutions, and recommend a course of action that would seek a balance between enhancement of the natural resources and maintenance of other important reservoir uses. By combining a broad-based committee with a strong commitment to public consultation, the managers hoped that any recommendations developed by the Steering Committee would have broad substantial public support for implementation throughout the region on both sides of the international border.

Steering Committee Formed

In May 1991 the Steering Committee was formed as a voluntary ad hoc group of nine individuals representing federal government, provincial/state government, private citizens from Canada and Minnesota, and the Boise Cascade Corporation. In keeping with the original concept, the goal of the Steering Committee has been to analyze and make recommendations regarding the management of water levels of the Namakan Reservoir system and Rainy Lake. The study, evaluation and deliberation process conducted by the Steering Committee during this two year period has involved extensive analysis, discussion, public consultation, and review. While several studies of water level management of these reservoirs have been undertaken by others in recent years, none has been as comprehensive in considering all water use interests, nor as aggressive in seeking and responding to the opinions of private citizens who use, live on, and, in some cases, gain their livelihood from these waters, as has the effort of this Committee.

Report Overview

This report is divided into eight major sections. After the Introduction in **Section I**, **Section II** provides background information for the reader who may be unfamiliar with the geography and hydrology of the Namakan - Rainy system and the manner in which water levels are currently managed. **Section III** provides a context for the Steering Committee recommendations by describing the recent efforts of others to modify the existing water level management system and recent U.S. Federal Energy Regulatory Commission re-licensing requirements. This Section also describes in detail how the Steering Committee developed its study process, conducted its analysis, formulated its recommendations, and solicited public opinion. **Section IV** contains the Steering Committee's evaluation of the benefits and liabilities of water level management according to the existing rule curves. The evaluation includes impacts of existing lake level fluctuations on navigation and dock access, aquatic vegetation, fish and wildlife, flood control, tourism, shoreline property and archaeological resources, hydropower generation, and water quality. **Section V** presents the specific recommendations of the Steering Committee for proposed rule curve modifications, operational modifications, monitoring and review, and structural modifications. **Section VI** presents some background information about one of the main tools the Steering Committee used in its analysis -- hydrologic models. **Section VII** describes the positive and negative impacts expected if the Steering Committee's recommendations are implemented. As in Section II, navigation and dock access, aquatic vegetation, fish and wildlife, tourism, shoreline property and resources, hydropower, and water quality impacts are addressed. In addition, this section addresses possible upstream and downstream effects considered by the Steering Committee. Finally, **Section VIII** contains the response of the public to the Steering Committee proposals. The public comments and reactions, both pro and con, that were solicited by the Steering Committee are compiled and discussed.

II. DESCRIPTION OF RESERVOIR SYSTEM AND WATER LEVEL MANAGEMENT

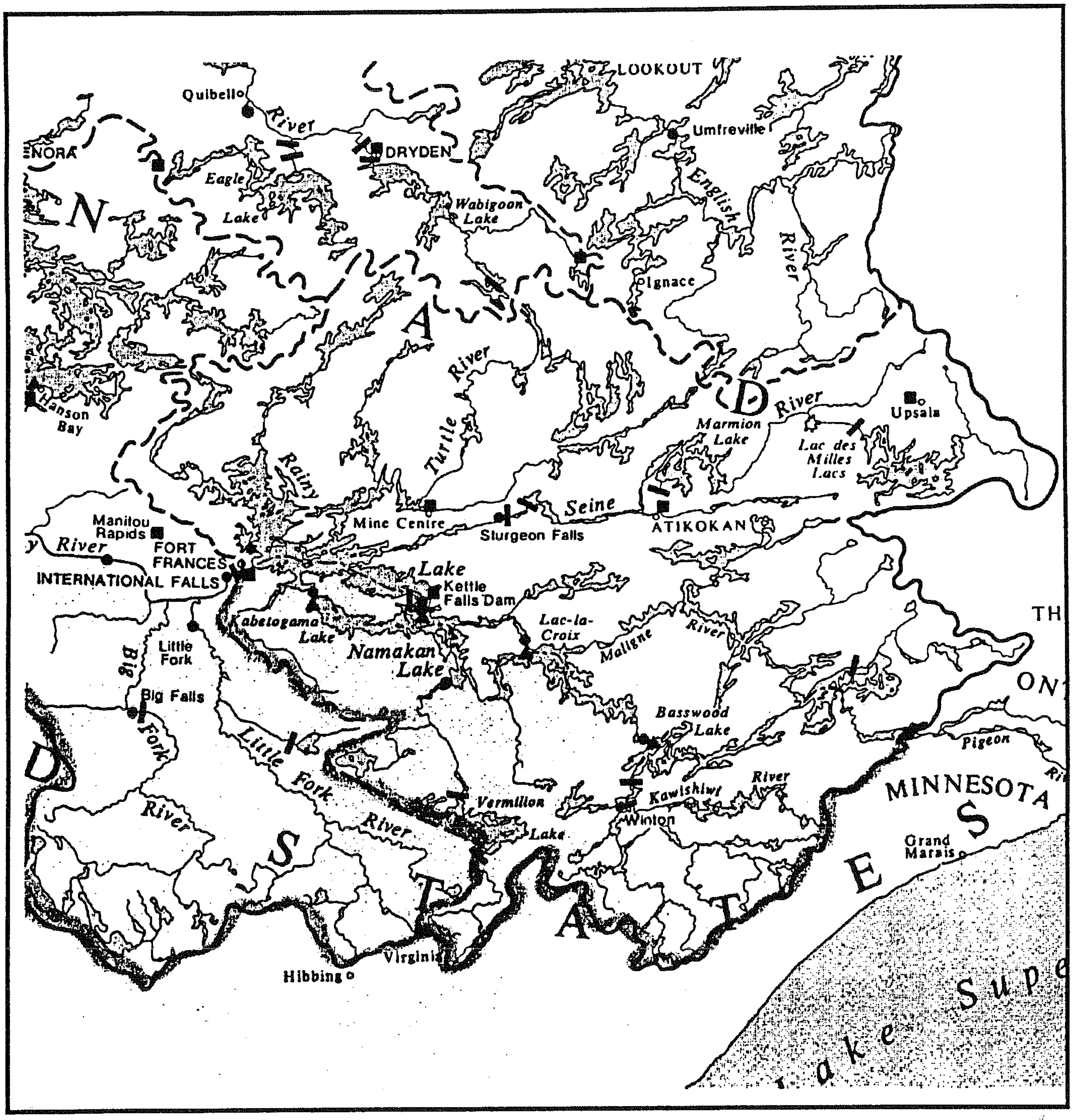
This section describes the basic setting -- geographic, hydrologic and regulatory -- within which the Steering Committee has conducted its evaluation and formulated recommendations for change. Readers who want to learn more about the Rainy Lake watershed, the manner in which the International Joint Commission has regulated reservoir operations, and the existing Rainy Lake and Namakan Reservoir rule curves will find this section helpful.

A. GEOGRAPHIC AND HYDROLOGIC SETTING

The Rainy Lake watershed drains a large area along the Minnesota-Ontario border of some 14,900 square miles (38,600 square km) and is part of the headwaters of the Hudson Bay watershed. Flow through the Rainy Lake drainage is generally in a westerly direction beginning at North Lake, 210 miles (338 km) east of Rainy Lake. Rainy Lake, at the foot of the watershed, is the largest of the principal lakes in the basin, which also includes Namakan, Kabetogama, Sand Point, Crane, Lac La Croix, Basswood, Pickerel and Saganaga Lakes (Figure II - 1). The Seine River and the northern lake system make up another significant part of the Rainy Lake drainage. In general, the entire watershed is forested and is characterized by frequent outcrops of igneous and metamorphic rocks, thin soil cover, and numerous lakes, ponds and connecting channels. The Rainy Lake watershed provides nearly 70 percent of the total inflow to Lake of the Woods.

Average flow at the Rainy Lake outlet for the period 1905 to 1979 was 9805 cubic feet per second (277 cubic meters per second). Flows have ranged between the

FIGURE II - 1
RAINY LAKE WATERSHED



extremes of 35 cubic feet per second (1 cubic meter per second) and 48,144 cubic feet per second (1360 cubic meters per second). The highest flows in the major rivers typically occur during the spring months of April through June.

The portion of the watershed affected by the Steering Committee's recommendations includes the lakes on which the water levels are controlled by dams at International Falls-Fort Frances (Rainy Lake) and Kettle and Squirrel Falls (Namakan Reservoir). These lakes are Rainy, Little Grassy, Grassy, and Shoal, and the Namakan Reservoir which includes Namakan, Kabetogama, Sand Point, Crane and Little Vermilion Lakes. The dams are operated by the Boise Cascade Corporation through its wholly-owned subsidiary, the International Falls Power Company on the U.S. side, and by Boise Cascade Canada on the Canadian side. The operation of the dams is controlled by regulations promulgated by the International Joint Commission (IJC). These regulations set minimum and maximum levels, called rule curves, within which the lakes can be fluctuated, and also provide for minimum flows into the Rainy River.

B. HISTORY OF WATER LEVEL CONTROL

With the construction of the Rainy Lake Dam in 1909 at the site of the former Koochiching Falls between International Falls, Minnesota, and Fort Frances, Ontario, the water level of Rainy Lake was managed for the generation of hydropower. Waterpower provided by the dam was also used directly for grinding wood into pulp for papermaking, and the reservoir provided a source of water for use in the mills which are located on both sides of river. In 1914, dams were constructed at Kettle Falls and Squirrel Falls on Namakan Lake, expanding the Namakan Reservoir. The Namakan dams are not equipped to generate hydropower, but serve to augment the water supply in Rainy Lake.

Over several decades of operation, it became evident that the management of water levels in the Rainy/Namakan system resulted in impacts to navigation and to landowners around the lakes in the form of high and low water effects. Until recently, the impacts of this management on the aquatic ecosystem were not assessed and were given relatively little consideration by water level regulators, even though resource agencies and citizens had expressed concerns about perceived effects.

The first international regulation of the Rainy/Namakan system came in 1940 through the actions of the International Joint Commission. In that year the United States and Canada ratified the Rainy Lake Convention. The 1940 Convention did not define upper or lower limits on water levels, but gave the IJC the power to determine when "emergency conditions" existed in the watershed and to adopt appropriate measures to deal with such conditions. In 1941, the IJC created the International Rainy Lake Board of Control and directed it to examine and report on the issue of emergency conditions.

After detailed study and recommendations by the Rainy Lake Board of Control, the IJC issued the first regulatory controls for the Rainy and Namakan Reservoirs in 1949. The IJC declared that emergency conditions existed on both Rainy and Namakan Reservoirs above and below specified water level elevations, and that the levels should be regulated using the existing control structures, according to the rule curves developed by the Commission. The development of the rule curves and subsequent changes have given primary consideration to hydropower production, the risk of flooding, and summer and fall navigation. The IJC order also specified minimum flows to be provided in the Rainy River below International Falls-Fort Frances when the level of Rainy Lake fell below the rule curve.

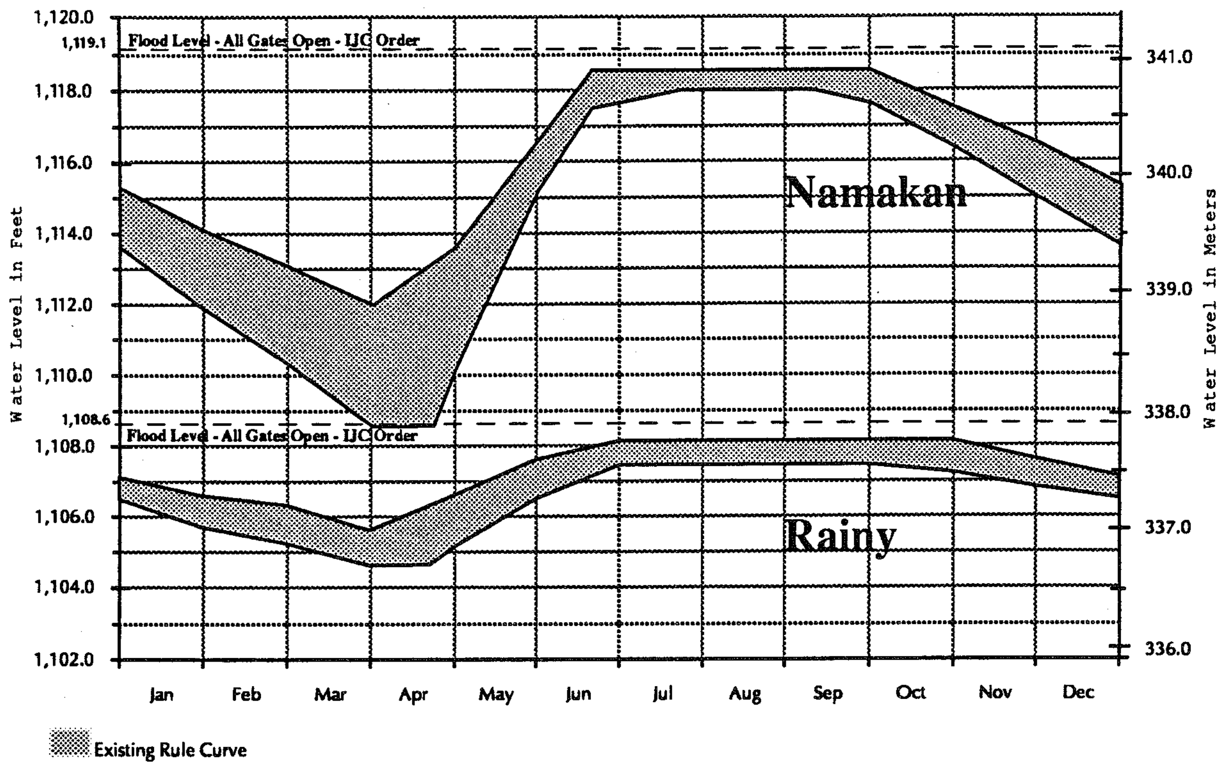
Excessive spring runoff during the years 1950 and 1954 caused both Rainy and Namakan Reservoirs to exceed their respective summer rule curve elevations. Both reservoirs reached their highest levels ever recorded in 1950 -- Namakan at over 1122.5 ft. (342 m) and Rainy at over 1112.0 ft. (339 m). Numerous complaints were lodged with the IJC regarding impacts associated with the high water levels. After an investigation by the Rainy Lake Board of Control, the IJC in 1957 adopted a Supplementary Order which for the most part confirmed the 1949 order, with two exceptions. First, the Commission authorized the Board to vary lake levels from the rule curve elevations at its discretion. Second, it adopted a maximum rule curve for Namakan Reservoir to be used in conjunction with the existing rule curve, thus providing greater flexibility of operation. Maximum allowable elevations on the lake were specified for the period from October 1 to June 1. This provided a band within which lake levels were to be maintained during the fall, winter and spring months.

C. EXISTING RULE CURVES

Because of both high and low water conditions on Rainy and Namakan Reservoirs from 1957 through 1968, the rule curves were violated on many occasions, culminating in the flood levels during July 1968 of 1110.16 feet (338.38 m) on Rainy, and 1121.09 feet (341.71 m) on Namakan. These lake levels resulted in reports of damage to tourist resorts on Crane and Kabetogama Lakes. Therefore, in 1968 the IJC again directed the Rainy Lake Board of Control to investigate the situation. Following the Board's review and recommendations, the IJC issued another Supplemental Order in 1970. The order redefined the levels at which emergency conditions were considered to exist by adding flow criteria to the previous water level criteria, and provided a band for both Rainy Lake and Namakan Reservoir of high and low elevations between which the lake levels must be maintained (Figure II - 2). It also required the operator to anticipate inflows into the lakes so as to prevent the occurrence of emergency conditions, and specified a maximum level for each lake, above which the dams are to discharge at maximum capacity. The order further provided for additional minimum flows in the Rainy River below International Falls. Rainy Lake and Namakan Reservoir have been operated under the 1970 rule curves up to the present time.

The most significant change incorporated into the 1970 order was the provision for year-around operating bands with upper and lower limits for both lakes, giving the operators more flexibility to respond to natural conditions as compared to a single-line rule curve. The 1970 order also delayed the spring refill of the reservoirs, especially Namakan, to reduce high water problems in the spring and to minimize ice damage. The 1970 curve provides high stable summer and fall water levels for navigation, access to docks and constant water supply to water intakes, and provides for fall and winter drawdown for hydropower production and spring flood control.

FIGURE II - 2 EXISTING RULE CURVES



The most significant provisions of the 1970 Order are as follows:

Rainy Lake

1. Emergency conditions exist when
   - water level exceeds 1108.1 ft (337.75 m) and inflow is greater than dam outflow capacity, or
   - water level is less than 1104.6 ft (336.68 m) and outflow equals the dam minimum discharge.
2. The water level is to be kept within the rule curve band (Figure II - 2) in so far as possible.
3. All dam gates are to be opened fully when water level exceeds 1108.6 ft (337.90 m).
4. When water level is less than the lower rule curve, outflow must equal 4000 cfs (113 m^3/s) between sunrise and sunset in May to October inclusive and 3300 cfs (93.4 m^3/s) at all other times.

Namakan Lake

1. Emergency conditions exist when
   - water level exceeds 1118.6 ft (340.95 m) and inflow is greater than the dam's outflow capacity, or
   - water level is less than 1108.6 ft (337.90 m) and outflow equals 1000 cfs (28.3 m^3/s).
2. The water level is to be kept within the rule curve band (Figure II - 2) in so far as possible.
3. All dam gates and fishways to be opened fully when water level exceeds 1119.1 ft (341.10 m).
4. When water level is less than the lower rule curve, dam outflow must equal 1000 cfs (28.3 m^3/s).

Since the 1970 rule curves went into effect, annual lake level fluctuations have averaged 8.9 feet (2.7 meters) on Namakan Reservoir and 3.6 feet (1.1 meters) on Rainy Lake. The fluctuation on Namakan is approximately 3 feet (0.9 meters) greater than the fluctuation that is estimated to have occurred naturally before the dams were built. The fluctuation on Rainy Lake is 2.6 feet (0.8 meters) less than the estimated pre-dam fluctuation. The overwinter drawdown (October to April) on Namakan Reservoir has averaged 7.5 feet (2.3 meters), which is 6.6 feet (2.0 meters) greater than the estimated natural fluctuation for this time period. The overwinter drawdown on Rainy Lake has averaged 2.6 feet (0.8 meters), which is close to the estimated natural fluctuation of 2.3 feet (0.7 meters). The timing of the fluctuations has also been altered under the regulated system, particularly on Namakan Reservoir. Regulated lake levels usually peak in late June or early July rather than late May or early June as they did prior to dam construction, and they remain stable throughout the summer rather than gradually declining.

Water Survey of Canada data for the years 1971 through 1989 show that under the 1970 rule curves, Rainy Lake levels deviated more than two inches above the upper rule curve on 415 days during the 19 year period, or about 6 percent of the time. The Rainy Lake levels deviated more than two inches below the lower rule curve on 938 days during the 19 year period, or 13.5 percent of the time. On Namakan Reservoir, lake levels deviated more than two inches above the upper rule curve on

555 days, or 8 percent of the time. The Namakan levels deviated more than two inches below the lower rule curve on 638 days, or 9.2 percent of the time.

D. EXISTING WATER LEVEL MANAGEMENT OPERATIONS

According to the rule curves, water levels in both reservoirs are drawn down during fall and winter, then allowed to rise in spring and early summer to peak levels that are maintained throughout the summer and early fall. The ability with which the operator of the dams can maintain the lake levels within the mandated limits are a function of several factors. The Rainy Lake Board of Control (RLBC) discussed these factors in its 1984 report to the IJC, Briefing Paper on International Rainy Lake Board of Control and International Lake of the Woods Board of Control.

The report notes that the ability to regulate water levels is a function of the variability and magnitude of the inflows, outflows and losses, and the physical characteristics of the system. With Rainy and Namakan Reservoirs, the ability to stay within the upper limits is constrained by topography, the outflow capacity of the structures, and the machinery available to open the sluiceways. The ability to maintain the lower limits is constrained by the net available inflows, the machinery available to close sluiceways, leakages at the dams, and uncontrolled overflows at Gold and Bear Portages.

The outlets of both of the Namakan Reservoir dams are stop-log structures. The Kettle Falls and Squirrel Falls dams were recently rehabilitated to correct structural deficiencies and make operation easier. However, these dams have no capability for remote operation. At times, crews must be brought in from Fort Frances or International Falls by boat or plane to change the stop-logs. For this reason, discharges are normally not adjusted more than once per week. Consequently, it is not possible to respond immediately to changing inflow conditions, and considerable delay may occur. Also, stop-log structures are conducive to errors when flow changes are made, due to the difficulty in determining the correct number of stop-logs to be added to or removed from a particular sluiceway.

Today it is possible to have a much better picture of existing conditions throughout the basin than was possible in the past, due to the number of stations providing precipitation and streamflow data on a real-time basis. It is doubtful that major inflows would go completely undetected as happened in the past. However, spatial coverage is still limited, inhibiting the estimation of the areal extent and magnitude of events. Also, due to access problems, gauge and telemetry malfunctions may result in missing data for extended periods.

These factors combine to create an imperfect foreknowledge of future inflows on which to base regulation decisions. Because of this, release decisions must of necessity consider the risks of not filling or of overfilling the reservoirs.

III. CONTEXT FOR CHANGE

This section presents the social, scientific and regulatory context for the work of the Steering Committee by describing the recent efforts of others to suggest water level changes to address current shortcomings and the mandate of the U.S. Federal Energy Regulatory Commission to Boise Cascade to develop its own water level management plan. This section contains a detailed description of the Steering Committee's methodology and a summary of the extensive public consultation effort undertaken by the Steering Committee.

A. PAST PROPOSALS FOR CHANGES IN WATER LEVEL MANAGEMENT

The Steering Committee effort represents only the latest of several recent attempts to analyze water level impacts and propose rule curve changes. Other studies, both formal and informal, by the U.S. National Park Service, Mr. F. R. Bokorney, a citizen from Ray, Minnesota, and a group of Crane Lake citizens have resulted in proposed modifications to the existing rule curves.

The most comprehensive effort was conducted by the U.S. National Park Service at Voyageurs National Park. The results of this study are reported in Alternatives for Reducing the Impacts of Regulated Lake Levels on the Aquatic Ecosystem of Voyageurs National Park, Minnesota (Kallemeyn and Cole 1990). This comprehensive study represented the culmination of five years of coordinated research on the correlation between lake level fluctuations and such features as reservoir hydrology, primary biological productivity, fish, furbearers, birds, aquatic vegetation, and boat docks.

The authors proposed a series of thirteen alternative rule curves for both Rainy and Namakan Reservoirs to test the effects of a variety of water level modifications on the various features studied. The authors found that biological factors would be maximized by water level changes that conformed to natural, pre-dam fluctuations. They concluded that one of their thirteen alternatives, designated T8, would "restore more natural hydrological conditions and cause biological conditions to improve on both Namakan Reservoir and Rainy Lake," with acceptable minor adverse impacts on flood risk and hydropower generation (Kallemeyn and Cole 1990). Key features of this proposal are an increase in the Rainy Lake winter drawdown, a decrease in the Namakan Reservoir winter drawdown, an earlier spring rise on Namakan to a lower peak, and a summer drawdown on both reservoirs.

Mr. F. R. Bokorney conducted his own analysis of the water level management problems in the late 1980s and developed a curve for both Rainy and Namakan Reservoirs that has been designated as the Bokorney compromise (1990). Mr. Bokorney was concerned about the need for improved navigability in May and proposed a reduction in the Namakan Reservoir over-winter drawdown and an earlier spring rise to provide safe boat access to commercial docks on the Namakan Reservoir for the mid-May fishing opener. Mr. Bokorney's proposal also provided for a reduction in the summer peak on Namakan Reservoir and a summer drawdown on both reservoirs.

A group of Crane Lake resort operators proposed, in 1990, a rule curve for Namakan Reservoir that would reduce the depth of the winter drawdown and the peak of the summer rise, having the general effect of flattening the Namakan rule curve. This proposal was intended to meet the Crane Lake operators' need for higher spring water level for improved dock access.

In the context of these public and private efforts to promote changes in the management of water levels in the system, the Minnesota Department of Natural Resources (MDNR) and the Ontario Ministry of Natural Resources (OMNR), with funding assistance from Boise Cascade, commissioned a study of the effects of Rainy Lake level fluctuations on the fishery resource (Cohen, et al. 1991). Some of the findings of this report are summarized in Section IV. C. of this report.

However, relevant to this discussion of water level fluctuation proposals was the suggestion that walleye populations would benefit from a greater than proscribed fluctuation on a regular, approximately 5 year, frequency. The authors concluded that such extreme fluctuations had occurred with a similar frequency in the past resulting in a substantial benefit to the lake's walleye fishery.

Because of these, and other, proposals for rule curve changes, there was a high degree of public awareness of the water level management issue, particularly on the U.S. side, in 1991 when the Steering Committee was formed.

B. FERC RELICENSING

Another issue affecting the context within which the Steering Committee began its work was the provision within the U.S. Federal Energy Regulatory Commission (FERC) license for the International Falls Power Company, a subsidiary of Boise Cascade, to prepare a new water level management plan.

On December 31, 1987, FERC issued a 40-year license to the International Falls Power Company, the licensee, to operate and maintain the International Falls Hydroelectric Power Project. This license is subject to the terms and conditions of the U. S. Federal Power Act, regulations of FERC, and various articles set forth in the license. The articles with the most relevance to this report are Articles 401, 402, 403 and 404.

Article 401 states: "The licensee shall operate the International Falls Hydroelectric Project according to the rule curve regulating the level of Rainy Lake as prescribed by the International Joint Commission."

Articles 402 requires that the licensee: "after consultation with the U.S. Fish and Wildlife Service (FWS), the National Park Service (NPS), and the Minnesota Department of Natural Resources (MDNR), develop a water-level management plan for Rainy Lake to ensure the protection and enhancement of water quality, fish and wildlife, and recreational resources in Rainy Lake."

This Article requires consideration of on-going studies by the licensee and stipulates that any recommendations for water level management changes requiring IJC approval must be submitted to the IJC before the plan is submitted to FERC. The plan must include any IJC comments and documentation of actions taken by the IJC. The full text of this Article is reproduced in Appendix B. FERC has granted the licensee until December 30, 1993 to develop and submit the plan required in Article 402.

Article 403 contains guidelines requiring the licensee to maximize water levels within the existing Rainy Lake rule curve for a period of 15 days after spring ice-out to enhance fish spawning. After the 15 days have passed, the operators must allow the water level to rise gradually to the summer lake levels as prescribed by the IJC rule curve.

Article 404 requires the licensee to develop and implement a cultural resources management plan to protect any significant archaeological sites and historic site remnants in the Rainy Lake area, but excluding the national park.

C. INTERNATIONAL STEERING COMMITTEE

1. Formation and Composition

The Rainy Lake/Namakan Reservoir Water Level International Steering Committee is the most recent and comprehensive group to examine the need for change in the management of water levels on Rainy Lake and the Namakan Reservoir. Studies by the Voyageurs National Park staff (1990) and Cohen, et al. (1991), mentioned above, that analyzed the effects of water level management practices on the Rainy/Namakan ecosystem led to the formation of the Steering Committee in May, 1991. Resource managers from Ontario, Minnesota and the National Park convened a small group of individuals representing the broad range of lake users who would meet to evaluate the study results and propose recommended water level management changes to the International Joint Commission.

The preliminary goal of the Steering Committee was to seek more natural hydrological and biological conditions in the reservoirs, while still meeting the needs of the various lake users. After modification by the Steering Committee at its earliest meetings, the goal became a more objective one of analyzing, first of all, the need for a change in water level management and then, if a change was warranted, deciding on modifications that would benefit as many of the users as possible. The Steering Committee met first in June 1991 and continued to meet approximately monthly until the completion of this report.

The membership of the Steering Committee, designed to achieve the objective of a few individuals representing broad interests as well as an international balance, is as follows:

- One Ontario MNR representative, also serving as co-chair;
- One Minnesota DNR representative, also serving as co-chair;
- Two Canadian citizen members;
- Two U. S. citizen members, one of which is a member of the Citizens Council on Voyageurs National Park;
- One Canadian Coast Guard representative;
- One Voyageurs National Park representative;
- One Boise Cascade representative.

A professional facilitator from the Minnesota DNR has presided at Steering Committee meetings. Current Steering Committee members are listed in Appendix C.

2. <u>Process and Schedule</u>

One of the first Steering Committee tasks was to define a process that would guide the work of the Steering Committee in achieving its objectives. The Steering Committee also adopted a set of operating guidelines that served to define its membership, identify its scope and goals and prescribe its decision-making procedures. These documents are included in Appendix C of this report.

3. Analysis and Development of Rule Curve Modifications

The Steering Committee adopted a methodology that included three primary steps for the formulation of its recommendations: 1) establish guidelines within which alternatives would be considered, 2) identify several single purpose rule curves that each maximize benefit to a particular water use or feature, and 3) combine the single purpose curves into one curve for each reservoir that would provide optimum benefits for the most uses.

In order to provide appropriate parameters and priorities within which to consider new water level management options, the Steering Committee first established some guidelines and criteria. These guidelines and criteria were based on the results of early public consultation.

(a) The public does not want an unacceptable risk of flooding. However, it is recognized that some flood events are Acts of God and beyond the control of the management system.

(b) The Steering Committee will not propose any curve that goes above or below existing IJC maximums or minimums, including maximum and minimum discharge rates.

(c) Upstream and downstream impacts must be considered.

(d) The physical and operating limits of the dams must be taken into account.

(e) The existing IJC rules must be considered.

(f) The Steering Committee will strive for the greatest benefits to as many concerns as possible.

The concerns listed by the Steering Committee included the following (not in any order of priority):

- navigation (power boating, sailboating, snowmobiling), including Loon and Ash River access
- fish and wildlife
- hydropower production
- flooding
- damage to shoreline property and archaeological resources

- aquatic vegetation, including wild rice
- public beaches
- archaeology sites
- Native peoples' interests
- water quality
- domestic water intake lines
- tourism
- upstream and downstream impacts

The second step was for the Steering Committee to identify a series of different rule curves or management objectives that would maximize benefits to the various users and features listed above. Each single purpose curve showed the annual water level changes that maximized benefits to a single use or user, as suggested from information obtained by the Steering Committee. The Steering Committee examined the similarities and differences of these curves to gain a better understanding of the ways in which need for certain water level regimes compete with one another. The single purpose curves are shown in Figures G-1 through G-5 (Appendix G). Several of the curves were compared to the estimated average pre-dam curves (Figure G - 6) to gain perspective on natural lake level fluctuations.

The third step was for the Steering Committee to search for similarities in the single purpose curves that would improve existing management for a majority of users. This process was facilitated by overlaying the various single purpose curves on the same graph (Figure G - 7). Areas of overlap obviously represent a consensus for water levels that provide more than one benefit. However, intensive discussion, negotiation, compromise and good will was required to develop acceptable modifications that would meet the Steering Committee guidelines and criteria. The rule curves developed by means of this process are presented in Section V.A.

D. PUBLIC CONSULTATION

From the beginning the Steering Committee has recognized the need for and pursued extensive public consultation with a variety of lake users. The Steering Committee conducted the following activities:

- provided a scheduled Public Input Time at each regular Steering Committee meeting to receive comments and respond to questions from the interested public;
- prepared an introductory public information brochure on the nature and purpose of the Steering Committee and then a more detailed brochure seeking public reaction to previous proposed rule curve changes;
- the co-chairs made themselves available for local radio and newspaper interviews regarding the nature and purpose of the Steering Committee;
- Native people were consulted at special meetings with local First Nations;
- the entire Steering Committee traveled to Lac La Croix in May 1992 to meet with the Lac La Croix First Nation to listen to First Nation concerns and to present preliminary findings regarding the impacts of possible water level management changes;
- Ontario MNR and Minnesota DNR officials conducted field surveys of Loon River navigation problems in late May 1992;
- Steering Committee members conducted over 30 public consultation meetings on the water level issue. Approximately 20 were held from August 1992 to February 1993;
- issued a third public information brochure in November 1992 identifying the Steering Committee's draft proposed rule curve modifications and seeking citizen comments.

The results of these public consultation efforts are presented in Section VIII.

IV. EVALUATION OF THE EXISTING WATER LEVEL MANAGEMENT SYSTEM

This Section presents the results of the Steering Committee's evaluation of the effects of water level management according to the existing rule curves on navigation and dock access, aquatic vegetation, fish and wildlife, tourism, flood control, shoreline development and archaeological resources, hydropower generation and water quality.

A. NAVIGATION AND DOCK ACCESS

1. Navigation

The effects of the regulation of Rainy Lake water levels extend across the entire lake, as well as affecting flows in the Rainy River from International Falls to Lake of the Woods and having a slight effect on levels in Lake of the Woods itself. The effects of the regulation of Namakan Reservoir at Kettle Falls and Squirrel Falls extend upstream to Loon Portage on the lower Loon River, a tributary to Namakan Reservoir.

Spring-time navigation by boat and motor up Loon River from Little Vermilion Lake is quite difficult until the reservoir reaches 1117 feet above sea level (340.5 m) as measured at the Kettle Falls dam. Under the existing rule curve this water level is not attained until the second or third week of June. The navigation problems are most troublesome at Loon Narrows where there are extensive mud flats, and at "56 Rapids" another mile and a half (2 km) upstream. Passage is difficult at "56 Rapids" until water levels reach 1117 feet (340.5 m) after which the rapids can be run, unless river flow is low due to drought.

People of the Lac La Croix First Nation, tourism businesses and recreationists use the Loon River for navigation between Crane and Sand Point lakes and isolated parts of the upper watershed on Loon Lake and Lac La Croix. They travel this route for personal, business and recreational reasons. Some businesses, particularly the mechanical portage businesses on Loon River, rely on this traffic for a major portion of their income. But the problem is most critical for people of the Lac La Croix First Nation.

The Lac La Croix band has indicated to the Steering Committee that restriction of boat access via the Loon River affects their livelihood, their safety with regard to medical emergencies, and their cost of living. The movement of anglers upstream to Lac La Croix tourism resorts from Crane Lake is also important to their livelihood. This is because a majority of men in the Lac La Croix First Nation are employed as fishing guides at those resorts.

Similar problems with low water for springtime navigation exist on Ash River at the east end of Lake Kabetogama. This affects seven tourism businesses on the river including a houseboat rental business, residents, cottagers and recreationists.

While navigation problems occur on Namakan Reservoir in the spring, the stable high summer and fall water levels provide additional navigation routes in some backwater channels.

Historically, the stable summer and fall water levels facilitated the booming of logs and navigation of large tugboats through shallow channels and bays. This practice ceased in the mid-1970s and is no longer a relevant factor.

2. Dock Access

There are severe dock access problems because of low spring water levels on the Namakan Reservoir. The resort communities on Lake Kabetogama, Ash River and Crane Lake (more than 50 resorts) have constructed large docks and waterfront development based on the 1970 rule curve which established the high water level or emergency conditions at 1118.6 feet (337.9 m). Since that time, there have only been four years when water levels were high enough to allow use of most docks on the Namakan Reservoir for the fishing season opener in mid-May.

Because of the large overwinter drawdown and slow rise in elevation during the spring with the existing rule curve, as few as 4.8 percent of these docks have a foot or more of water by May 1 and only 36.5 percent have that much water by the fishing opener around May 15, if lake levels are at the bottom of the rule curve. Approximately 25 percent of the docks would still not have at least one foot (0.3 m) of water by that date even if the water level were at the top of the existing rule curve. It is after June 1 before some docks are accessible. Not only does this seriously impact the resorts, but it is a major inconvenience for residents, cottagers and recreationists on all lakes of the reservoir.

Because of the smaller fluctuation on Rainy Lake, the impact is less drastic with only 20 percent having less than a foot of water by May 1 and all docks being accessible by June 1. Even if water levels on Rainy Lake are at the bottom of the rule curve on May 15, 90 percent would have at least one foot (0.3 m) of water. The Rendezvous and Rainy Lake Yacht Clubs have indicated that low water levels on Rainy Lake in spring make maneuvering for launching and docking difficult if not impossible for keeled boats in shallow bays. In Sand Bay at Fort Frances, all boaters commonly have spring-time dock access problems.

There are generally not problems with dock access due to low fall water levels except during periods of drought when dam operators are not able to maintain water levels within the rule curves.

B. AQUATIC VEGETATION

The type of aquatic plant community determines the characteristics of fish and wildlife habitat, i.e. aquatic plants provide food and shelter for invertebrates, fish and wildlife. For example, diverse, abundant aquatic vegetation provides a diverse, abundant supply of food and hiding places, which improves the reproduction, survival and diversity of fish and wildlife. Whenever the natural diversity or abundance of aquatic vegetation is reduced, most fish and wildlife are adversely affected.

At present the annual fluctuation of Namakan Reservoir is larger than natural, and on Rainy Lake it is less than natural. Both reservoirs have high water levels throughout the growing season. This unnatural pattern has adversely affected the aquatic ecosystem. Indeed there is a noticeable shortage of marshes and wetlands in bays and shallows of Namakan, Sand Point, Crane and Little Vermilion lakes, and where marshes exist on shallow Lake Kabetogama, they exhibit poor species diversity.

Wilcox and Meeker (1991) found that near-shore aquatic vegetation was less abundant and exhibited lower species diversity in Namakan Lake than in Lac La Croix, an unregulated lake located 19 miles (32 km) upstream. In Rainy Lake, the abundance of near-shore aquatic vegetation was similar to that in Lac La Croix, but the species diversity was significantly less. These differences were attributed primarily to three characteristics of the existing rule curves: 1) unnatural winter drawdown, 2) high, stable summer and fall water levels, and 3) restricted year-to-year variation in water levels. On Rainy Lake and Namakan Reservoir, emergent wetland plants and near-shore aquatic plants occur at relatively high elevations because high stable lake levels are maintained throughout the growing season. As a result of the large winter drawdown on Namakan Reservoir, these plants are exposed to dry, freezing conditions. On Rainy Lake, the plant communities, although not exposed to the severe winter conditions, are affected by the stable growing season levels and the lack of year-to-year variation in water levels. The latter factor also affects plants in Namakan Reservoir. This stability prevents aquatic vegetation from growing at a range of elevations (Kadlec 1962, Harris and Marshall 1963).

C. FISH AND WILDLIFE

The existing water level regulations adversely affect fish and wildlife on both Rainy Lake and Namakan Reservoir, according to the Steering Committee's analysis and the results of numerous studies. Water level management under the existing rule curves kills birds, furbearers, and fish. It also reduces fish spawning success and wildlife survival by negatively altering aquatic plant communities and spawning shoals. Loon and grebe nests are flooded and destroyed due to large unnatural changes in June water levels which the birds cannot adapt to. Fish eggs are dried due to unnatural large drawdowns, and in some cases, eggs are retained or absorbed in female fish because of a lack of suitable spawning habitat. Lake bottom organisms, which are food for young fish, are stranded and killed by excessive winter drawdowns on Namakan Reservoir. At a public meeting, one resident of Sand Point Lake asked the Steering Committee, "Why do we find so many dead snapping turtles floating on the shore in spring?" The likely answer is they freeze and die when the water recedes overwinter. The altered aquatic plant communities, created by the unnatural seasonal water level changes of the existing rule curves, reduce habitat for fish and wildlife. This creates less habitat for invertebrates, reduces abundance of invertebrates as food for waterbirds and fish, reduces winter food supplies for muskrats, reduces the potentially available spawning habitat for northern pike, and limits the nursery habitat and adult feeding habitat for many species of fish.

1. Fisheries Resources

a. *Historical Perspective*

Concerns about the effects of the water level regulation on the fisheries resource of Rainy Lake and Namakan Reservoir have existed ever since the dams were constructed. In 1925, when the Governments of the United States and Canada submitted the Rainy Lake Reference to the IJC for their consideration, they expressed their concerns by requesting "for fishing purposes" be included as one of the advantageous uses of the waters of Rainy Lake and the other border waters. The IJC's Final Report on the Rainy Lake Reference (1934) included statements from numerous parties expressing concerns about the possible impact of raising and regulating lake levels. The State of Minnesota and the Province of Ontario, in particular, expressed concerns about the possible negative impact to fish and recreation. These concerns were apparently recognized because in its 1949 Order the IJC included recreation and other beneficial public purposes in its list of advantageous uses of these waters.

Recently completed research programs by natural resource agencies, which conducted investigations on Rainy Lake and Namakan Reservoir, found that the present water level management does, in fact, adversely affect the environment (Kallemeyn and Cole 1990, Cohen and Radomski 1993).

b. *Fish Impacts*

While approximately 50 fish species occur in Rainy Lake and Namakan Reservoir, concerns about the effects of regulated lake levels on fish have centered on walleye, northern pike, whitefish and cisco. These species have been discussed because of proven changes in their population size or reproduction, and because of their economic importance.

Walleye and northern pike have been an important local economic resource for a long time. From the 1920s through the 1980s, they, along with whitefish, were the principal species in the commercial fishery. Toward the end of this period, the amount of commercial fishing was greatly reduced by government buy-outs. Since the 1950s, the economic value of tourism and recreation based on fishing has increased to the point where it is now a major component of the region's economy.

Fisheries managers have documented declines of fish stocks in the area (Minnesota DNR, et al. 1992). The declines of greatest concern are with walleye and cisco in Rainy Lake and northern pike in the Namakan Reservoir (Kallemeyn 1987a and b; Wepruk et al. 1992).

On Rainy Lake, the primary factor causing decline is overharvest for walleye, and perhaps for cisco, but water levels are an important secondary factor. On a population basis, overharvest affects how long adult fish live, while water levels affect how many young fish enter the fishery. On Namakan Reservoir there is a documented recruitment problem with northern pike and water levels are the major cause of the problem (Kallemeyn 1987b; Radomski 1989; Kallemeyn and Cole 1990).

The OMNR and MDNR are currently addressing overharvest problems by initiating comprehensive regulation and management changes through a public consultation process. Such changes in themselves, however, will not be sufficient to achieve full recovery of walleye, pike and cisco. It is also necessary to address adverse impacts of the existing water level management system.

The existing rule curves have a detrimental effect on walleye reproduction (Johnson and Scidmore 1965; Chevalier 1977; Kallemeyn 1987a; Kallemeyn and Cole 1990). The low water levels occurring in late April and early May prevent walleye from accessing some of the good rock rubble spawning sites on shorelines, river mouths and shoals. Also, the stable water levels in summer and early fall hinder the cleaning of walleye spawning beds. The preferred spawning habitat for walleye is rock rubble 4 inches to 12 inches in diameter with clean spaces between the rock, free of silt and algae. In spring, walleye eggs incubate in these spaces, receiving oxygen from currents or wave action, while being protected from predators.

Wave action and desiccation are the primary mechanisms by which shoals are cleaned and thereby improved for egg-hatching success. High, stable summer water levels contribute to poor spring spawning conditions by cleaning rock at levels higher than those submerged in spring, and by not allowing for the drying out and killing of algae by a summer drawdown. This, in combination with low spring levels makes submersion of preferred rock rubble at spawning time less likely.

Northern pike reproduction has also been negatively affected by the existing rule curves (Sharp 1941; Osborn et al. 1981; Kallemeyn 1987b). The best spawning habitat for northern pike is submerged cattails, sedges and grasses in flooded wetlands or marshes. Pike lay their sticky eggs on the matted vegetation on the bottom, or their eggs adhere to standing vegetation in the water. Where this habitat exists on Namakan Reservoir, it is primarily at elevations above 1117.0 feet (340.5 m) -- levels at which it became established during the growing season. However, lake levels during late April or May, the period when pike are trying to spawn, are at 1110.0 to 1114.0 feet (338.3 to 339.6 m). This is at least 3.0 feet (0.9 m) below their best spawning habitat. As a result, in some years no substantial reproduction of pike occurs on Namakan Reservoir (Kallemeyn 1987b; Radomski 1989; Kingsley 1990).

This is evident to the public. For example, one Minnesota resident on Lake Kabetogama asked the Steering Committee, "Why do we catch large female northern pike in June that have not spawned?" It is obvious the northern pike are not able to find any suitable spawning habitat and, as a result retain their eggs.

Although there is no documented reproduction problem for northern pike on Rainy Lake, there would likely be reproductive benefits if spawning pike could better access the best spawning habitat.

Whitefish and cisco can be affected by the winter drawdown of the existing curves. These species spawn from October through December, and their eggs incubate on the bottom until spring when they hatch. Many spawn on the shallow rock rubble of shorelines, river mouths and shoals. An overwinter drawdown greater than three feet (0.9 m) causes significant mortality of these eggs (Scott and Crossman 1973). Winter drawdown on Namakan Lake is from 6 to 10 feet (1.8 to 3.1 m); on Rainy it is from 2 to 3.5 feet (0.6 to 1.1 m).

On Rainy Lake, there has been a documented decline of cisco on all basins since the 1950s and 60s, and for whitefish on the North Arm and Redgut Bay (Wepruk et al. 1992). The reasons for these declines are not clear, but in addition to the lake level effects, they may include excessive harvest by the commercial fishing industry and the introduction of exotic species such as black crappie, bass and bullheads (Wepruk et al. 1992). Unfortunately on Namakan Reservoir, MDNR data are not adequate to determine if cisco and whitefish have declined.

Harvest rates for whitefish and cisco have been brought under control by commercial fish buy-outs and by reduced quotas. The effect of exotic species is not only difficult to assess, but virtually impossible to counter.

Beyond seasonal effects, there are long-term effects of the existing rule curves which negatively impact fish and wildlife. Existing water level management significantly affects the health of the fishery by altering cycles in annual water level fluctuations. Cohen and Radomski (1993) found that annual water level fluctuations and fish populations cycle. They also showed that those cycles were similar; that is, they found significant correlations between cycles in the annual fluctuation of water levels and cycles in fish populations.

There is information that suggests a cause and effect relationship. As noted above, water levels affect the abundance and diversity of aquatic vegetation, which in turn affect the abundance and diversity of fish and wildlife. Stable water levels tend to reduce this over time (Kadlec 1962; Harris and Marshall 1963); so do consistently severe winter drawdowns (Meeker and Wilcox 1991). But a period of modest annual fluctuations followed by a single large fluctuation may allow aquatic vegetation to be rejuvenated, and fish and wildlife in turn, to flourish. This is the management strategy Ducks Unlimited uses to manage its marshes.

In Rainy Lake, walleye and lake whitefish populations showed significantly similar cycles to water levels. All had 3-year cycles. In Namakan Reservoir, only the whitefish cycle was significantly similar to this 3-year cycle.

Cohen and Radomski (1993) also found that Lac La Croix and Rainy Lake had similar cycles in annual fluctuation, even though Lac La Croix is unregulated. However, Namakan Reservoir was different, perhaps because Namakan levels are dramatically drawn down to meet the needs of hydropower production at Rainy Lake.

Cohen and Radomski further found that water level regulation, through its effects on water level fluctuation, changed species interactions. This emphasizes the connection between changes to a lake through water level regulation and changes to fish populations. A lake's water level fluctuations are an index of change to the lake itself -- shoals are exposed and inundated, nutrients are recycled, and the diversity and abundance of aquatic plants are affected. Shoals and emergent plants provide spawning habitat for walleye and northern pike.

Thus, changes to water level fluctuation cycles may be expected to be correlated with changes in fish abundance cycles. Earlier, Cohen et al. (1991) recommended that periodic (1 year in 5) extreme annual fluctuations in the range of water levels be incorporated into a water level management plan if the major goal was to restore a healthy fishery. Later, Cohen and Radomski (1993) suggested that, for the health of the native fish and wildlife, changes to the existing rule curves were needed that would restore the natural cycles in the water level fluctuations.

They concluded, as had Wilcox and Meeker (1991) in regard to the aquatic vegetation, that the water level management system should allow for year to year variability in water levels. They stated that one should also be concerned with changes to the cycles of yearly water level fluctuation. For assuring adequate fish habitat, they recommended that these cycles correspond to those of Lac La Croix.

2. Lake Bottom Organisms

The existing water level regulations adversely impact benthic (bottom-dwelling) organisms as well, such as invertebrates. Winter drawdown on Namakan Reservoir can de-water up to 25 percent of the reservoir bottom and cause a massive layer of ice to be in contact with the substrate for periods exceeding 100 days. These conditions, which typically extend to levels 6.5 to 10 feet (2 to 3 m) below summer elevation of the reservoir, have reduced both the density and number of invertebrate species in this drawdown zone (Kraft 1988). Stranding and subsequent mortality appear to be a major contributing factor in the observed reduction. Stranding of organisms and exposure to air and ice cover have been found to reduce or alter benthic communities elsewhere (Kaster and Jacobi 1978).

Adverse effects of the existing rule curves on invertebrates in Namakan Reservoir are most obvious in the drawdown zone. Alderfly and mayfly densities were low in this zone compared to what would be expected naturally (Kraft 1988). Instead, this zone was dominated by midge larvae, insects that can quickly colonize recently inundated areas. The Namakan drawdown also negatively impacts mussels; overall mussel densities were low and no individuals were found in shallow water where they are typically most abundant (Dr. W.L. Downing, Hamline University, St. Paul, Minnesota, personal communication).

3. Shore and marsh nesting birds

The existing rule curve for Namakan Reservoir calls for a large increase in water level in May and June. The June changes, in particular, were found to adversely affect the hatching success of shoreline and marsh nesting birds (Reiser 1988).

During the period from 1983 to 1985, 47 percent of the attempted common loon nests on Namakan Reservoir were lost to submergence, while on Rainy Lake 27 percent were lost. Red-necked grebes were even more sensitive to lake level changes. From 1983 to 1985, 77 percent of the grebe nests on Namakan Reservoir were lost to submergence; on Rainy Lake 45 percent were lost.

Reproductive success of loons was significantly higher on both Rainy Lake and Namakan Reservoir when lake level changes during June were less than 0.7 feet (0.2 m). On Rainy Lake, the mean number of fledged young was approximately 33 percent greater. On Namakan Reservoir it was 100 percent greater. June lake level changes of less than 0.7 feet (0.2 m) have occurred on Rainy Lake approximately 75 percent of the time since the 1970 rule curve went into effect, while on Namakan Reservoir such favorable conditions have occurred in less than 20 percent of the years.

Similar relationships were observed between lake level changes in June and the proportion of flooded out nests of other marsh-nesting birds. Nest losses due to flooding were higher for pied-billed grebes and black terns, which nest on the water surface, than for the red-winged and yellow-headed blackbirds, which nest above the water.

4. Aquatic furbearers

High stable summer and early fall water levels caused beaver to build their lodges and food caches at elevations that left them extremely susceptible to Namakan Reservoir's larger than natural winter drawdown (Smith and Peterson 1988, 1991). The winter drawdown forced nearly 80 percent of the beaver to abandon their lodges and food caches. As a result, the beaver spent the winter in wood-chip nests under the ice outside their lodge and were forced to find alternative food sources. While widespread mortality did not occur, these beaver lost more weight and had fewer offspring than beaver from more stable, inland ponds. They were also more susceptible to predation, particularly in the spring. Movements resulting from lodge abandonment, which was 100 percent when water was absent from lodge entrances in spring, exposed the animals to predation by gray wolves. Approximately 25 percent of spring mortality of beaver on the Namakan Reservoir lakes was attributable to wolf predation.

Impacts on muskrats in Namakan Reservoir were similar even though the animals abandoned houses and constructed new ones in deeper water as lake levels fell before freeze-up in October and November (Thurber et al. 1991). Even with this adjustment, the muskrat's primary food sources became inaccessible as water levels continued to fall throughout the winter. The continued drawdown also apparently led to increased predation pressure by mink. These limiting factors caused muskrat densities in Namakan Reservoir to be significantly lower than in Rainy Lake, which experiences a relatively low over-winter drawdown.

The regulated lake levels affected river otter primarily by making shallow bays inaccessible during winter (Route and Peterson 1988). Summer observations of unmarked family groups and estimated home ranges of radioed family groups indicated shallow, backwater bays were important as rearing areas. As the winter drawdown proceeded and the ice collapsed onto the bottom of the bays, otter shifted their home ranges to deeper water. While these shifts occurred on both Rainy Lake and Namakan Reservoir, they appeared to be greater on the latter where the winter drawdown is approximately three times larger.

D. TOURISM

In addition to the contribution of Boise Cascade's manufacturing business to the local economy, tourism generates a substantial economic benefit to the boundary lakes region. The total gross tourism income generated by angling in this area is $10.2 million (US) annually (Minnesota DNR et al. 1992). In addition, over 450 jobs are directly dependent on fishing in the area.

Tourism businesses that are directly dependent on the lakes affected by the water level fluctuations are, not surprisingly, also affected by those fluctuations. Many of the factors evaluated in this section also affect the tourism business, directly or indirectly. For example, because of the strong tie between the private resort business and fishing, the quality of the lakes' fishery has a direct impact on the local economy.

A more direct impact of water level management is the effect of low spring water levels, primarily on Namakan Reservoir, on angler access to resort and recreation facility docks. Resort businesses on Namakan Reservoir and on the Ash River Trail have complained that in most years their docks are not accessible by boat until June due to the late spring water level rise required by the existing Namakan Reservoir rule curve. The resulting loss of business during the first two to three weeks of the fishing season results in significant loss of potential income.

Namakan Reservoir business people estimate that up to 40 percent of their potential capacity goes unfilled during the first three weeks of the fishing season because anglers stay away until the water level gets high enough to float their boats up to the resorters' docks and access ramps. They estimate this economic loss at $812,000 (U.S.), according to the analysis summarized in Appendix E. This is a significant direct loss to the local economy and does not include the effect of any economic multiplier.

E. SHORELINE PROPERTY AND ARCHAEOLOGICAL RESOURCES

1. High Water and Flood Events

As used by the Steering Committee in this report, a **high water event** occurs when the water level exceeds the maximum rule curve elevation: 1108.1 ft. (337.75 m) on Rainy Lake and 1118.6 ft. (340.95 m) on Namakan Reservoir. Within this definition of high water events, the Steering Committee has chosen to define a **flood event** as an occurrence when the water level exceeds the IJC-determined all-gates-open condition at 1108.6 ft. (337.90 m) on Rainy Lake and 1119.1 ft. (341.10 m) on Namakan Reservoir.

Although no independent assessment of potential property or other damages exists, the Steering Committee recognizes that high levels on Rainy Lake and Namakan

Reservoir can cause property damage. The levels at which such damage commences are estimated to be within the range of:

- 1108.1 ft (337.75 m) and 1108.6 ft (337.90 m) on Rainy Lake
- 1118.6 ft (340.95 m) and 1119.1 ft (341.10 m) on Namakan Reservoir.

The existing rule curves call for both the Namakan Reservoir and Rainy Lake to fill gradually until early July and then for water levels to remain high throughout the summer and early fall. These levels are between 1107.4 feet (337.54 m) and 1108.1 feet (337.75 m) on Rainy Lake and between 1117.8 feet (349.71 m) and 1118.6 feet (340.83 m) on Namakan Reservoir. The dam operator must keep water levels on both reservoirs no less than 1 foot (0.3 m) below flood stage for an entire four month period. This appears to be very difficult, for there have been many occurrences in which water levels have exceeded the IJC maximums during late summer and early fall.

According to the Rainy Lake Board of Control (1984), very high inflows make it very difficult to keep water levels below the top of the rule curves because of physical and operating constraints. Water Survey of Canada data for the years 1971 through 1989 show that under the 1970 rule curves, Rainy Lake levels deviated more than two inches above the upper rule curve on 415 days during the 19 year period, or about 6 percent of the time. On Namakan Reservoir, lake levels deviated more than two inches above the upper rule curve on 555 days, or 8 percent of the time.

The Steering Committee evaluated the relationship between Namakan Reservoir elevations as measured at Kettle Falls and at Crane Lake. From 1970 to 1980, the differences between Kettle Falls and Crane Lake elevations ranged from -0.6 to +2.9 feet during the open water months. Crane Lake was on average two to three inches higher than Namakan Lake as measured at Kettle Falls. It was also noted that Crane Lake elevations were higher than Kettle Falls elevations during fall high water and flood events (e.g., 1977). This condition was observed by local residents, and many expressed the need for monitoring and management of water levels for Crane Lake.

2. Storm Damage

High water events, in conjunction with strong winds, have caused much of the erosion which occurs throughout the area and in particular, as indicated to the Steering Committee by residents of the area, on the south shore of Sand Bay on Rainy Lake.

Shoreline development, including docks and boathouses, are susceptible to damage from wave action and storms. For example, high water and waves can lift planks off of submerged permanent docks.

Archaeological surveys conducted by the University of Minnesota indicated the majority of prehistoric and historic occupants of the area now included in Voyageurs National Park lived along the shorelines of the large lakes (Gibbon 1977). Surveys of beaches exposed during the spring when water levels are low, demonstrated that prehistoric and historic Indian sites were present in high numbers, but that about 75 percent had been partially or totally destroyed by the rise in lake levels resulting from the building of the dams (Gibbon 1978; Lynott et al. 1986).

Although some archaeological sites on the Namakan Reservoir lakes are located at higher elevations, the majority are located between the elevations of 1116 and 1118 feet msl (340.2 and 340.8 m. msl), and thus lie in the beach zone which is subject to the annual fluctuations in lake levels (Lynott 1984). A similar distribution of sites has been found on Rainy Lake, with the majority occurring between the elevations of 1107.6 and 1110.6 feet msl (337.6 and 338.5 m. msl). Even those sites located above the present maximum lake levels are impacted by the fluctuating water levels. Intense wave action during the prolonged period when lake levels are at the top of the curve through summer and fall is particularly destructive since it causes undercutting and bank slumping. The only sites which have escaped damage are those located behind and protected by bedrock shorelines.

3. Ice Damage

Ice damage can occur in both the spring and the fall. During spring breakup, winds can move an ice pack onto shore damaging not only structures within the water but any facility within several feet of the shoreline.

When fall water levels are at or near the top of the existing rule curve, much damage is caused to riparian structures after freeze-up due to ice build up. Ice weighs approximately 1360 pounds per cubic yard and thus exerts a great deal of stress upon these structures. Stress is intensified as lake levels are dropped and ice thickness increases throughout the winter. Thus many structures have a tremendous amount of heavy, thick ice hanging from them by spring. This hanging ice pulls down many structures.

F. HYDROPOWER GENERATION

As described in Section II. above, one of the primary purposes for which Rainy Lake and Namakan Reservoir are regulated, and a significant benefit of the existing rule curve, is the generation of electricity at Boise Cascade's hydroelectric plants at the outlet of Rainy Lake. Even though the existing rule curves do not provide optimum flows for hydropower generation, the maintenance of high water levels throughout the summer and early fall provides excellent conditions for hydroelectric generation.

Because Boise Cascade's demand for electricity exceeds its capability to generate at all times, all energy that can be generated has a value to the corporation. According to the analysis of hydropower generation by Acres International Ltd., the average amount of electricity generated at the International Falls-Ft. Frances dams is 106,000 megawatt hours (MWhrs). This average is based on the flows available for hydroelectric turbines during the period 1957-1992. The value of this electricity is approximately $5,000,000 (US) in 1993 dollars. This quantity, which represents a significant contribution to the total electric consumption of the Canadian and American mills, would otherwise have to be purchased from outside producers --

Ontario Hydro and Minnesota Power. The actual cost of that electricity varies on each side of the border, as follows:

(i) On the Canadian side, the price of purchased energy in 1993 varies from on-peak (7 am to 11 pm) to off-peak (11 pm to 7 am) times, as well as varies during the year as follows:

	On-Peak Value ($US/MWhr)	**Off-Peak Value** ($US/MWhr)
January	121.60	18.60
February	120.40	19.20
March	47.70	17.60
April	43.20	13.90
May	39.60	17.80
June	63.00	7.40
July	62.80	9.70
August	63.70	13.50
September	39.80	11.10
October	40.00	12.60
November	40.20	14.90
December	111.00	15.80

(ii) On the U.S. side, the price of energy is a flat $31.20 (US)/MWhr which does not vary during the day. However, in addition, there is a "demand" charge which is $6.10/KWhr/month which is determined on the basis of the maximum power purchased by Boise Cascade during the month.

Considering these factors, it is to Boise Cascade's financial advantage to vary its output on the Canadian side to minimize its purchases during the more expensive on-peak periods. At other times, the turbines are run at their maximum output throughout the day.

The sharing of water between the Canadian and American plants is done on an equal basis whenever the lake outflow is less than the full turbine flow. This sharing, however, is adjusted during week days when on-peak Canadian power generation is maximized, and is equalized on the off-peak weekday and weekend hours. This is a relatively recent innovation at Boise Cascade and is anticipated to continue in the future.

G. WATER QUALITY

Water quality investigations have generally found the water to be of high quality on Rainy Lake and the Kabetogama, Namakan, and Sand Point basins of Namakan Reservoir (Kepner and Stottlemyer 1988; Payne 1991). Rainy, Namakan, and Sand Point Lakes, which receive most of their inflows from a large area of exposed bedrock and thin noncalcareous glacial drift, are oligotrophic to mesotrophic, having low dissolved solids and alkalinity (Payne 1991). Kabetogama Lake receives much of its inflow from an area to the south and west that is overlain by calcareous glacial drift and as a result is eutrophic, having higher dissolved solids and alkalinity (Payne 1991). Values for trophic state condition estimators (e.g. specific conductance, chlorophyll-a concentrations, and carbon assimilation rates) from Kabetogama Lake are typically two to three times higher than from the three less productive lakes (Kepner and Stottlemyer 1988).

Depth-volume curves for Kabetogama, Namakan, and Sand Point Lakes show that differences also exist between Kabetogama Lake and the other two lakes in regard to the impact of drawdowns on their respective volumes. The annual drawdown of 2.7 m decreases the volumes of Namakan and Sand Point Lakes by approximately 20 and 23 percent, respectively. The same drawdown results in a 34 percent reduction in volume on Kabetogama Lake. Kepner and Stottlemyer (1988) concluded that these volume changes may affect the availability of nutrients required by algae and other aquatic plants. Concentrations of the nutrients would tend to increase with reductions in volume and decrease with increases in volume, assuming nutrient inputs from other sources remain the same. Winter drawdowns, by killing off the aquatic vegetation in the drawdown zone, may increase decomposition and nutrient re-mineralization with restored lake levels in the spring. This could conceivably result in more nutrients being released into the lake, thereby, increasing the numbers and perhaps changing the species composition of the primary producers. Conceivably, the effect would be greatest on Kabetogama Lake since it experiences the greatest fluctuation in volume.

Organic matter resulting from the dead aquatic vegetation may also be contributing to the elevated levels of mercury in fish in some of these lakes. Although organic matter from flooded terrestrial sources is generally considered to be the principal factor contributing to increased production of methyl mercury in reservoirs, organic matter produced within reservoirs can also be a contributing factor (Jackson 1988).

Rainy River water quality is in compliance with IJC objectives for conventional water quality parameters as a result of minimum flow requirements and pollution abatement measures taken by private and public parties (Beak Consultants Limited 1990). Under low flow conditions, however, significant increases in levels of various water quality parameters may still occur due to discharges from Boise Cascade's mills, which constitute the only significant point source of contaminants to the river. Abatement measures are being taken by Boise Cascade to reduce loadings of chlorinated organic compounds into the river from their bleached kraft mills.

V. STEERING COMMITTEE RECOMMENDATIONS

This section identifies the specific recommendations that the Steering Committee is making to the IJC for modification of the water level management of Rainy Lake and the Namakan Reservoir. These recommendations include a proposed modification of the rule curves, additional methods for improved inflow prediction, and the use of such methods to anticipate water level changes.

A. RULE CURVE MODIFICATIONS

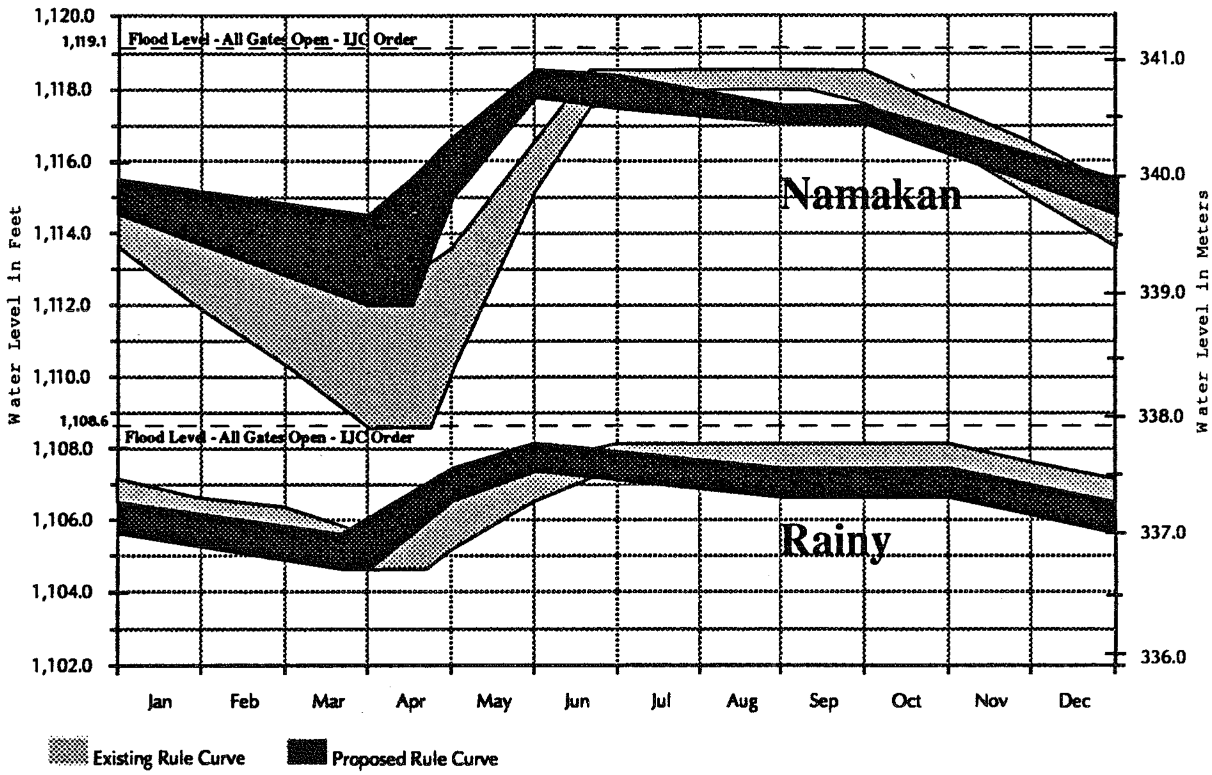
The Steering Committee recommends the modification of the existing (1970) rule curves for Rainy Lake and Namakan Reservoir to conform to those presented in Figure V - 1.

Modifications are recommended to the rule curve for each reservoir. Common features proposed for both include:

- an earlier rise in spring water levels:
  - to provide better conditions for spawning of walleye and northern pike
  - to provide better conditions for dock access and navigation
- stable or declining June water levels:
  - to improve loon and grebe nesting success
- a slight summer drawdown:
  - to improve diversity and abundance of aquatic vegetation and fish and wildlife habitat
  - to reduce property damage from late summer and fall high water events
  - to provide better access to beaches

- a reduced overwinter drawdown:
    - to improve whitefish and cisco spawning success
    - to improve overwinter survival of invertebrates, amphibians, turtles and furbearers
    - to reduce overwinter ice damage to docks.

FIGURE V - 1 RULE CURVES PROPOSED BY THE STEERING COMMITTEE



The proposed rule curve for Rainy Lake has the same maximum and minimum levels as the existing rule curve but includes minor modifications to better balance the effects of lake level management on all water users. Table V - 1 lists the existing and proposed water level elevations at key points on the rule curve.

Table V - 1. Rainy Lake Proposed Rule Curve Elevations (feet above MSL) at Selected Dates.

Date	Lower Curve Limit	Upper Curve Limit
Jan 1	1105.6	1106.5
March 20	1104.6	1105.6
April 1	1104.6	---
May 1	1106.5	1107.4
June 1	1107.3	1108.1
Sept 1	1106.5	1107.4
Nov 1	1106.5	1107.4

On Namakan Reservoir, the upper limit of the proposed curve is the same as the existing curve, but the winter drawdown is not nearly as severe. Table V - 2 lists the existing and proposed water level elevations at key points on the rule curve.

The Steering Committee decided not to recommend a periodic (1 year out of 5) extreme annual water level fluctuation on Rainy Lake and Namakan Reservoir, as proposed by one scientific study (Cohen et al. 1991). Although the Steering Committee recognized the environmental benefits of the fluctuations, the potential impacts to lakeshore owners' water intake lines precluded such a recommendation.

Table V - 2. Namakan Reservoir Proposed Rule Curve Elevations (feet above MSL) at Selected Dates.

Date	Lower Curve Limit	Upper Curve Limit
Jan 1	1114.5	1115.5
April 1	1112.0	1114.5
April 15	1112.0	---
May 1	1115.0	1116.6
June 1	1117.8	1118.6
July 1	---	1118.3
Sept 1	1117.0	1117.5
Oct 1	1117.0	1117.5

B. WATERSHED MONITORING / INFLOW PREDICTIONS

The Steering Committee recommends that the IJC enforce the following provision from the 1970 Supplemental Order regarding operation to prevent emergency conditions: "Insofar as possible, high and low inflows to Rainy and Namakan Lakes should be anticipated so that the discharge capacities of the dams at International Falls and Kettle Falls are used to best advantage to prevent the occurrence of emergency conditions."

Specifically, the Steering Committee recommends improvements be made in hydrologic monitoring and modelling of the drainage basin to facilitate anticipation of high and low flow into Rainy Lake and Namakan Reservoir and to improve water management.

Considerable public and Steering Committee discussion has focused on the need to anticipate and respond to short-term changes in watershed inflows to the reservoirs. Inflow prediction would allow the dam operators to manage water levels with a higher degree of reliability and avoid emergency conditions.

It is acknowledged that this is a complex technical issue. At present, dam operation decisions are based on measuring changes in the water levels of Rainy and Namakan Reservoirs. Changes in water levels are anticipated only on the basis of probabilities derived from historical data. The Steering Committee believes this method is inadequate, and that predictive gains are both possible and worth pursuing. Improvements in predicting inflows and in operating the dams, plus the use of computer modeling, would mitigate adverse impacts of the proposed rule curve modifications on risk of flooding and hydroelectric production.

Better hydrologic monitoring and modelling of the watershed would improve the forecasting of flood peaks, enabling better control of the peaks through dam operations. For example, water level data from lakes in the upper watershed (e.g. Lac des Milles Lacs, Lake Vermillion, Marmion, Basswood, Lac La Croix), and the use of stream gauges on major inflow streams (e.g. Seine River, Vermillion River, Maligne River), could provide the basis for inflow predictions. This approach takes advantage of the fact that nature synthesizes all the effects of precipitation, evaporation, transpiration, and ground water dynamics into a net result. The addition of a water level gauge on Crane Lake, where lake levels vary with respect to Kettle

Falls readings, would provide important low and high water level data on the upper part of the existing water level management system to one of a reservoir-wide strategy. The compilation and use of these data, as they become available, by computer models would improve water level management by providing dam operators with information and a list of potential management options rapidly.

Dam operation improvements could range from improving response time to modernization and automation of the dams. For example, maintaining 24-hour capability to operate the Namakan Reservoir dams would improve the reliability of water level management. Furthermore, computer modeling that incorporates data on inflow and outflow dynamics seems to be long overdue.

C. INDEPENDENT HYDROLOGICAL ANALYSIS

The Steering Committee recommends that the IJC conduct a hydrologic analysis of the Steering Committee recommendations.

The Steering Committee used peer-reviewed research, scientific publications, and independent expert opinion in analyzing the existing water level management system and its recommendations. However, the Steering Committee did not have the resources to conduct its own hydrologic modelling. It relied heavily on the output from the SIMUL8 model developed for Boise Cascade by Acres International Ltd. and a model developed by the U.S. National Park Service. Because of the IJC authority and expertise in dealing with large-scale water systems, the Steering Committee feels that it is appropriate for the IJC to conduct the independent and objective hydrologic analysis of these systems and to determine the effects of the recommendations on flood-prone properties.

D. MONITORING AND REVIEW

The Steering Committee recommends that upon implementation of the recommended rule curve modifications that extensive monitoring and research be conducted by appropriate agencies to determine if the rule curve modifications are reducing the negative impacts on various interests or users without seriously conflicting with other uses.

The OMNR, the MDNR and the U.S. Park Service should monitor changes in aquatic vegetation and loon nesting success, as well as continue their established monitoring programs for fish and wildlife, and angling and recreational use patterns. An annual review of the hydrology should occur, and can be presented at annual Rainy Lake Board of Control public meetings. Of particular interest will be the relationship of high and low water events to rule curve modifications. All study results could serve as the basis for further modification. An objective evaluation of how these reservoirs should be managed will be facilitated by the sharing of information and continuing dialogue of interested and affected parties.

E. STRUCTURAL CONSIDERATIONS

1. Dredging for Late Summer Dock Access

The Steering Committee recommends that alternative methods, including dredging, be permitted to provide late summer dock access in those areas where it would be restricted by the proposed rule curves.

Both the MDNR and OMNR have existing legislation and programs to protect water resources and fish habitat. These programs require each dredging proposal to be evaluated on its environmental impact and authorized by permit. A typical evaluation may take one to six weeks, and often conditions are added to approved projects, such as timing restrictions during spawning periods. Alternative methods for navigation or dock access may be required to reduce environmental impact. If the existing rule curve is modified, dredging proposals must still conform to the existing legislation and program requirements. However, a project proposer who can document that dock alternations are required primarily due to the change in water level management would receive special consideration by the OMNR and the MDNR.

2. Dock Repair and Modifications

The Steering Committee recommends that water resource regulating agencies grant special consideration to facilitate dock repairs and modifications that may be needed as a result of the implementation of the proposed rule curves.

The conditions outlined above for dredging proposals would also be required for dock repair and extension proposals.

In Minnesota, crib docks constructed to allow free flowing water and that are less than 6 feet wide by 50 feet long do not need a permit. For larger docks or breakwaters a permit could be obtained, with minimal review time, for routine reconstruction to the exact same size. Reconstruction proposals that involve enlargement of structures would go through a more thorough review.

In Ontario, any construction or repair of docks requires review and authorization by a work permit. Because the Steering Committee recognizes that some shoreline property owners on the Namakan Reservoir may wish to reconfigure their docks if the rule curve is modified as recommended, regulating agencies should expedite the necessary approvals.

3. Loon River Modifications

The Steering Committee recommends against physical alteration of the Loon River at its outlet or at "56 Rapids".

The Steering Committee acknowledges that no stream or lake bed modifications are practical for the Loon River outlet area. Alteration of the "56 Rapids" is not recommended because the constriction in the river bed elevates water levels upstream through a damming affect. Removing rocks and deepening the channel at the "56 Rapids" may cause navigation problems upstream.

F. LIABILITY ISSUES

It is the conclusion of the Steering Committee that if the IJC approves a modification of the rule curves that may marginally increase the number of high water events, the International Falls Power Company and Boise Cascade Canada, as dam operators, would not be liable for any shoreline property damage that may occur from those events as long as the dams are operated reasonably according to the stipulated IJC and FERC conditions.

One issue addressed by the Steering Committee is the legal liability of the dam operators, International Falls Power Company and Boise Cascade Canada, for damages resulting from high water events on the reservoirs. This issue was addressed by the attorney for Boise Cascade Corporation, Richard Baxendale, at the Steering Committee's August 1991 meeting.

Mr. Baxendale explained that the International Falls Power Company operates under license from the U.S. Federal Energy Regulatory Commission (FERC). This license, as described in Section III.B. of this report, establishes certain conditions under which the dams are operated. In addition, the Company has the responsibility to operate in accordance with the IJC rule curves as described in Sections II.C. and D.

Mr. Baxendale indicated that as long as the dams are operated in accordance with the license and IJC requirements and the company acts to control unusual events in a reasonable manner without negligence, they are not liable for property damages caused by high water, or other natural flow extremes. Avoidance of negligence involves operating as a reasonable gatekeeper under the circumstances, using a reasonable number of staff, and reviewing and considering flow data in a reasonable manner.

Furthermore, it is not the intent of the Steering Committee in proposing the modification of the rule curves to increase the legal liability for either company.

VI. HYDROLOGIC MODELS

The Steering Committee used the results of computer-driven hydrologic models as a tool to analyze some of the impacts of the proposed rule curve modifications as compared to the impacts of the existing rule curves. This section of the report provides some background information on the basic theory of hydrologic models and a description of the features and assumptions of the two models used by the Steering Committee.

A. WATER RESOURCE ENGINEERING

In water resource engineering, it is common practice to use historical hydrological data to test proposed new modes of reservoir regulation. This is done by mathematically simulating the outflows and lake levels that would have occurred given the actual, historical lake inflows, and the new rules of operation. Simulated water levels can then be compared to gain insight into the relative effects of the change in operation strategy. This procedure can also be used to assess effects on hydropower generation.

However, the reader should be aware that the models create a "simulated" result of what would have happened given the assumptions and inflow data used. This simulated result is helpful for making relative comparisons between the existing and proposed rule curves, but it cannot be used as a prediction of future real-life events because the assumed conditions and inflows will not occur in an actual hydrologic cycle. Conclusions about relative impacts must be based on comparisons of simulated results with simulated results, not actual historic water levels. Simulated water levels from the models follow the rule curves better than water levels actually recorded in the past. Although some models can be trusted to provide accurate comparisons of different rule curves, they may not reflect the extremes experienced in water levels historically or in the future. Nevertheless, broad comparisons of operating schemes are reasonable with this technique and can be indicative of future trends.

This simulation technique based on historical lake inflows has been used to assess the implications of rule curve changes for the Rainy Lake and Namakan Reservoirs. Two computer models were available to the Steering Committee. The first was developed by Marshall Flug (1986) as part of the National Park Service research program. The second model, SIMUL8, was developed for Boise Cascade by Acres International Ltd. (March 1993). Both models are based on assumptions about inflows and management behavior that affect both the results and the interpretation of those results.

B. THE FLUG MODEL

Flug (1986) simulated the multi-lake system beginning with inflows to Namakan Reservoir and ending with outflows from Lake of the Woods, a large lake located approximately 78 miles (130 km) downstream from Rainy Lake. To restrict the modelling effects to this area, the model was designed to give priority to outflows from Lake of the Woods and to match the actual recorded releases from that lake. The model also provided for all legally mandated discharges for pollution abatement. This model routes mean monthly inflows through the system, and consequently is not intended for daily operation of the reservoir in real time.

Constraints placed on the model, in addition to continuity, include maximum outflows through existing outlet works, minimum flow requirements in the Rainy River for water pollution control, both maximum and minimum lake levels, and others as appropriate. Some of these constraints may in some instances be treated as "operating rules", which are the attributes by which the model is instructed to allocate and route water through the system. The variable constraints and operating rules included: maximum and minimum limits in each flow link; maximum turbine discharge; overall turbine efficiency as included in the power factors for each lake level; monthly desired lake levels for each reservoir; priorities for each reservoir and demand node; and the order of spilling water from each reservoir. Spilling, however, occurs only if the continuity relationship cannot be adhered to given all the specified input data and constraint limits.

Two separate simulations were made with the Flug model: one representing a range of flow conditions for a ten year period and another representing a worst case scenario of ten years of high flows. The first simulations used flow conditions from the period 1972 to 1981. Based on mean annual flows for the Namakan River during the period 1923-85, this ten year span was considered representative because flows were in the lower and upper quartiles two and three years, respectively, and between the extreme quartiles the other five years. The second simulation assessed the feasibility of maintaining lake levels under high flow conditions by running ten high flow years through the model consecutively. The high flows selected were from the years 1947, 1950-52, 1966, 1968, 1969, 1971, 1972, and 1974. The mean annual flow from the Namakan River for all these years was in the upper quartile for the 1923-85 period. Output from the model simulation runs include the resulting lake levels, reservoir outflows, and hydropower generated each month.

C. THE SIMUL8 MODEL

The database used in the SIMUL8 model consisted of lake level records for Rainy Lake and Namakan Reservoir for the years 1957 to 1992. The recorded lake levels were smoothed using a 5-day moving average so as to eliminate short term wind effects. Inflows to Rainy Lake were further adjusted so that the effect of water released from, or retained in, storage in Namakan Lake would be eliminated.

SIMUL8 was designed to follow steps similar to those taken by Boise Cascade in their daily decision making in operating the dams. The model averages the previous three days of lake inflows and projects that over the future five days as an approximation of future events. Outflows are set for both reservoirs so that water levels reach the upper three quarters point between the rule curves after five days. Constraints such as riparian flows in the Rainy River, and the maximum capability of the structures to pass water are acknowledged in selecting the outflow of the day. In addition, stoplog movements at the Namakan dams are only made twice per week. Gate and stoplog openings are selected to achieve the target outflow, and then actual lake inflows are used to determine the actual response of the lakes during that day. The procedure is then repeated on a daily basis throughout the simulated period, 1957-1992.

D. COMPARISON OF THE MODELS

Like the Flug model, SIMUL8 provides projections of lake levels, reservoir outflows, and hydropower generation. The main difference between the two models is that Flug's model uses monthly data values (12 data points per year) and the SIMUL8 model uses daily values (365 data points per year). Monthly values can easily mask shorter term peaks. The SIMUL8 model, therefore, may give a better simulation of shorter term events. The Flug model provides estimates of hydropower production from the dams on the outlets of both Rainy Lake and Lake of the Woods. The SIMUL8 model only provides projections of daily energy generation at the

International Falls-Fort Frances dam. The usefulness of a simulated result in predicting future events relies on calibration of the model to track historical data. The Flug model was calibrated, but the SIMUL8 model was not.

Despite these shortcomings, the Steering Committee relied primarily on the SIMUL8 model to compare the relative impacts of the existing and proposed rule curves because it can identify short-duration hydrologic events and it used data from a longer period of record. It is important to note that the Steering Committee used simulated results to make hydrologic comparisons between the existing and proposed curves.

VII. EVALUATION OF STEERING COMMITTEE RECOMMENDATIONS

This section of the report contains the evaluation of the impacts of the Steering Committee's recommended rule curves on the same parameters on which the existing IJC rule curves were evaluated in Section IV. above.

A. NAVIGATION AND DOCK ACCESS

1. Navigation

The proposed rule curves will improve spring navigation on both reservoirs, especially on Namakan Reservoir in the areas of Loon and Ash Rivers. They will improve spring navigability of straits and island channels. They will also allow one month earlier access through the Loon River for the Lac La Croix First Nation residents and local tourist businesses.

On Rainy Lake the elevation on which all navigation charts are based is 1107.0 feet (337.4 m). The Steering Committee took this fact into consideration when designing the proposed Rainy Lake rule curve. For example, the September and October midpoint of the proposed curve is 1107.0 feet (337.4 m). Only one user group indicated that the proposed summer drawdown would be a problem for navigation. This group, members of the Rendezvous and Rainy Lake Yacht Clubs, said the summer drawdown would restrict their ability to travel Brule Narrows and shallow bays under sail. The Steering Committee considered that this potential inconvenience was outweighed by the benefits to other environmental and economic interests.

On Namakan Reservoir, information obtained from the Lac La Croix First Nation, area residents, and tourist operators on Sand Point and Crane lakes suggests that the rule curve should not go below 1117.0 feet (340.5 m) before the end of September. The Steering Committee took this concern into account and designed the proposed Namakan curve so that it would not go below 1117.0 feet (340.5 m) before October 1.

Some Crane Lake residents suggested that in years when Loon River experiences low flows in autumn, a level of 1117.0 feet (340.5 m) may not be adequate because the reservoir would be too low to create a "backing-up" or dam effect of the river above "56 Rapids". They suggested that the reservoir level should not be reduced below the lower limit of the existing rule curve during autumns with low flow conditions. In considering this suggestion, the Steering Committee weighed the loss of fish and wildlife benefits in the entire reservoir against the need for assurance that navigation from "56 Rapids" to Loon Portage will be easy during dry autumns. Another consideration was that an all-weather road is being constructed from Highway 11 in Ontario to the Lac La Croix reserve. This road will provide alternate access for the Lac La Croix First Nation during periods when the river is not easily navigated. On balance, the Steering Committee decided not to recommend a provision for higher autumn water levels in dry years.

A potential benefit of the proposed Namakan rule curve is improved winter ice conditions for snowmobiling. Reduced overwinter drawdown will reduce shell ice hazards, and reduced ice settling will help alleviate existing shoreline slush accumulations.

2. Dock Access

The Steering Committee proposed rule curves will improve dock access on both Rainy Lake and Namakan Reservoir by promoting an earlier rise in spring water levels. The effects of this change would be clearly seen on the Namakan Reservoir where the overwinter drawdown will be reduced to approximately 5.0 feet (1.5 m) from the average 7.5 feet (2.3 m) that has occurred with the existing rule curve. Consequently, the percentage of docks that would have at least one foot (0.3 m) of water at their end on May 15 would increase from 37 percent if the water level were at the bottom of the existing rule curve to 84 percent if the water level were at the bottom of the proposed rule curve. Based on the simulation of water levels for both rule curves according to the SIMUL8 model, there would be enough water for all docks at the end of May in 94 percent of the years with the Steering Committee's proposed rule curve, but under the existing rule curve only 18 percent of the years would have access to all docks by the end of May.

The Steering Committee proposed rule curve for Rainy Lake will have a similar effect. The earlier rise in spring water levels will improve access to boat ramps and wharfs for all boaters. While the members of the Rendezvous and Rainy Lake Yacht Clubs requested and agree with this change, they have a concern that the proposed summer drawdown will make it more difficult to use traditional wharfage areas and remove keel boats in the early autumn. The Steering Committee designed the proposed rule curves to provide adequate water to meet the late summer dock access needs of most boaters. Where dock access would be restricted, the Steering Committee recommends mitigation by dredging (Section V.C.1.).

B. AQUATIC VEGETATION

The Steering Committee recommendations will improve the diversity and density of aquatic vegetation in Rainy Lake and Namakan Reservoir. A reduction in annual fluctuation for Namakan Reservoir will improve plant diversity important to fish and wildlife. Plants such as wild rice will benefit from reduced fluctuations since less substrate will be exposed to ice, thereby affording seeds a greater chance of surviving the winter. However, improvements in the occurrence and abundance of some species of aquatic plants, which fish and wildlife need, are limited because only a slight summer drawdown is proposed.

C. FISH AND WILDLIFE

1. General Effects

The Steering Committee recommendations offer changes in water level management that will improve the fisheries and the aquatic ecosystem. The four changes recommended that will have positive impacts include: higher water levels during walleye and northern pike spawning periods, a summer drawdown, reduced overwinter drawdown, and a reduced annual fluctuation on Namakan Reservoir.

Fish spawning conditions will be improved because of favorable spring water level elevations. Walleye spawning habitat will be improved due to fall rubble cleansing, and northern pike spawning habitat will be improved because of the restoration of emergent plant stands. On Namakan Reservoir, the reduction in annual fluctuation will restore aquatic plant diversity important to fish and wildlife. Good nesting conditions for loons and grebes would be produced with the recommendations, thus nesting success of these species should increase.

2. Fish

The proposed rule curves will improve spawning conditions for both walleye and northern pike. Water levels in the spring will be at elevations where suitable spawning shoals exist for walleye. Walleye spawn on shoals, in rivers and along shallow shorelines shortly after ice-out, and they have specific spawning habitat requirements. Rocky, wave-washed substrates are needed for lake spawners. On Rainy Lake the strongest walleye year-classes have been produced when lake levels are greater than 1107.3 ft (337.5 m) during spawning (Chevalier 1977). The higher water levels in the spring will also increase the probability of having submerged vegetation at ice-out for northern pike spawning. Over 90 percent of the vegetation in Namakan Reservoir is found above 1115.1 ft (339.9 m) (Kallemeyn 1987b). Spring water levels must be within 2.5 feet (0.8 m) of the summer elevation for northern pike to have access to these beds. The Steering Committee recommendations create conditions favorable for fish spawning.

A summer drawdown will benefit fish spawning and improve the survival of young fish. It will benefit spawning by expanding the range of elevations covered by emergent vegetation and the amount of wave-washed gravel at lower elevations. The resulting increase in the abundance and diversity of aquatic vegetation increases the amount of food and escape habitat for young fish.

Decreasing the rate of winter drawdown on Rainy Lake and Namakan Reservoir and the amount of overwinter drawdown on Namakan Reservoir will benefit lake whitefish, cisco, lake bottom organisms, and aquatic vegetation. The fall spawners, lake whitefish and cisco, deposit their eggs in shallow water, and winter drawdowns greater than 3 feet (1 m) desiccates incubating eggs, which do not hatch until early spring. The improvement on Namakan Reservoir, however, will be limited due to the overwinter drawdown continuing to exceed 5.0 feet (1.5 m).

The proposed rule curve changes would also affect the fishery in the Rainy River below the dam at International Falls/Ft. Francis. Walleye spawn in Rainy River during mid-April to the third week in May, and the eggs incubate for up to three weeks. Sturgeon spawn in the river during May and early June; incubation time is two weeks. Under the existing rule curve then, discharges to Rainy River are restricted when downstream walleye and sturgeon are spawning, and their eggs are incubating.

The proposed rule curve calls for the level of Rainy Lake to begin increasing on March 20 each year. The inflection point of the ascending limb of the curve should be reached in late April. This means that the period of time when discharges would be reduced is from about March 15 to late April. Thereafter, discharges will likely be increased to prevent the lake level from exceeding the top of the rule curve.

The slope of the ascending limb of the proposed Rainy Lake curve is slightly steeper than that of the existing curve. At first glance, it appears that spring discharges from Rainy Lake may have to be reduced more than they are now, to allow lake levels to track the proposed curve. However, the overwinter drawdown on Namakan Reservoir is reduced by 34 percent in the proposal. This means that discharges from Namakan Reservoir into Rainy Lake may increase sooner, because less water will be required to fill Namakan Reservoir. In turn, discharges from Rainy Lake may have to be increased sooner, offsetting the possible reduction effect of the proposed Rainy Lake curve.

The timing of spring fill-up for Rainy Lake is shifted 11 days earlier with the proposed curve, moving the period of discharge reduction partially out of the sensitive walleye spawning and incubation period, and completely out of the spawning and incubation time for sturgeon. Given this shift, and the mitigating effect of Namakan discharges on Rainy Lake discharge reductions, it appears the influence of the proposed rule curves on downstream walleye spawning and egg incubation should be negligible. With regard to sturgeon in Rainy River, there should be benefits for sturgeon spawning and egg incubation, compared to the present flow regime.

Some benefits to downstream fish may occur in late summer from the proposed curves. Under the existing Rainy Lake rule curve, discharges to Rainy River are reduced in late summer to keep the level of Rainy Lake high. This can cause significantly reduced flows in Rainy River, especially during dry years. Low flows can lead to warm water temperatures and reduced oxygen tension in the river. Such conditions can lead to downstream fish kills, especially in shallow back eddies and bays in the lower river. While the existing minimum discharge limit set by IJC is designed to avoid these problems, the proposed rule curve should reduce the need to cut back discharges in late summer. This should not harm downstream fish populations and may even benefit them.

While the Steering Committee's proposed rule curves will benefit fish and the aquatic community, the recommendations are limited in two important areas. The recommendations propose only modest summer drawdowns and do not incorporate long-term cycles in yearly water level fluctuations and their benefits to fish populations. Yearly water level fluctuations cause shoals to be exposed and inundated, nutrients to be recycled, and the diversity and density of the aquatic plant community to be maintained. Shoals and emergent vegetation provide spawning habitat for fish. Long-term cycles in water levels affect the frequency and amplitude of fish population cycles. For assuring adequate fish spawning habitat and fish recruitment, the frequencies of these long-term water level cycles should correspond to those of Lac La Croix. Likewise, appropriate amplitudes of water level cycles should mimic the estimated natural hydrological regime.

3. Lake Bottom Organisms

The survival of lake bottom invertebrates, such as clams, mayfly larvae and crayfish, will increase due to the decrease in the rate and magnitude of winter drawdown. The proposal allows invertebrates to move with the receding water levels during drawdown.

4. Shore and marsh nesting birds

The proposal will reduce the maximum possible lake level fluctuation in June from 3.3 feet (1.0 m) to 1.0 feet (0.3 m) on Namakan Reservoir and from 1.5 feet (0.45 m) to 1.0 feet (0.3 m) on Rainy Lake. With these reduced fluctuations, the frequency of occurrence of June water level changes of less than 0.7 feet (0.2 m) should increase significantly, thereby providing better nesting conditions for loons and other shore and marsh nesting birds.

5. Aquatic furbearers

Conditions for aquatic furbearers on Rainy Lake will remain approximately the same as under the existing water management system since there will be only a small decrease in the amount of overwinter drawdown.

Although the proposal will reduce the maximum extent of the winter drawdown on Namakan Reservoir by 4.5 feet (1.4 m), it will still exceed 5.0 feet (1.5 m) due to the limited nature of the summer and fall drawdown. Thus, there would only be a marginal improvement in conditions for aquatic furbearers. The overwinter drawdown will continue to force beaver and muskrats out of their houses and away from their food sources. Assuming ice out dates remain approximately the same, the earlier spring rise in water levels may enable beaver to return to their houses and thus reduce their susceptibility to predation by wolves. The earlier rise and the stable or slightly declining June water levels could also reduce flooding of muskrat houses while the animals are raising their young.

D. TOURISM

Implementation of the Steering Committee proposed rule curves is expected to result in a significant benefit to the regional tourism industry, particularly on the Namakan Reservoir. Improvement of spring access to docks during the first three weeks of the fishing season is expected to result in additional direct revenues of up to $812,000 (U.S.) to resort and other tourism-related businesses.

In addition, an improvement in the quality of the fishery on Rainy Lake and Namakan Reservoir will have direct benefits for the tourism economy.

E. SHORELINE PROPERTY AND ARCHAEOLOGICAL RESOURCES

1. High Water and Flood Events

The Steering Committee considered both the SIMUL8 and Flug hydrologic model results to compare the risk of **high water events** and **flood events** from the Steering Committee's proposed rule curves with the corresponding risk under the existing IJC rule curves. (For the Steering Committee's definition of the terms in boldface type see Section IV.E.) The results of the analyses are summarized in Tables VII - 1 and VII - 2 and Figures VII - 1 to VII - 3; and Tables F- 1 to F - 8 and Figures F - 1 to F - 6 (Appendix F). The theory and use of hydrologic models in water resource engineering is summarized in Section VI of this report.

Although both analyses indicated the proposed curves are hydrologically feasible, the output from the models differed with respect to the risk of high water. The SIMUL8 model showed an increased risk of flood events and the Flug model showed a decrease in flood events with the Steering Committee proposed changes. However, wishing to err on the side of caution, the Steering Committee relied more heavily on the SIMUL8 results in its analysis.

That analysis indicates that with the Steering Committee recommended modifications in place, the overall number of **high water events** is expected to decrease and fall **flood events** will be nearly eliminated; however, spring **flood events** may increase. This increased springtime risk could be reduced by a more comprehensive watershed monitoring system to better anticipate inflows, as recommended by the Steering Committee in Section V.B.

In the following sections, the results of the analyses from both models are presented for Rainy Lake first and then for Namakan Reservoir. In each case high water and flood events are compared for frequency (number of events), duration (time during which water level exceeds limits), and magnitude (maximum amount that water level exceeds limits). A quantified assessment of potential property or other damages would require analyses that were beyond the capabilities of the Steering Committee. However, shoreline property owners will be able to make some general conclusions about potential impacts from the analysis summarized in this section.

Rainy Lake

SIMUL8 MODEL

As to frequency, the SIMUL8 model results (Table VII - 1) indicate a 38 percent reduction in the number of total high water events but a 100 percent increase in the number of flood events for the Steering Committee proposal compared to the existing rule curve. The proposed modifications reduce the number of fall high water events but increase the number of spring flood events. The model suggests that over the 36-year period of flow data the proposed rule curve would result in a total duration of flood events of 118 days (average = 19.7 days per flood event) compared to the existing total duration of 56 days (average = 18.7 days per flood event). As to magnitude of flood events, the peak water levels would be approximately 1 to 5 inches higher for the proposed rule curve compared with the existing curve.

FLUG MODEL

Flug's model, which was calibrated with 1972-1981 flow conditions, indicated no high water events would have occurred on Rainy Lake with the Steering Committee's proposed rule curve. During the same time frame under the existing rule curve, two flood events occurred on Rainy Lake, in 1974 and 1977. As noted in Section VI, the Flug model results are based on fewer data points than the SIMUL8 model, but the Flug model was calibrated to track the historic data.

Flug's analysis of the Steering Committee's Rainy Lake rule curve over ten consecutive high water years showed that the simulated elevation would have exceeded the flood level in only one year, which corresponded to the 1950 data point, the year of the flood of record. Based on the simulation results, the lake level in Rainy Lake would have exceeded the flood level by about 2.0 feet (0.6 m).

Namakan Reservoir

SIMUL8 MODEL

As to frequency, the SIMUL8 model results (Table VII - 2) indicate a 32 percent decrease in the total number of high water events, but a 50 percent increase in the number of flood events for the Steering Committee proposal compared to the existing rule curve. The proposal decreases the number of fall high water events but increases the number of spring flood events.

The model suggests that over the 36 year period of flow data the proposed rule curve would result in a total duration of flood events of 109 days (average = 18.1 days per flood event) compared to the existing curve total duration of 87 days (average = 21.8 days per flood event). As to magnitude of flood events, the peak water levels would vary from approximately 5 inches lower to 6 inches higher for the proposed rule curve compared with the existing curve.

FLUG MODEL

Flug's model, which was calibrated using 1972-1981 flow conditions, indicated no high water events would have occurred with the Steering Committee proposed rule curve. During the same time frame under the existing rule curve, one flood event occurred on Namakan Reservoir, in 1977.

Flug's analysis of the Steering Committee Namakan Reservoir rule curve over 10 consecutive high water years showed that the simulated elevation would not have exceeded the high water level or the flood level.

TABLE VII - 1

SUMMARY OF ACRES INTERNATIONAL HYDROLOGICAL MODEL (SIMUL8) AS IT RELATES TO HIGH WATER AND FLOOD EVENTS FOR RAINY LAKE

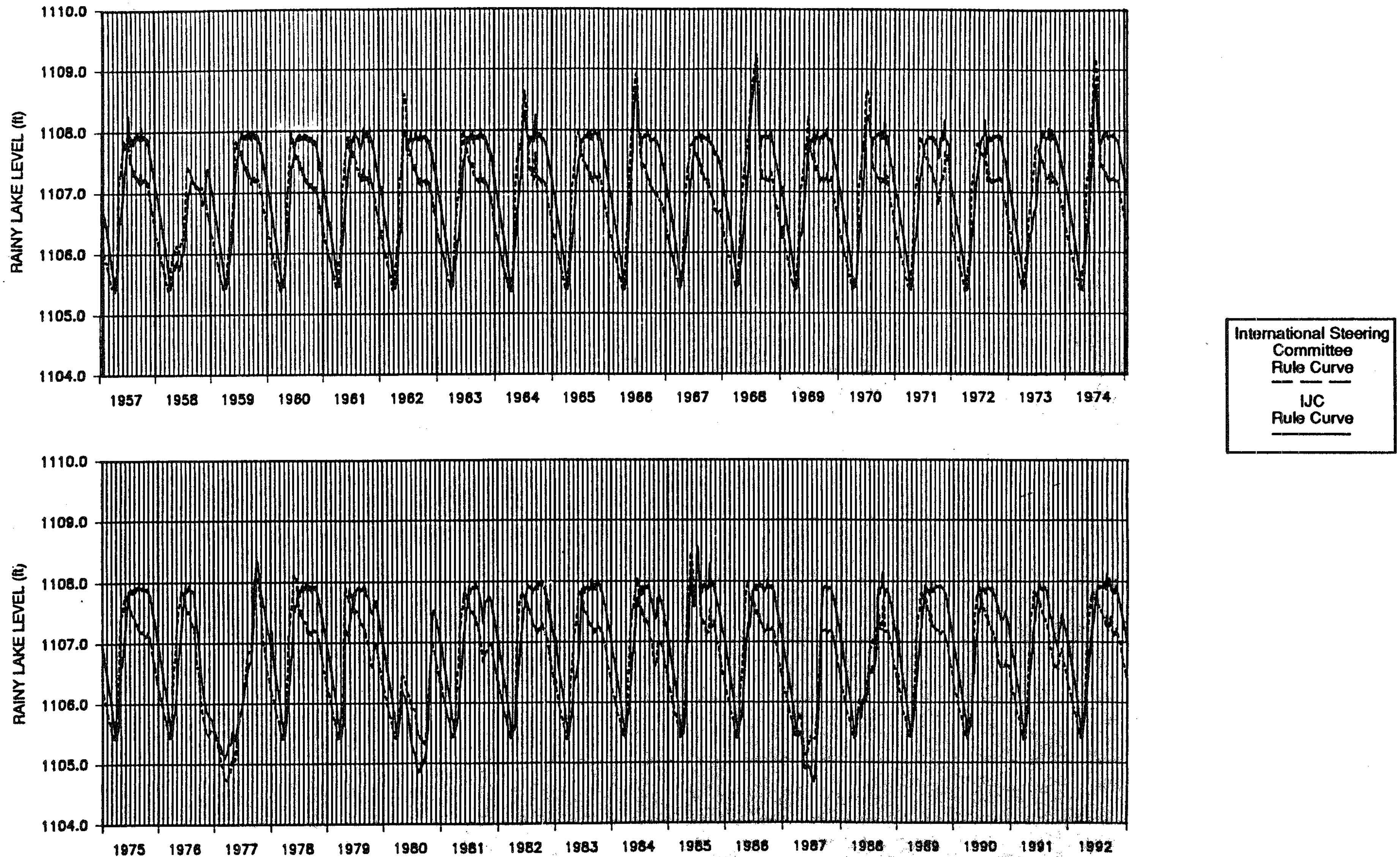
Period	Existing	Proposed	Percent Change
Number of High Water Events			
May - July	9	10	11% increase
August - October	8	1	88% decrease
Total	16	10	38% decrease
Number of Flood Events			
May - July	3	6	100% increase
August - October	0	0	No change
Total	3	6	100% increase
Duration of High Water Events (Days)			
May - July	190	300	58% increase
August - October	66	8	88% decrease
Total	256	308	17% increase
Duration of Flood Events (Days)			
May - July	56	118	111% increase
August - October	0	0	No change
Total	56	118	111% increase

TABLE VII - 2

SUMMARY OF ACRES INTERNATIONAL HYDROLOGICAL MODEL (SIMUL8) AS IT RELATES TO HIGH WATER AND FLOOD EVENTS FOR NAMAKAN RESERVOIR

Period	Existing	Proposed	Percent Change
Number of High Water Events			
May - July	11	13	18% increase
August - October	14	3	79% decrease
Total	22	15	32% decrease
Number of Flood Events			
May - July	2	5	150% increase
August - October	2	1	50% decrease
Total	4	6	50% increase
Duration of High Water Events (Days)			
May - July	146	206	41% increase
August - October	124	37	70% decrease
Total	270	243	10% decrease
Duration of Flood Events (Days)			
May - July	60	96	60% increase
August - October	27	13	52% decrease
Total	87	109	25% increase

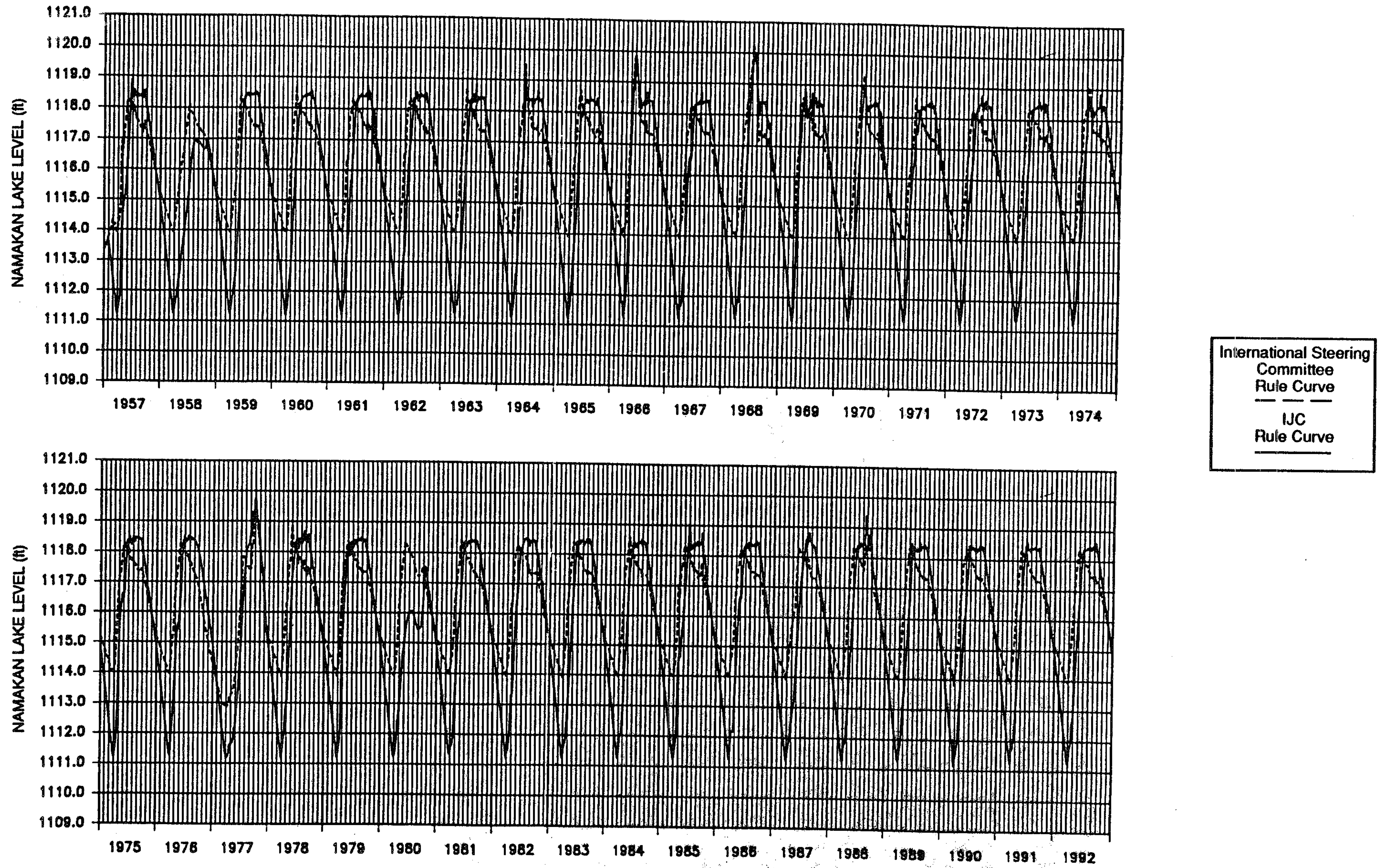
FIGURE VII-1
RAINY LAKE LEVELS - COMPARISON OF PROPOSED RULE CURVE TO EXISTING IJC RULE CURVE FOR YEARS 1957 - 1992



Source: Acres International Ltd.

FIGURE VII-2

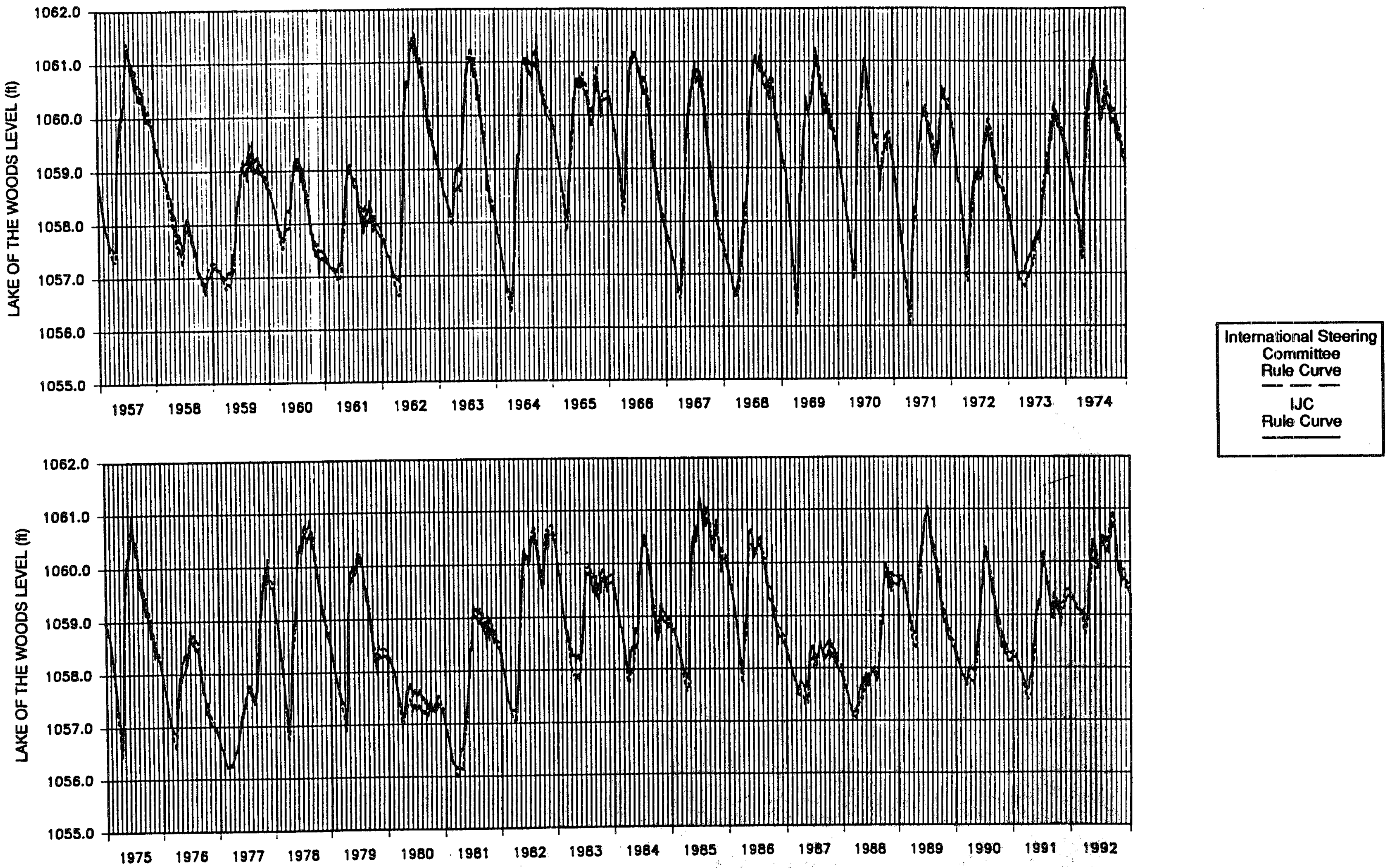
NAMAKAN LAKE LEVELS - COMPARISON OF PROPOSED RULE CURVE TO EXISTING IJC RULE CURVE FOR YEARS 1957 - 1992



Source: Acres International Ltd.

FIGURE VII-3

LAKE OF THE WOODS LEVELS - COMPARISON OF PROPOSED RULE CURVE TO EXISTING IJC RULE CURVE FOR YEARS 1957 - 1992



Source: Acres International Ltd.

2. <u>Ice Damage Potential</u>

The Steering Committee proposed rule curves call for a gradual reduction in water levels from early June through early fall. This feature reduces the risk that water levels will be close to the IJC maximum at freeze-up. Also, the amount that the lake levels drop through the winter will be less than at present. The combination of these factors will reduce the amount of damage caused by hanging ice pulling down shoreline structures.

In the spring, the proposed rule curves may increase the probability of damage from moving ice. If spring water levels are sufficiently high, ice can break away from the shoreline and move with the wind. The force exerted by moving ice is such that it can destroy docks and other structures. A strong wind can even propel the ice onto land.

3. <u>Archaeological Resources</u>

The potential for damage to archaeological sites in early summer would not be changed because the maximum levels would be the same as under the 1970 rule curves. However, because of the summer and fall drawdowns, damage to archaeological resources from fall equinox storms would be reduced.

F. HYDROPOWER GENERATION

Both SIMUL8 and Flug's model were used to assess the impact on hydroelectric energy production at the International Falls Power Company and Boise Cascade Canada hydroelectric facilities resulting from the Steering Committee's proposed rule curves. The Flug model also assessed the impacts on hydroelectric generation at Boise Cascade Canada's Kenora dams at the outlet of Lake of the Woods. The findings of these analyses are contained in <u>Report on Analysis of Proposed Changes to Rule Curves of Rainy and Namakan Lakes</u> (Acres International Ltd. 1993a)and in an appendix section to Flug's 1986 report.

The results of the SIMUL8 analysis are based on a comparison of the daily total energy generated in the Canadian and U.S. powerhouses given the varying conditions of available flow and hydraulic head predicted by the model for the existing and the proposed rule curves. The comparative simulations indicated that, on average, over the 36-year period of water conditions used in the model, the Steering Committee's proposed rule curves would result in an average annual decrease in energy of 4,550 MWhrs from the Canadian powerhouse and 3,870 MWhrs from the U.S. powerhouse. This represents a seven percent reduction in average generation potential compared to simulated generation under the present IJC rule curves. The cost to Boise Cascade in additional purchases from electric utilities to make up this short-fall is estimated by the simulation model to be $345,000 (US) per year on average at 1993 prices (Acres International Ltd. 1993a).

The loss in hydropower generation capacity, according to the model, is attributed to the following factors:

(i) the reduction in useable storage in Namakan Lake tends to cause an increase in spillage of water at the downstream powerhouses;

(ii) the drawdown of Namakan Lake between June 1 and September 1 can cause additional spillage of water at the hydro plants in some wet summers;

(iii) the drawdown of Rainy Lake between June 1 and September 1 can cause additional spillage of water in some wet summers, particularly in conjunction with a similar drawdown of Namakan Lake;

(iv) the generally lower water levels on Rainy Lake between June 1 and March 15 cause a significant loss of head at the powerhouses, which results directly in a lower production of energy (Acres International Ltd. 1993a).

Flug's analysis, which was done using flow data for the 1972 to 1981 time period, found that there would be a 2.1 percent increase in hydropower production at the Rainy Lake dam compared to what would have been produced if the 1970 rule curves were in effect. For the same time frame, hydropower production from Boise Cascade's Lake of the Woods dams was projected to decrease 1.0 percent. Overall production from the two sites was projected to increase about 0.6 percent or about $30,000 (US) per year on average at 1993 prices.

G. WATER QUALITY

Impacts of the proposed rule curve modifications on water quality would probably be most obvious in Namakan Reservoir since it would experience the greatest change in timing and magnitude of lake level fluctuations. Modeling results indicated peak spring total phosphorus concentrations in Kabetogama Lake would be reduced under natural lake level fluctuations

(Kepner and Stottlemyer 1988). It was suggested this may be due to: (l) a reduction in bottom areas exposed by drawdown and accompanying sediment-water interactions, (2) reduced nutrient inputs resulting from die-off of littoral vegetation, and (3) reduced nutrient concentrations due to volume changes. The authors, stressing the model was uncalibrated, concluded that a return to natural fluctuations could reduce phytoplankton biomass and the accompanying primary production and that these changes could have ramifications throughout the food web. Conceivably, the proposed curve could also cause a change in total phosphorus levels since it calls for lake level fluctuations closer to those occurring under natural conditions than does the existing water management system. The exact magnitude of this change, however, is unknown. This uncertainty also makes it difficult to predict what the possible impact of any such changes might be on water quality in the receiving waters of Rainy Lake. Water quality changes resulting from changes in the Rainy Lake rule curve are expected to be minimal because overall lake fluctuations will not change.

Predicting the effect of the proposed rule curves on the bioaccumulation of mercury by fish in Rainy Lake and Namakan Reservoir is difficult. Although more organic matter may be produced as a result of the slight summer drawdowns, it may not be as available to stimulate mercury methylization, as compared with what is currently produced, due to the proposed reduction in total annual fluctuation. Evaluation of the effects of the recommended rule curves is further complicated by the effects of other factors such as the continuing atmospheric input of mercury (Sorenson et al. 1990) and variations in water chemistry (Helwig and Heiskary 1985; McMurtry et al. 1989).

The existing minimum flow requirements for the Rainy River would continue under the proposed rule curves. As a result, no change is expected in the water quality in the river.

H. UPSTREAM AND DOWNSTREAM IMPACTS

1. Upstream Impacts

Upstream impacts of the Rainy Lake proposal should be minimal because most rivers flowing into the reservoir have waterfalls at their discharge points to the lake, or there is substantial fall to their slope before discharging to Rainy Lake. Hence, the relatively minor seasonal changes to Rainy Lake levels involved with the proposal should not extend very far upstream, if at all.

There was some concern expressed during the public consultation process by four parties on the Seine River-Marmion Lake system (Figure II - 1) that water might be pulled from Marmion Lake and the Seine River during times of drought for the purpose of regulating Rainy Lake. Similarly, there was a concern that water might be held back during times of flood for the benefit of Rainy Lake. This is not proposed by the Steering Committee, and indeed the idea was never entertained by the Steering Committee. It may be that shoreline owners on Marmion Lake experience water level problems because of the management of Lac des Milles Lacs upstream, conflicting with the needs for efficient operation of the Crilly and Calm Lake dams downstream, but such circumstances are not related to the management of water levels on Rainy Lake.

As discussed in Section VII. A. above, potential upstream impacts from the Namakan proposal were recognized for navigation at Loon and Ash rivers, particularly at Loon River upstream to Loon Portage, at the east end of the Namakan Reservoir. The proposal was designed to provide a net improvement for navigation on these rivers.

The Steering Committee is not aware of any other upstream impacts that may arise from the proposals.

2. <u>Downstream Impacts</u>

The IJC order governing the regulation of Rainy and Namakan Reservoirs also provides for minimum flows in the Rainy River. A separate IJC order governs the regulation of the level of Lake of the Woods, which is controlled by the operation of two dams at Kenora.

Both the Flug and SIMUL8 computer models were used to assess the impact that the proposed rule curves would have downstream on Lake of the Woods. Both models indicated there would be very little change in water levels on Lake of the Woods that could be attributed to the proposed changes in the rule curves (Figure VII - 3; and F - 6 (Appendix F)). This is primarily attributed to the fact that Lake of the Woods is four times larger than Rainy Lake and Namakan Reservoir combined. A contributing factor to this result from Flug's model was that the outflows from Lake of the Woods were given the highest priority and were forced to match actual historic outflows.

With regard to Rainy River flows, the Steering Committee recommendations adhere to the existing IJC maximum and minimum discharge requirements. In other words, maximum and minimum discharges from Rainy Lake will not change under the proposed curve from the existing management system. However, the timing and amount of discharge will be changed slightly, within these limits.

The existing rule curve calls for the level of Rainy Lake to start increasing on April 1 of each year. The ascending limb of the curve is steepest from April 1 to May 31. The inflection point of the curve, the point at which the rate of filling starts to slow, is generally reached in late May. After this time, discharges are increased to prevent the lake level from exceeding the top of the rule curve. Also, the United States Federal Energy Regulatory Commission requires the dam operator to keep the lake level as close as possible to the top of the rule curve for fifteen days after ice-out, to benefit fish spawning in Rainy Lake.

In order to meet these existing requirements, discharges from Rainy Lake are reduced from about April 1 to late May each year.

VIII. PUBLIC RESPONSE

This section summarizes the response of the public from both Canada and the United States to the Steering Committee draft proposal as it was presented in public meetings and brochures during the last few months of 1992 and the first half of 1993. It also summarizes the response of the Boise Cascade Corporation, and the Steering Committee's objective review of Boise Cascade's consultant reports which were submitted to the Committee in response to the proposal.

A. RESIDENT AND RESOURCE USER RESPONSE

The methods used by the Steering Committee to assess public reaction to proposals and to find out what issues were of most importance to the public are described in Section III. D. above.

As a result of these formal and informal public consultation measures, the draft proposal has been modified in response to the expressed concerns and knowledge of the region's lake users. The Steering Committee has received comments from hundreds of people.

Of the total of 363 written responses to the Steering Committee proposal received by mid-September 1993, 83 percent expressed support (Table VIII - 1). The 15 percent who expressed opposition are mostly concerned about a potential increase in frequency and magnitude of high water events. Most of these were from the U.S. side of Rainy Lake. Three percent were undecided.

The Steering Committee received one-third of its written responses from Ontario residents, and the remainder from U.S. residents (Table VIII-2). However, the proportion of responses does reflect the demographics of the area. The responses for Rainy Lake were about equally balanced between Canadian and U.S. residents (118 and 154, respectively), as are the populations. We received few responses from Canadian residents about Namakan Reservoir, but the shoreline on the Canadian side of Namakan Reservoir is essentially not developed.

Ninety percent of the Canadian responses favored the Steering Committee proposal, and 80 percent of the U.S. responses supported the Steering Committee proposal.

A compilation of all comments received, both pro and con, is included in Appendix A.

B. BOISE CASCADE CORPORATION RESPONSE

The meeting summaries in Appendix D reflect the position Boise Cascade Corporation took in this process. Boise Cascade Corporation's response to other interests or individual concerns has been consistent, in that the Corporation believes that the existing rule curves are very good at balancing overall interests. In earlier Steering Committee meetings, Boise legal and engineering experts attended and made presentations. Their knowledge and expertise was sought by the Steering Committee, and through dialogue with Boise representatives the Steering Committee proposals were modified. Acres International Ltd., Boise's hydrologic consultant, was instrumental in providing technical information important in the development of the rule curve modifications which represent the Steering Committee's best effort to balance all interests and to maximize benefits to as many concerns as possible.

During the public review period for the Public Review Draft of the Final Report and Recommendations (July 1993), Boise Cascade Corporation submitted to the Steering Committee its consultant reports relating to fish, wildlife, and flooding. The Report on the Assessment of Flood Damage Potential on Rainy/Namakan Lake System (Acres International, Ltd. July 1993b) stated "consequently, it can be concluded that consideration of flooding does not carry a decisive weight in the overall balance of benefits and disbenefits of the proposed rule curve changes". However, the Boise consultant fish and wildlife reports concluded that the impacts to fish and wildlife populations from the Steering Committee recommendations would be small, not necessarily beneficial, and have high uncertainties. Boise Cascade has also expressed the strongly held view that while the issue of the proposed rule curve changes and their beneficial effect on fish populations are being considered (a proposition which it does not support), the impact of overfishing is not being effectively addressed. Boise Cascade believes that the best approach for improving the fisheries is to reduce harvests so that the populations can build up to desired levels, and then manage harvests at optimum sustainable yields through better controls on harvest.

The Steering Committee submitted those reports to experts for review and analysis to seek an objective scientific assessment of the facts. Those assessments are found in Appendix H.

C. STEERING COMMITTEE CONCLUSIONS

The Steering Committee has concluded that changes to the existing rule curves are warranted -- in fact, they are necessary -- to improve both the environment and economy of the area. The analysis presented in this report indicates that in addition to fish and wildlife benefits, implementation of the proposed recommendations will generate real improvements in navigation and the local tourist economy.

While the Steering Committee acknowledges that overharvesting of walleye is a problem, they also recognize that a healthy walleye fishery can only exist where habitat is suitable for spawning, young fish survival, and production of the small fish that walleye eat. Natural resource managers involved in the Steering Committee process have concluded that to restore the Rainy Lake walleye fishery, and the Namakan Reservoir northern pike fishery, just controlling the harvest is not enough. It is also necessary to restore the habitat for those species by modifying the existing water level management system.

Moreover, resource managers, and a significant number of the public, have concerns about the health of the entire lake ecosystem. Walleye and northern pike are but two of the 50 fish species and hundreds of other animals and plants affected by the alteration of habitat due to the existing water level management regime. The Steering Committee, as well as the resource management agencies, have concluded that the scientific literature and research related to fish and wildlife support this key finding: the existing rule curves have a detrimental effect on the aquatic resources and the recommended changes will benefit the Rainy Lake and Namakan Reservoir ecosystems. The recommended biological monitoring (Recommendation V. C.) is intended to further refine and expand knowledge of the relationship between water levels and the ecosystem.

Throughout the Steering Committee process and in its final recommendations, the Steering Committee has recognized and sought to address the concerns of the Boise Cascade Corporation: the loss of hydropower, potential flooding increases, and liability issues. The public consultation process revealed that a number of lake users share some of these concerns. The

Steering Committee recommendations, which include mitigation of potential adverse effects, were developed with the intent of finding a balance between all affected interests. The Steering Committee believes that with its Final Report and Recommendations it has succeeded in that intent.

TABLE VIII - 1

SUMMARY OF PUBLIC RESPONSE TO QUESTION:

DO YOU SUPPORT THE STEERING COMMITTEE PROPOSAL?

(Based on Responses Received August 20, 1992 to Present)

Lake	Yes	No	Undecided
Rainy / Both ** (269 responses)	216 (80.3%)	44 (16.4%)	9 (3.3%)
Namakan (94 responses)	85 (90.4%)	9 (9.6%)	0 (0%)
Total Number (363 responses)	301 (82.9%)	53 (14.6%)	9 (2.5%)

** The Rainy Lake and the "both" lake responses are combined here, since most of the people who indicated an interest in both lakes on the response form are Rainy Lake residents

TABLE VIII-2
WRITTEN RESPONSES
SUMMARY BY LOCATION OF RESIDENCE

Lake	Yes	No	Undecided
Rainy[1] / Both			
Canada, Ontario	103	7	5
U.S.			
Koochiching Co.	85	33	3
St. Louis Co.	13	3	0
Other	14	0	1
Unknown	1	1	0
Namakan[2]			
Canada, Ontario	3	0	0
U.S.			
Koochiching Co.	2	2	0
St. Louis Co.	40	6	0
Other	38	0	0
Unknown	2	1	0
Totals by Location			
Canada, Ontario	106	7	5
U.S.			
Koochiching Co.	87	35	3
St. Louis Co.	53	9	0
Other	52	0	1
Unknown	3	2	0
Grand Total	301	53	9

[1] There are about 29,500 people living year-round in the immediate area of Rainy Lake and upper Rainy River, split evenly between Ontario and Minnesota.

[2] There are 2 areas of localized habitation on Namakan Reservoir, both in Minnesota: the unorganized territories of northwest St. Louis County, primarily on Kabetogama Lake; and the small community of Crane Lake.

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