INTERNATIONAL RAINY LAKE BOARD OF CONTROL
IRLBC

REPORT ON YEAR 2001 HIGH WATER LEVELS IN THE RAINY/NAMAKAN BASIN

Submitted to

The International Joint Commission

October 26, 2001

INTERNATIONAL RAINY LAKE BOARD OF CONTROL
REPORT ON YEAR 2001 HIGH WATER LEVELS IN THE RAINY/NAMAKAN BASIN

1. INTRODUCTION

This report has been prepared by the International Rainy Lake Board of Control (IRLBC) in response to a June 12, 2001 letter request from the International Joint Commission (IJC) to provide the Commission with a detailed report on the year 2001 high water event in the boundary waters of Rainy and Namakan lakes. The Commission asked the Board to address six specific areas in its report, as noted below:

- a description of the hydrologic conditions as the situation developed in the spring of 2001;
- an assessment of the actions and decisions taken by the Companies (Boise Cascade Corporation and Abitibi-Consolidated Incorporated) and the Board in response to these conditions and their impacts;
- the impact of the new rule curves generally including actions taken to target for other than the middle of the band;
- any physical changes that may have been made since the original IJC Order which would have reduced the outflow capacity at the Fort Frances/International Falls dam;
- any other information the Board considers relevant;
- any Board recommendations for further action or follow-up by the Board or the Commission.

The Commission's June 12 letter also requested an interim report addressing the May 24 through May 31 shut-down of the International Falls Power Company's powerhouse at International Falls, Minnesota, owned and operated by Boise Cascade Corporation. This shutdown reduced the outflow from Rainy Lake at the time when inflows to the lake were at their highest. To address this issue, the Board asked Boise to provide specific information, including a computational assessment of the impacts of the shutdown. The company's final response was submitted to the Board under cover dated August 9, 2001, and consisted of their consultant's (KGS Group, Winnipeg, Manitoba) report as well as a separate prepared by company officials. Information and results from these reports are included herein.

In general, the high water levels in 2001 were due to very heavy and persistent precipitation from the beginning of April through to the end of July. The rainfall total for this period over the Rainy-Namakan basin was the highest since 1948. High water levels were experienced not only on Rainy and Namakan lakes, but right from their headwaters through these lakes and downstream to Lake of the Woods and the Winnipeg River.

Sections 2 through 7 of this report address in turn the six subject areas identified by the Commission, while Section 8 provides overall conclusions. Figures supporting the text may be found at the end of the report. Figure 1 is a map of the drainage basin.

2. DESCRIPTION OF THE HYDROLOGIC CONDITIONS IN THE RAINY-NAMAKAN BASIN AS THE SITUATION DEVELOPED IN THE SPRING OF 2001

The Rainy-Namakan basin experienced very high water levels and flows during the spring and summer of 2001. This event was driven by extreme amounts of rainfall occurring within two periods, generally from early April through mid-June and again during the second half of July. Hydrologic conditions at the end of March in the Rainy-Namakan basin consisted of a near normal water content in the snowpack, normal to somewhat higher than normal (localized) soil moisture and well below normal base-flow in the basin's rivers and streams. In the United States portions of the basin in northern Minnesota, the National Weather

Service's (NWS) March 22, 2001 final Spring Snowmelt Flood Outlook was forecasting no flooding to minor flooding for the region. This outlook was based upon soil and snowpack conditions and is shown in Figure 2.

In April the Rainy-Namakan basin received 117 mm (4.6 in) of rainfall, which is nearly three times the median amount of 40 mm (1.6 in) and represents the highest April total since 1948. By the end of May the April-May rainfall totalled 238 mm (9.4 in), which is nearly 2.5 times the median amount of 102 mm (4 in) for this period and represents the second highest April-May total since 1948. By the end of July the April-July rainfall totalled 519 mm (20.4 in), which is the highest recorded for the period since 1948. The April-July rainfall total represented approximately 80% of the normal annual rainfall for the basin. Upstream, in the Lac la Croix basin, rainfall totals and rankings were very similar to the Rainy-Namakan basin, except for being somewhat less during June and July. The quarter-month rainfall totals for these two basins for 2001 (to report date) are shown graphically in Figure 3, while rainfall totals and their rankings for the ten highest ranked years since 1948 are shown in Figure 4. (A legend for Figure 3 can be found after the final Figure.)

In response to this rainfall, Namakan Lake inflows rose from 50 m^3/s (1,770 ft^3/s, a 1 in 10 year low value) in early April to 325 m^3/s (11,480 ft^3/s) by April 15 (maximum of record for that date) and eventually peaked near 800 m^3/s (28,250 ft^3/s) in late May. Average inflow to Namakan Lake was the second highest since 1957 for the April-May time period and highest since 1957 for the April-June and April-August time periods, as shown in Figure 5, which compares the 10 highest ranked Namakan and Rainy Lake inflows, respectively, for these time periods (note that Rainy inflow data is available since 1912, while Namakan data is only available since 1957). Due to these high inflows, Namakan Lake rose sharply. From its initial level in early April at the three-quarter point within the operating band defined by the IJC, it reached the upper rule curve of this band by mid-April, continued rising along the upper rule curve to the end of April, and then rose above the band on May 1. Namakan Lake rose above the IJC upper emergency level of 340.95 m (1,118.6 ft) on May 17, and then rose above the IJC "all gates open" level of 341.1 m (1,119.1 ft) on May 22, peaking at elevation 341.45 m (1,120.23 ft) on May 30. This level was the highest seen on the lake since 1968, the ninth highest level since 1912, was 50 cm (19.7 in) above the IJC upper emergency level (the highest point on the upper rule curve) and was 35 cm (13.7 in) above the IJC "all gates open" level. A ranking of the 10 highest Namakan Lake annual levels since 1912 is shown in Figure 6. Declining from May 30, the lake returned to its "all gates open" level on June 17, after 27 days above this point, and declined further to its upper emergency level on June 21, after 36 days above this point. After 54 days above the upper rule curve, the lake declined back within its operating band on June 24, where it remained until very heavy rainfall in late July caused a rapid increase in inflow. This resulted in lake levels that exceeded the upper rule curve for a further 27 days from August 1 through 27. The maximum deviation above the upper rule curve during August was 18 cm (7 in), but the upper emergency level was not exceeded in August. The heavy late July rainfall essentially resulted from one storm that deposited widespread amounts of 50-125 mm (2-5 in) over the region, with up to 170 mm (6.7 in) in some locations. Following the August rise, the level of Namakan Lake remained near the middle portion of its band (to report date). A graphical representation of Namakan Lake levels, net inflow and outflow is shown in Figure 7. (A legend for the Namakan level and flow graphs, and for other similar graphs for other sites, can be found after the final Figure.)

Rainy Lake inflows also rose very quickly in response to the rainfall. From only 107 m^3/s (3,780 ft^3/s, a 1 in 20 year low value) in early April, they reached near 700 m^3/s (24,720 ft^3/s) by mid-April (maximum of record for that date) and 1,380 m^3/s (48,730 ft^3/s) by late May. Average inflow to Rainy Lake was the highest since 1912 for the April-May time period, second highest since 1912 for the April-June time period and third highest since 1912 for the April-August time period as shown in Figure 5. From its initial level in early April, just below the mid-point of its IJC operating band, the lake rose above its upper rule curve on April 16, rose above its IJC upper emergency level of 337.75 m (1,1108.1 ft) on May 21, rose above its IJC "all gates open" level of 337.90 m (1,108.6 ft) on May 24, and kept rising, peaking at elevation 338.24 m

(1,109.71 ft) on June 9. This was the highest level reached since 1968, the seventh highest since 1911, was 49 cm (19.3 in) above the IJC upper emergency level (the highest point on the upper rule curve) and was 34 cm (13.3 in) above the IJC "all gates open" level. A ranking of the 10 highest Rainy Lake levels since 1911 is shown in Figure 6. Declining from June 9, the lake returned to its "all gates open" level on June 30, after 38 days above this point, and declined further to its upper emergency level on July 4, after 45 days above this point. Rainy Lake was almost two weeks later than Namakan Lake in declining back within its operating band, but did so by July 5, having been above its upper rule curve for 80 days. As with Namakan Lake, the level of Rainy Lake also remained within its band until the very heavy rainfall in late July caused a rapid increase in inflow and resulted in lake levels that exceeded both the upper rule curve and the upper emergency level for 19 days from August 1 through 19, and exceeded the IJC "all gates open" level for 8 days from August 3 through 10. The maximum deviation above the IJC upper emergency level and upper rule curve during August was 19 cm (7.5 in), while the maximum deviation above the IJC "all gates open" level during August was 4 cm (1.6 in). Following the August rise, the level of Rainy Lake remained near the middle portion of its band (to report date). Rainy Lake levels, net inflow and outflow are shown graphically in Figure 8.

Water levels and flows along the Rainy River were impacted not only by the very high outflow from Rainy Lake, but also by the high flows from local tributaries. The maximum flow recorded in 2001 in the Rainy River at Manitou Rapids was 1,693 m^3/s (59,790 ft^3/s) on May 25. The combined flow of the Big and Little Fork rivers peaked on April 14 at 731 m^3/s (25,810 ft^3/s), but rose again to 571 m^3/s (20,160 ft^3/s) on May 25 in response to another period of heavy rain. The very heavy rainfall experienced over the Rainy-Namakan basin in late July produced only a moderate rise in the combined flow of the Big Fork and Little Fork rivers (to 147 m^3/s or 5190 ft^3/s). The outflow increases from Rainy Lake in response to this heavy rainfall provided the bulk of the flow recorded (1,254 m^3/s or 44,280 ft^3/s) during a secondary peak of the Rainy River at Manitou Rapids in early August. This early August rise, although substantial, produced flows and river levels well below those recorded in May. As a result of the high May flows, the Rainy River rose to levels not seen since 1974, with the level below the Fort Frances - International Falls dam peaking at 332.05 m (1,089.40 ft) on May 25 and the level of the Rainy River at Manitou Rapids peaking at 329.53 m (1081.1 ft). Following the August rise, the level of the Rainy River fell to and remained near median levels (to report date). Graphical representations of Big Fork River, Little Fork River and Rainy River (at Manitou Rapids) flows are shown in Figure 9, while Rainy River levels below Fort Frances and at Manitou Rapids are shown in Figure 10.

In summary, the high water levels and flows experienced by the Rainy-Namakan system in 2001 were due to very heavy and recurring precipitation from the beginning of April through to the end of July. These conditions existed not only on Rainy-Namakan, but extended along the main stem of the Winnipeg River basin, from the headwaters above Rainy and Namakan (including Basswood Lake and Lac la Croix) through to Lake of the Woods (below Rainy Lake) and down the Winnipeg River into the Province of Manitoba. These wet conditions were in marked contrast to most river basins to both the west and the east of this area, which experienced drier than normal conditions in 2001. On Rainy and Namakan lakes the 2001 levels were the highest since 1968 and exceeded the upper emergency and "all gates open" levels for both lakes as defined by the IJC. On Lake of the Woods and downstream along the Winnipeg River, the 2001 levels were the highest since 1950, which is at or near the flood of record for the area. Figure 11 shows graphically how the peak levels experienced in 2001 on Lac la Croix (not regulated), Namakan Lake and Rainy Lake compared to "normal" summer levels and to the historic peaks for these lakes.

3. ASSESSMENT OF THE ACTIONS AND DECISIONS TAKEN BY THE COMPANIES AND THE BOARD IN RESPONSE TO THESE CONDITIONS AND THEIR IMPACTS

3.1 Actions and Decisions

On balance, and in the Board's viewpoint, hydrologic conditions in the Rainy-Namakan basin leading up to the beginning of April tilted toward concern over the potential for a below normal spring snowmelt runoff as had occurred the previous year. The primary factors in this concern were the very low lake inflow, below normal snowpack through early February and the NWS March 22, 2001 Spring Snowmelt Flood Outlook, forecasting no flooding to minor flooding for the region. There were no indicators of the extreme rainfall amounts that would occur from April through the end of July.

On February 8, given the very low inflow to Rainy and Namakan lakes and the potential for a below normal snowmelt runoff based upon early February indications, the Board directed the Companies to target Namakan Lake levels for the middle of the upper quarter of its band at the end of March and to target Rainy Lake levels for the middle portion of its band at the end of February and then the middle of the upper quarter of the its band at the end of March. These targets were subject to review and change as warranted by future change in basin conditions. Under the new IJC Order[1], both lakes are normally targeted for the middle portion of their respective IJC rule curve bands, unless otherwise directed by the International Rainy Lake Board of Control. Given the apparent low risk of spring flooding, the IRLBC exercised its authority to move the end-of-winter target levels higher in order to provide environmental benefits, such as improved water levels during the spring fish spawning period. On February 28, due to significant additional precipitation in the basin since February 8 and consequent concerns raised by the Companies, the targets were adjusted downward. The Namakan target was lowered to 75% of band by the end of March, while the Rainy target was lowered back to the middle portion of the band as specified in the new Order. The targets were reviewed again on March 6, during the Board's annual meeting with the Companies in the basin, and left unchanged. High runoff from combined snowmelt and very heavy precipitation commenced near the end of the first week in April. The well above normal rainfall continued through to mid-June, fell below normal in the later half of June and early July, and then returned to well above normal from mid-July into August. Due to this, the already high runoff in early April continued to increase to a peak in late May, then declined to the normal range in July, but rose to a second (but lower) peak in early August, after which it declined back to the normal range by mid to late September. The inflows to Namakan Lake and Rainy Lake are shown on Figures 7 and 8 respectively.

On Namakan Lake, the Companies responded to the first rapid increase in inflows by pulling the first stop-logs from the dams at Kettle Falls on April 9. All sluices were flowing by April 17, and the dams were fully open by May 2, well before the IJC "all gates open" level was reached (May 22) and thus in compliance with the IJC Order. However, the inflows significantly exceeded the outflow capacity of the dams until late May, and so the lake level rose. Figure 7 shows how quickly and significantly the outflow was increased in response to the rising inflow. It also shows how the outflow capacity is limited by the level of the lake. When the first sluices were opened, the graph shows that the outflow increased very rapidly. However, even

---

[1] Following an extensive study by the IRLBC, the IJC issued a Supplementary Order dated January 5, 2000 which implemented new "rule curves" for Rainy and Namakan lakes, directed the Companies to normally target for the "middle portion" of the operating band defined by these rule curves, and gave the IRLBC authority to direct the Companies to target elsewhere in the band. With this Order, the previous rule curves implemented in 1970 were replaced, and operational flexibility within the band was transferred from the Companies to the Board, although in fact this had been severely constrained in recent years by new constraints imposed under Boise's operating licence. Under this licence, FERC had required Boise to try to have both lakes at their upper rule curves in the early spring period. On February 28, 2001, a new IJC Consolidated Order became effective which embodied the "new" or Year 2000 rule curves and directions.

after all but three logs had been removed from the dam on April 24, it can be seen that the outflow continued to increase at a steady rate as the lake level rose to its peak. Once the lake level peaked in late May and then declined through June, it can be seen that the outflow declined with the lake level, although all sluices remained open until late June when the lake level was about to re-enter the IJC operating band. At this point the companies closed sluices in order to keep the lake level within the band, and the outflow fell more sharply into mid-July. When inflows increased again in early August, outflows were very quickly increased again by the companies, as shown by the steepness of the outflow graph, and in compliance with the IJC Order. The lake level did not rise as high as the first peak, due to the inflow being less.

On Rainy Lake, as with Namakan, the companies responded to the rising inflows in April by quickly beginning to increase the outflow from the lake. Outflow more than tripled within 5 days of the initial April 6-7 rainfall, and thirteen of the 15 available gates at the International Falls - Fort Frances dam were open by April 24. Two of these gates had to be subsequently closed because of low forebay levels just upstream of the dam, endangering the ability of the Abitibi-Consolidated mill to withdraw water for emergency fire control needs. Due to restrictions in the river channel near the lake outlet, at Pither's Point and elsewhere, the upper Rainy River cannot deliver to the dam all of the water that the dam could release until the lake is at higher levels. Opening dam waste gates, in excess of the river's ability to convey water to the dam, unnecessarily lowers the forebay level, while providing little or no increase in outflow. The companies continued to open gates, as possible as the lake level rose, and all were fully open by May 16, well before the IJC "all gates open" level was reached (May 24) and thus in compliance with the IJC Order. Nevertheless, with inflows rising quickly and soon exceeding the amount of water that could be released through the dam, the lake level continued to rise. Figure 8 shows that the outflow from Rainy Lake initially increased rapidly as gates were opened, but then continued to rise at a slower rate, as the lake level rose, in spite of more gates being opened. This was due to the limited flow capacity of the upper river. Figure 8 also shows the rapid response of the companies in increasing outflow in early August in response to the second abrupt increase in inflows. However, this time the Companies were not quite in compliance with the IJC Order in that equipment breakage caused a delay in getting the last two of the 15 gates fully open. The lake was above the "all gates open" level from August 3 through 10, but at the start of this period 13 gates were fully open and the other two partially open. Abitibi undertook repairs with all possible haste and had 14 gates fully open by August 7 and all 15 gates fully open by August 14.

An emergency situation developed at the International Falls powerhouse on May 24. According to Boise, the tailrace water elevation at the powerhouse had been rising as much as 0.5 inches (1.3 cm) per hour for several days preceding the 24th and began coming up through floor cracks and drains in the hydro building which houses the turbines and electrical generators. Boise Cascade took immediate action to plug and sandbag the cracks and drains and installed additional sump pumps to handle the influx of water into the powerhouse. The tailrace level continued to rise throughout the afternoon of the 24th, with additional intermittent seepage through the floor cracks. Vibration and undulation of the hydro building floor were also observed by hydro personnel. Company officials were concerned that continued uplift force from the rising tailrace level could result in a structural failure of the floor, or inundation of the electrical generators with a resultant major electrical fault. Such a fault would have posed a serious safety hazard to hydro personnel and could have resulted in a lengthy shutdown of the 7 turbines at the powerhouse, resulting in a total loss of discharge capacity from the powerhouse at a time when Rainy Lake inflow was at its peak. These risks were deemed unacceptable by the company and hydro units 1, 2, 3 and 4 were de-energized and shut down by about 3:00 p.m. on May 24. With the continued rise of the tailrace level, hydro units 5, 6 and 7 were subsequently de-energized and shut down by about 7:20 a.m. on May 25. The Board was notified by the company, early on May 25, of its decision to shut down the powerhouse. By the evening of May 30 the tailrace level had dropped about 25 cm (10 in) and the company began bringing their hydro units back on line. Several of the generating units sustained some wetness to their electrical field windings, requiring drying, but this was accomplished and all 7 units were operating at 100% of gate by 5:15 p.m. on the 31st.

In the aftermath of the powerhouse shut-down and to enable the Board to respond to the Commission's June 12, 2001 request for a detailed written report on this year's high water event and an interim report on the powerhouse shut-down, the Board requested on June 11 (with an advance copy of the Commission's June 12 letter) that Boise Cascade provide the following:

- an explanation as to why the powerhouse had to be shut down in 2001 when it had stayed running during past events with higher tailwater levels;
- an assessment of what could be done to prevent future powerhouse shutdowns under conditions of high tailwater;
- Boise Cascade's plans (with time-line) to rectify this situation in the future;
- a computational assessment, for Board review, of how much Rainy Lake water was held back by the shutdown and how much the lake rose as a result. The resultant lake level and discharge should be modelled for three scenarios:
  - with the powerhouse shutdown as occurred;
  - if no powerhouse shutdown had occurred;
  - with no powerhouse shutdown and with the old turbine outflow capacities, prior to turbine rehabilitation in the early 1990's (this third scenario was to allow assessment of the fact that, to some extent, the greater flow capacity of the refurbished turbines was a positive compensating factor in this event).

To deal with some of this work, and especially the modelling work, Boise Cascade enlisted the help of its engineering consultant, KGS Group (Winnipeg, Manitoba). Further, Boise asked KGS to model the resultant Rainy Lake level and discharge for two additional scenarios:

- if the old 1970 rule curves were still in place on Namakan Lake, and the end-of-March target level had been the mid-point of the old rule curve band;
- if the end-of-March target level on Namakan Lake had been the mid-point of the new 2000 rule curve band instead of the 75 percent point within this band as directed in 2001 by the IRLBC.

This latter scenario was one that the Board had planned on modelling itself.

There were several delays in the completion of the company's final reports, due to data errors found in the course of the computational assessment that needed to be corrected and additional work by the company's consultant in response to Board review comments on the consultant's initial draft report. Boise's initial draft response was submitted to the Board under cover dated July 24, 2001 and the final response was submitted under cover dated August 9, 2001. It consisted of a KGS report dealing with the computational aspects of the work and an assessment of proposed measures to prevent future shut-downs, and a separate report, prepared by company officials, dealing with an explanation for the powerhouse shut-down and Boise's plans to rectify the situation. Based upon the Board's brief review of the KGS report, the consultant's findings appear to be reasonable. The report prepared by the company is believed by the Board to be an accurate representation of the facts as known by the company. Both reports are listed in the References.

3.2 Assessment of Actions and Decisions

End-of-Winter Lake Level Targets

After reviewing its decisions regarding the targeting of Rainy and Namakan lake levels this past spring, the Board believes its decisions were proper in light of the hydrologic conditions that existed in early February, the additional basin precipitation through the end of March and the concerns expressed by the companies. The decision was also tempered by the poor early spring runoff of the previous year and the Board's very successful use of targeting above the middle portion of the band in dealing with that situation, which prevented below normal spring water levels on both lakes in 2000.

On Namakan Lake, if an end-of-March target level in the upper quarter of the IJC band is likely to be desirable, the decision to move in this direction must be made by early February. Due to the downward slope of the IJC band, if the lake level continues to follow the middle portion of the band beyond this time-frame, the level will fall lower than the possible end-of-March target, which would mean that the lake level would possibly have to be raised later in February-March in order to meet a higher target level (see Figure 7). Raising water levels under ice cover conditions can be very harmful. (For example, the lifting forces of ice adhered to crib docks and boathouses displaces and damages these structures.) Thus, given the basin conditions in early February, the apparent low risk of snowmelt flood, and the desirability of having higher spring levels when possible for environmental reasons, the decision was made at that time to start holding the level of Namakan Lake above the middle portion of the band. Then, late in February, with more snow having fallen, the target level was moved downward somewhat (from 88% of band to 75% of band) in recognition of the additional water content to produce runoff. This target was maintained through to the end of March, based on the water content of the snow being determined to be not above normal, low base flow in local rivers, and modelling results from the rule curve study which had showed that higher end-of-March levels on Namakan were not likely to significantly raise the peak level of the lake if high inflows did occur.

On Rainy Lake, due to the lesser slope of the IJC band, it is not necessary to start holding the lake level higher in the band as early in the season in order to avoid raising the level later to meet an end-of-March target level above mid-band. Thus, while a higher end-of-March target level seemed desirable and possible on Rainy in early February, there was no need to take action at that time. Thus only an intent was stated, depending on conditions. Later, with the extra snowfall on the ground, the concerns of the Companies, and recognizing the more significant impact of end-of-March level on an ultimate peak level on Rainy compared to Namakan, the decision was made to hold with the default target of “middle portion of the band”. However, with water content of the snowpack determined to be in the normal range and with low base flows, it was not deemed necessary to draw the lake level any lower than the middle portion.

Making a decision to target higher or lower on both lakes in the spring carries uncertainty, because long-term forecasts of future precipitation amounts are highly inaccurate beyond even a few days with current technology. The peak high water levels in 2001 on both lakes resulted from the highly unusual and excessive precipitation that occurred within the Rainy-Namakan basin in April and May. Similar or worse conditions of high water than those of 2001 have occurred in the past and will undoubtedly occur again in the future, under extreme hydrologic conditions, irrespective of any actions taken by the Companies or the Board. The modelling conducted by KGS indicated that the peak level of Namakan Lake would have been virtually the same, and the peak level of Rainy Lake would have been about 1 in (2.5 cm) lower than the level actually reached, if the Namakan Lake end-of-March target level had been mid-band instead of 75% of band as directed by the IRLBC.

Response to Rapidly Increasing Inflows

The Board carefully reviewed the adequacy and timeliness of the response by the Companies and itself to the extremely rapid rise in inflow to both lakes this spring, beginning in early April. Throughout the high water event, the Board and Companies maintained close communication on all actions taken. Initial increases in discharge from the dams at the outlets of Rainy and Namakan lakes were aimed at containing both lakes within their respective IJC bands. As rainfall, heavy at times, continued through April and May, discharges were increased until the dam at the outlet of Rainy Lake was nearly wide-open by April 24 (13 of 15 gates, all 15 by May 16) and the dams at the outlets of Namakan Lake were fully open by May 2. On both lakes the dams were fully opened prior to exceeding the IJC “all gates open” level, in compliance with the IJC

Order. The outflows from both lakes were ramped up quickly, but at reasonable rates in light of the limited hydraulic capacity of the Kettle Falls dams at low lake levels, the hydraulic constraint imposed by the natural flow control at Pither's Point, the unpredictability of the volume and the timing of the inflow yet to come, and the impact on downstream interests. Rainy and Namakan lakes were experiencing very high inflow at the same time that the Rainy River below International Falls - Fort Frances was experiencing extremely heavy runoff. Ice cover was still a factor along portions of the Rainy River and especially at its mouth on the relatively constricted Four Mile Bay of Lake of the Woods. There was concern that the increased flows could lead to a significant ice jam as had occurred several years ago. Based upon these factors, the Board found that the actions taken by the companies and itself regarding outflow increases were consistent with the intent and letter of the IJC Order. Overall, the Board's review concluded that no appreciable improvement could have been made in the handling of the event, given the information available at the time.

International Falls Powerhouse Shutdown

The shut-down of the International Falls powerhouse beginning on May 24 and ending on May 31 contributed an incremental increase in the peak water level reached this year on Rainy Lake. The consultant's report found that the powerhouse shut-down caused the level of Rainy Lake to rise approximately 2.5 in (6.4 cm) more than it would have if the shut-down had not occurred. The report noted that the loss of some 7,000 ft^3/s (200 m^3/s) in discharge capacity at the powerhouse, during the shut-down, actually resulted in a loss of only about half that amount in reduced lake outflow capacity due to compensating hydraulic factors in the response of the river and discharge facilities on the Canadian side of the dam in Fort Frances. The report also found that the increased powerhouse discharge capacity from turbine upgrades in the early 1990's resulted in the 2001 peak Rainy Lake level being 2.5 inches lower than it would have otherwise been, assuming the shutdown in both cases. Further, the report found that, if the old turbines were still in place, the peak level in 2001 would have been about 1 in (2.5 cm) higher than actually occurred, even if there had been no shutdown with the old turbines. Thus the modelling indicated that the peak level reached on Rainy Lake in 2001, even with the shutdown, was lower than what would have occurred if Boise hadn't refurbished its turbines.

The Board reviewed Boise's written report providing background information on the powerhouse and its operation as well as an explanation of their actions concerning the shut-down of the powerhouse. The Board believes that the company reacted swiftly and appropriately to shut down the powerhouse under the circumstances in 2001, given the very real safety hazard to hydro personnel of a major ground fault and potential for structural damage to the powerhouse. Structural damage, or electrical shorting of the generators, could have resulted in an extended powerhouse shut-down and the associated loss of discharge capacity for a period significantly greater than a week. The Board believes that the length of the shut-down was minimized by the timely actions taken by Boise. The Board is satisfied with the company's explanation of its actions and reasons for the powerhouse shut-down.

The Board also asked Boise for an explanation of why the powerhouse had been able to stay running in past high water events when the tailrace water level had been even higher than in 2001. The tailrace level had been about 40 cm (15.7 in) higher in 1950 and about 25 cm (9.8 in) higher in 1974 with no apparent problems. In its report, the company was not able to offer a suitable explanation for this situation, citing a lack of availability of hydro personnel associated with Boise's hydro operation in 1950 and 1974, and a lack of any records, log books, reports or any other documentation that would provide insight as to the physical conditions, mitigation measures or risk assessments made at that time. In its explanation, the company took the position that, without such information, it could not know the physical circumstances or risk assessment decisions made in 1950 and 1974, but that it dealt with the situation at-hand using its best engineering and management judgement. In reviewing the initial draft of the company's report, the Board pointed out that such a complete lack of any documentation of past hydro operations did not seem reasonable. The company reiterated its position, as outlined in its report, that essentially this was the best information they could provide, and so the Board has presented it in this report.

Finally, in response to the Board's request, Boise's consultant identified and recommended several areas for an initial study phase to address the risks created by high tailrace levels. These areas, dealing with the structural integrity of the generator hall floor, flooding of the powerhouse, generator pit dewatering and estimation of tailrace levels, are outlined in detail on pages 25-26 of the KGS Report. As discussed on page 5 of the company's report, the company intends to hire a consultant to carry out the KGS recommendations. This process is expected to start in the fall of 2001 and be completed by June 30, 2002, with the IJC being advised of the consultant's findings by July 31, 2002. Based upon the study results, the company plans to develop measures, appropriate to the potential level of risk, to deal with future floods. The Board concurs with Boise's proposed plan of action and believes it to be sound.

4. IMPACT OF THE NEW RULE CURVES GENERALLY, INCLUDING ACTIONS TAKEN TO TARGET FOR OTHER THAN THE MIDDLE PORTION OF THE BAND

Overall, the impact of the new Year 2000 IJC rule curves for Rainy and Namakan lakes in an extreme high water year like 2001 is relatively minor, when compared to what the impacts on lake levels would have been under the 1970 IJC rule curves. In revising its Order for the lakes in 2000, the IJC recognized that the change would result in a slight increase in flood risk in order to achieve an improved balance in lake level management, particularly for environmental purposes such as the fishery. It was also recognized in the Board's October 26, 1999 Final Report on the "Review Of The IJC Order For Rainy And Namakan Lakes" that differences in peak lake levels between the 1970 and 2000 IJC rule curves would be small for large flood events such as this year's event. That report also recommended a trial period of at least 10 years under the new IJC Order in order to gather a variety of data over a sufficiently long time period so as to have an adequate base of information from which to be able to draw meaningful conclusions from a comprehensive assessment. As finally implemented by the Commission, the new Order is subject to review in 15 years or as otherwise determined by the Commission. In addition, the Board's 1999 Final Report recommended that the resource management agencies with responsibilities in the Rainy-Namakan basin implement monitoring programs to collect the necessary environmental data with which to make a future assessment of any environmental benefits and adverse impacts under the new IJC Order. The IJC has encouraged this effort and should continue to do so.

Inasmuch as the 2001 event occurred in only the second year under the new rule curves, represented an extreme event, did not result in levels or flows unanticipated by the extensive study upon which the new Order was based, and the necessary comprehensive environmental data monitoring is not yet in place, the Board determined that it would be premature to perform a detailed assessment of impacts of the new IJC rule curves. Rather, the Board believes that a simple comparison of peak levels under the two rule curve regimes, in response to the actual 2001 inflows, is adequate at this time. On Namakan Lake, the mid-point of the IJC operating band at the end of March is 90 cm (35.4 in) higher with the 2000 rule curves than it was with the 1970 rule curves, and the 75% point with the 2000 rule curves is 108 cm (42.7 in) higher than the 50% point of the 1970 rule curves. On Rainy Lake, there is virtually no difference in the two sets of rule curves at the end of March. The KGS modelling work found that, if Namakan Lake had been at 50% of its 1970 rule curves instead of at 75% of the 2000 rule curves at the end of March (i.e. starting nearly 43 inches lower), and with Rainy Lake at its 50% point as it actually was (no difference in rule curves), the level of Namakan Lake would have peaked about 1 in (2.5 cm) below its 2001 peak and the level of Rainy Lake would have peaked about 3 in (8 cm) lower than its 2001 peak. Although these differences are relatively small, they most likely overestimate the difference that would actually have occurred. This is due to the fact that Namakan Lake was only rarely drawn down to the mid-point of its band with the 1970 rule curves. The 30-year mean end-of-March level on Namakan Lake (ending in 1999) was 18 cm (6.9 in) above the 50% point, and in the last 10 years under the 1970 rule curves (1990-99), the mean end-of-March level was 47 cm (18.4 in) above the 50% point (the 1990-99 minimum end-of-March level was 37 cm or 14.4 in above this point).

The issue of the Board targeting for an end-of-March level at the 75% point in the 2000 rule curve band instead of the 50% point in the same band has been discussed fully in section 3.2. The difference in elevation on Namakan Lake between these two points is 19 cm (7.3 in). The KGS modelling work found that the peak level on Rainy Lake in 2001 would have been about 1 in (2.5 cm) lower if Namakan had started at 50% of band instead of 75% of band.

5. PHYSICAL CHANGES THAT MAY HAVE BEEN MADE SINCE THE ORIGINAL IJC ORDER, WHICH WOULD HAVE REDUCED THE OUTFLOW CAPACITY AT THE FORT FRANCES/INTERNATIONAL FALLS DAM

As discussed in Sections 3.1-3.2, the Board asked Boise Cascade for an explanation of why the powerhouse had been able to stay running in past high water events when the tailrace water level had been even higher than it was in 2001. The tailrace level had been about 40 cm (15.7 in) higher in 1950 and about 25 cm (9.8 in) higher in 1974 with no apparent problems. When this situation developed in late May, the only apparent explanation was that perhaps there had been changes to Boise's outlet works that resulted in lowered outlet capacity. The only factor of which the Board was aware was related to the turbine rehabilitation at Boise's powerhouse in the early 1990's. However, the improved efficiency of the new turbines actually increased the outlet capacity and was a positive compensating factor in the 2001 event. As discussed in Section 3.2, the company was not able to provide an explanation. There are no known physical or structural changes, apart from the normal minor ones that apply to any such aging structure. Thus this question remains unanswered and, without company records documenting the circumstances of hydro operations in 1950 and 1974, it may never be satisfactorily answered.

6. OTHER INFORMATION THE BOARD CONSIDERS RELEVANT

6.1 Communications

Administrative

Throughout the course of this year's high water event, Board staff were in frequent contact with Boise Cascade and Abitibi-Consolidated dam operators regarding decisions and actions taken on lake levels and outflow. Board staff also provided frequent updates on conditions to staff of the IJC. On June 12, a conference call was held between the Board and the Commission regarding conditions and actions taken. On June 12-13, Canadian Board staff inspected high water impacts at the west end of Rainy Lake, the flow constrictions in the upper Rainy River and in the dam forebay area, and high water impacts along the lower Rainy River from the dam downstream to the Baudette / Town of Rainy River area. These staff also met at the same time with staff of the Water Survey Division of Environment Canada, and reviewed their results from flow meterings conducted below the dam.

Public

The Companies actively provided the public with frequent updates on changing conditions and actions being taken through direct contact with callers, via daily and weekly newspaper ads, and via the Boise web site at lakes.bc.com. A similar service was provided by Board staff. Several dozen individuals called the Board staff, seeking information on the event and its causes, and on current and projected water levels. A number of these callers also provided information on damages being suffered, questioned the actions of the Companies and the Board and asked why more couldn't be done, and gave other comments or criticism. In addition to these calls from individuals, Board staff received a number of calls from the media, and over the course of the event provided information to, and answered questions from, newspaper and radio station reporters stretching from Duluth and Thunder Bay in the east to Winnipeg and Grand Forks in the west. The latest hydrologic information was also made available to the public through the Lake of the Woods Control Board web site (www.lwcb.ca) and the St. Paul District Corps of Engineers web site (www.mvp-wc.usace.army.mil). On June 7, when the level of Namakan Lake had peaked and Rainy Lake was very close to peaking, the Board issued a detailed news release regarding both of these lakes and the Rainy River. This provided a description of the event, reported water levels, flows and the actions taken to date, and explained the problems in initially getting water to the Rainy Lake dam due to constrictions in the upper river and thus why it was not effective to open all gates earlier. It also noted that the Board was aware of concerns being expressed by basin residents regarding the regulation of the lakes during the high water event, that the Board would be preparing a report on the causes and handling of the event at the request of the IJC, that all concerns raised would be addressed in the report, and that the report would be made public. The news release also listed the web sites to obtain information and the names and phone numbers of Board staff.

Public Concerns

As mentioned above, some of the callers to Board staff described the damages they were suffering. These included, but were not limited to, dock damage due to uplifting from ice, shoreline erosion (Rainy River and Namakan Chain of lakes), damage to fixed crib docks and attached utilities (electrical power and marine gasoline pumps), flooding of docks and boathouses, limitations on access to docks and resorts, flooding of shoreline property, inconvenience and extra work to use (and keep usable) docks and other shoreline facilities, flood threat to at least one personal dwelling, lost usage of septic leech fields due to high water (Crane Lake), loss of resort business, and loss of commercial floatplane and boat transportation services. Board staff discussed the caller's concerns with them, provided current hydrologic data and lake level forecasts, and tried to get across the message that the variability of inflows provided by nature is greater than our ability to regulate them; noting that water levels will inevitably rise into the hazard land zone around lakes and rivers from time to time, and that property in this zone is consequently at risk.

Concerns or criticisms were also raised by callers regarding the regulation of the lakes during the high water event. Some people were concerned that having the level of Namakan Lake above the mid-point of its IJC operating band, when the rains started, contributed to the high levels. Some were concerned that the new IJC rule curves, which reduced the winter drawdown on Namakan Lake and provided for an earlier refill, contributed to the event. Some were concerned that the sluices in the Namakan and Rainy dams were not opened quickly enough. Some were also concerned that Boise Cascade had to shut down its powerhouse from May 24 through May 31, and thereby reduced the outflow from Rainy Lake for this period. It was also noted that, on the Namakan Chain of lakes, flow constrictions in some of the connecting channels result in the upstream lakes (especially Crane Lake) having a significantly higher water level than the downstream lakes during periods of high inflow. Due to this physical factor, again some felt that the Namakan rule curves should be revised as the level now starts too high in the spring and is raised higher too early.

All but the last point have already been addressed in Section 3 of this report. It was acknowledged that the new rule curves on Namakan Lake, and starting at the 75% point in the band on Namakan, resulted in somewhat higher levels than they otherwise would have been on Rainy and Namakan lakes, but it was shown that the difference was quite small, even with the extreme inflows experienced in 2001. Higher levels of these small magnitudes were recognized in the rule curve study as a consequence of changing the rule curves, and operating higher in them, but were deemed an acceptable tradeoff for the perceived environmental benefits, given the low frequency of occurrence of such inflow events. Regarding the timeliness of opening the dams, it was noted that the initial outflow increases were made very soon after the initial rainfall event, and that further increases were made promptly as more became known about the magnitude of the event. In this regard, it must be remembered that it was impossible to know, in the early days of the event, how much rain would eventually fall. Throwing all gates open immediately at the first sign of rain would be an irresponsible way to regulate, and would have unnecessary and negative impacts in most years. Also, as explained in Section 3, it is not effective to open all gates on Rainy Lake while the lake level is still low. Regarding the shutdown of the Boise powerhouse, it is acknowledged that this was unfortunate and did raise Rainy Lake somewhat, but action is intended to address this in the future, and the impact was offset by the fact that Boise's refurbished turbines pass more water. This leaves the last concern noted above, regarding higher levels on Crane Lake, which is addressed in Section 6.2 below.

August 14, 2001 IJC/Board Presentation To Koochiching County Board of Commissioners

Board and IJC staff attended the August 14 meeting of the Koochiching County Board of Commissioners (United States) at their request. The meeting was also attended by about 40 basin residents, several representatives from Boise Cascade and Abitibi-Consolidated, and a representative from U.S. Senator Paul Wellstone's office. Board and IJC staff gave a presentation on the structure and role of the IJC, hydrologic conditions in the Rainy-Namakan basin in 2001, and regulation of Rainy and Namakan lakes in response to these conditions. The meeting provided a forum for the discussion of concerns held by basin residents as well as the county commissioners. The views expressed included:

- seems to be a relationship between the implementation of the new IJC Order in January 2000 and the fact that the basin experienced high water this year.
- concern that the new IJC Order takes some discretionary authority (under the 1970 IJC Order) to determine lake levels, away from the hydropower companies and gives it to the Board, when some prefer any such discretionary authority to lie with the Companies.
- concern over the targeting of levels other than the middle portion of the band under the new IJC Order and in particular the Board's targeting of higher levels this year on Namakan Lake.
- belief that lake levels should always tend to be at the lower portion of the IJC band on Rainy and Namakan lakes during the end of March and early April to limit flood damage potential.
- concern that the dams at Kettle Falls and the outlet of Rainy Lake were not opened fast enough in response to rapidly increasing inflow this spring.
- belief by county commissioners that regulation of the lakes could be managed better.
- concern that lake levels might some day go even higher than anything experienced to date and what actions should be taken, and by whom, in anticipation of this possibility.

A number of the concerns raised at the meeting have been addressed elsewhere within this report. The remainder are addressed below. Regarding the new Order taking discretionary power from the Companies and giving it to the Board, it was noted in the footnote on page 4 that this had already largely happened with the old Order due to interventions by other parties, which limited the flexibility originally intended by the IJC and provided by the operating band. The intent of this change in the Order was thus to restore to the IJC complete authority over operations within the operating bands, and a mechanism was provided for this to be a consultative process between the IJC's Board and the Companies, albeit with the Board having final say. Regarding the opinion that both lakes should be drawn to their lower rule curves each spring, in order to limit flood damage potential, such an approach would ignore the multi-purpose nature of the lakes. The impetus for the recent rule curve study on Rainy and Namakan lakes, leading up to the new IJC Order, stemmed primarily from the desire of basin interests to find an improved balance in lake level management, particularly for environmental purposes such as the fishery. The new Order is in fact an embodiment of the efforts toward this objective. Further, always drawing to the lower rule curve would negate the whole purpose of having an operating band with some width to respond to basin conditions. The intent is to be able to deviate higher in the band in years with low snowmelt runoff potential, and deviate lower in years with high runoff potential. Always drawing to the lowest allowed level would mean operating the lakes solely for flood management purposes, to the detriment of all other interests in most years. Any decision to target the lower portion of the rule curve bands at the end of March should be based on a threat of flooding from snowmelt, and this was simply not the case in 2001, as discussed in Section 3. Regarding the viewpoint of the county commissioners, it is noted that the Companies and the Board continue to try to do the best job possible with the information at hand, and that both parties are open to comment and input. At the conclusion of the meeting, the Board and IJC staff agreed to meet again with the county commissioners, within the next 6 months or at the Board's annual spring meeting in the basin, to continue discussion of concerns and management of lake levels. Regarding the last point, it is noted that lake levels have been higher in the past than they were in 2001 (see Figures 6 and 11), and the study of hydrology would suggest that they are likely to go higher still at some point in the future. This is a valid concern. The designation of appropriate floodplain or hazard land zones, and provision of emergency response services, normally falls to state, provincial or local governments.

6.2 Hydraulic Capacity Constraints

Certain hydraulic capacity constraints were mentioned in Section 3 regarding the outflow capacity of the Namakan and Rainy lake dams. These are expanded upon here, and the issue of channel constraints impacting water levels in the upper Namakan Chain is also addressed.

Namakan Lake Outlet

The dams at Kettle Falls at the outlet of Namakan Lake are relatively low head dams, particularly at the beginning of April when the lake level normally reaches its lowest point, prior to the spring refill. Under this relatively low head condition, the dam simply does not have enough hydraulic capacity to keep pace with rapidly rising inflow, as was the case this year, and the lake level rises very rapidly. The rise in lake level increases the head on the dam, thereby increasing the outflow. At some point in time, with the outflow increasing as the lake level rises, and possibly in combination with inflows to the lake starting to decline, the outflow becomes equal to the inflow and the lake level then reaches its peak. Levels will then begin to fall if the inflow is declining. This point was not reached this year on Namakan until May 30. Because of this hydraulic capacity constraint at the Kettle Falls dams and the need for increased head from a rising lake level to provide the needed outflow capacity, the peak lake level attained in a high inflow year becomes less and less a function of the starting level in the spring as the magnitude of the high inflow increases. Overcoming this constraint would require a significant enlargement of the existing dams (if physically possible) at tremendous cost and would certainly increase the burden of flood-weary interests on Rainy Lake and further downstream on the Rainy River and Lake of the Woods.

Rainy Lake Outlet

With Rainy Lake, the dam is not actually at the outlet of the lake but is located some 4 km (2.5 mi) down the Rainy River. As noted previously, a natural flow constriction known as the Ranier Rapids exists in the Rainy River near the outlet from the lake at Pither's Point. Under low flow conditions, this is not a significant constraint and the water level surface only has a small slope from the lake to the dam. However, as the dam is opened and flow down the river increases, this constraint (and others along the upper river, including some right in the forebay area) becomes more and more significant. The slope of the water surface down the river becomes much greater, with quite low levels just above the dam. In effect, the river channel becomes the limiting factor to the amount of outflow, and the dam is "starved" of water. The upper river cannot deliver to the dam all of the water that the dam is capable of releasing. Then, as the level of the lake rises, the flow constraints in the upper river become more submerged and provide less resistance to flow, the flow area of the river increases, more water moves down the river, and the slope of the water surface lessens so that the water is deeper just upstream of the dam, which results in more head to push more water through the sluices. Until Rainy Lake reaches higher levels in a large runoff year like 2001, opening dam waste gates in excess of the river's ability to convey water to the dam unnecessarily lowers the forebay levels at both the Boise and Abitibi powerhouses, while providing no increase in outflow. This situation most typically occurs in years of heavy early spring runoff, when Rainy Lake levels have not yet had time to rise substantially above their winter drawdown levels. When it occurs, this situation has the potential to impair the ability of the Abitibi-Consolidated mill to withdraw water for emergency fire control needs. This potential exists whenever the forebay water level at the Abitibi powerhouse falls below about elevation 335.2 m (1,099.7 ft), as the mill firewater intake is located in the forebay area. Further, some of the Abitibi turbines start cavitating (drawing in air, leading to vibration and potentially severe damage if allowed to continue) at a slightly lower level, 335.05 m (1,099.2 ft). Thus opening too many waste gates too early, so as to significantly lower the forebay, is not only of little or no benefit in releasing more water, but could actually result in less water being released if the Abitibi powerhouse must be shut down. Drawing the forebay down below the limit of the fire water intake toward the turbine water level limit does not provide enough additional flow to be worth the risk to the mill. Nevertheless, Abitibi has plans to eventually address this limitation, to eliminate any possibility for loss of emergency supply of water for protection of the mill.

Higher Water Levels in the Upper Namakan Chain

As noted in Section 6.1, property owners on Crane Lake were especially impacted by high levels in 2001 because of the constricted flow channels connecting their area to Namakan Lake proper. While under low flow conditions there may be little difference in water level from the bottom end to the top end of the Namakan Chain, the difference in level increases as the inflow coming down through the system increases. Due to the backwater effect of these constrictions, water levels on Crane Lake may be one or more feet (30 or more centimetres) higher than Namakan levels when inflows are high. Figure 12 is a map of the Namakan Chain of lakes and shows the constricting channels between the main lakes (Namakan and Kabetogama) and the upper lakes (Sand Point, Little Vermillion and Crane).

This backwater effect has been known for many years and is a function of the natural shape and size of the water courses. In most years in the past it has not been a severe problem because inflows are either typically not high enough or occur for only a short time while lake levels are still low. This is most likely to hold true for the future as well. However, little is known or documented about the hydraulics of this part of the system. Some daily level data exists for 1970 through 1980 from an old gauge at the south end of Crane Lake, and a temporary gauge was established at the same location by the U.S. Army Corps of Engineers in 2001, with daily data collected from May 31 through June 20.

With Namakan Lake now starting at a higher level, and being filled earlier, with the new 2000 rule curves in place, there is a possibility that the upper lakes could experience more frequent high water events and/or higher peak levels. Data required to assess this possibility should be collected, and the assessment done, for input into the review of the IJC Order which is to occur either in 15 years time or earlier if deemed necessary. Re-establishment of the Crane Lake gauge, and possibly the addition of other gauges on the upper lakes as well, would be required.

6.3 Floodplain Management, Zoning And Hazard Land Utilization

While a high water event such as experienced in 2001 is relatively rare, with levels at most sites typically not seen since 1968 or earlier, it is noted that higher levels have occurred in the past (see Figures 6 and 11) and will likely occur again at some point in the future. In its contacts and dealings with the various affected interests in the Rainy-Namakan basin concerning this year's high water event, the Board endeavored to provide a perspective on past and present flooding, to foster an awareness of floodplain and hazard land management by the responsible bodies in the U.S. and Canada, and to point out the need for wise and prudent planning of property developments to accommodate periodic high water events.

Although floodplain and hazard land delineations exist to one extent or another in both the U.S. and Canada, there does not appear to be a solid or widespread understanding or awareness by basin interests of these delineations or of the ramifications and responsibilities associated with development within the floodplain or hazard land. Although management of the floodplain and hazard land is the responsibility of local government, it appears to the Board that more work needs to be done in this area to foster understanding and prudent development of the floodplain and hazard land. Shorefront property owners need to understand that the variability of inflows provided by nature is much greater than our ability to regulate it. Hazard lands will be flooded from time to time. The public needs to be aware of the water levels that may occur, take action to limit their incursion into the hazard land zone and, for structures such as docks and boathouses that must be in this zone, recognize that they are at risk and design/construct them to minimize inconvenience and damage when levels do inevitably rise.

7. BOARD RECOMMENDATIONS FOR FURTHER ACTION OR FOLLOW-UP BY THE BOARD OR THE COMMISSION

Based on its review of the 2001 high water event, the Board has the following recommendations:

1) Boise Cascade should proceed with its plans, outlined in its August 2001 report to the Board, to address the risks to its powerhouse created by high tailrace levels. The company should proceed with its initial study phase to examine: the structural integrity of the generator hall floor, measures to prevent flooding of the powerhouse, measures to reduce inflow to the generator pits and improved methods of estimating tailrace levels versus discharge. The company should advise the Board and the Commission of its consultant's findings and the resultant measures it intends to implement as a result of those findings. The company has stated in its report to the Board that it intends to advise the IJC of those findings by July 31, 2002. The Board feels this is a reasonable time-frame to complete the initial study work. A time-line for implementation of recommended measures will depend upon the consultant's findings and should be left open until the Board and IJC have had an opportunity to review the consultant's report.

2) The Commission should continue to encourage the resource management agencies to gather the environmental data that will be needed in any future assessment of benefits or adverse impacts to the environment under the 2001 IJC Order for Rainy Lake and the Namakan Chain of lakes. The gathering of the required environmental data should be given a high priority by the resource agencies.

3) The potential for the upper Namakan Chain of lakes (especially Crane Lake) to experience more frequent high water events and/or higher peak water levels should be evaluated. Data required to assess this possibility should be collected, and the assessment done, for input into the review of the IJC Order which is to occur either in 15 years time or earlier if deemed necessary by the IJC. Re-establishment of the Crane Lake gauge, and possibly the addition of other gauges on the upper lakes as well, would be required. This work would most appropriately be done by, or under the supervision of, the Board and its affiliated agencies, but the required resources must be found.

4) The IJC and the Board should promote awareness of the high water levels to be expected, the limitations of regulation, the necessity for floodplain definition and zoning and the need for minimal development in the floodplain.

8. CONCLUSIONS

The main findings or conclusions of the International Rainy Lake Board of Control regarding the 2001 high water event are:

- the high water levels experienced in the Rainy-Namakan basin in 2001 were due to very heavy and persistent precipitation from early April through to the end of July. Total rainfall during this period was the highest since 1948 (54 years).

- the Companies (Boise Cascade Corporation and Abitibi-Consolidated Incorporated, owners and operators of the dams) and the Board responded to the rapidly increasing inflows in a timely and appropriate manner. The dams on both lakes were opened progressively over time as quickly as was prudent and effective to do so, given the available knowledge of future inflows, impacts on downstream areas, capacity limitations of the Kettle Falls dams due to low head, and flow constraints in the upper Rainy River at low lake levels. The Companies were in full compliance with the IJC Order in handling the first lake level peaks in late May - early June. In handling the second peaks in August, the Companies were in full compliance on Namakan but not quite on Rainy in that equipment breakage caused a delay in getting the last two gates (of 15) fully open.

- the peak level reached on Namakan Lake in 2001 was 341.45 m (1120.2 ft) on May 30. This level was the highest seen on the lake since 1968, the ninth highest level since 1912, was 50 cm (19.7 in) above the IJC upper emergency level and was 35 cm (13.7 in) above the IJC "all gates open" level. The peak level reached on Rainy Lake in 2001 was 338.24 m (1,109.7 ft) on June 9. This was the highest level reached since 1968, the seventh highest since 1911, was 49 cm (19.3 in) above the IJC upper emergency level and was 34 cm (13.3 in) above the IJC "all gates open" level.

- the Board's requirement that the Companies target Namakan Lake higher in its IJC operating band at the end of winter had minimal impact on the peak lake levels. The Board had specified that Namakan Lake be at 75% of its IJC operating band and Rainy Lake be at 50% of its operating band at the end of March in 2001. If both lakes had been at 50 % of their bands (i.e. Namakan would have been 19 cm or 7.3 in lower) prior to the start of the rainfall, there would have been a negligible difference in the peak level of Namakan Lake and the peak level of Rainy Lake would have been about 2.5 cm (1 in) lower.

- the adoption of new rule curves by the IJC in 2000 also had minimal impact on the peak lake levels reached in 2001. On Namakan Lake, the mid-point of the IJC operating band at the end of March is 90 cm (35.4 in) higher with the 2000 rule curves than it was with the 1970 rule curves, and the 75% point with the 2000 rule curves is 108 cm (42.7 in) higher than the 50% point of the 1970 rule curves. On Rainy Lake, there is virtually no difference in the two sets of rule curves at the end of March. If Namakan Lake had been at 50% of its 1970 rule curves instead of at 75% of the 2000 rule curves at the end of March (i.e. starting nearly 43 inches lower), and with Rainy Lake at its 50% point as it actually was (no difference in rule curves), the level of Namakan Lake would have peaked about 2.5 cm (1 in) below its 2001 peak and the level of Rainy Lake would have peaked about 8 cm (3 in) lower than its 2001 peak. Although these differences are relatively small, they most likely overestimate the difference that would actually have occurred. This is due to the fact that Namakan Lake was only rarely drawn down to the mid-point of its band with the 1970 rule curves. The 30-year mean end-of-March level on Namakan Lake (ending in 1999) was 18 cm (6.9 in) above the 50% point, and in the last 10 years under the 1970 rule curves (1990-99), the mean end-of-March level was 47 cm (18.4 in) above the 50% point.

- the Boise powerhouse shutdown near the peak of the high inflows in 2001 had only a small impact on the peak lake levels reached, and this was off-set by turbine-generator refurbishment work done by Boise in the early 1990's. The powerhouse was forced to shut down from May 24 through May 31 due to high tailwater level. This caused the level of Rainy Lake to rise approximately 6.4 cm (2.5 in) more than it would have if the shut-down had not occurred. However, the increased powerhouse discharge capacity from the unit refurbishment resulted in the 2001 peak Rainy Lake level being about 6.4 cm (2.5 in) lower than it would have otherwise been, assuming the shutdown in both cases. Further, if the old turbines had still been in place, the peak level in 2001 would have been about 2.5 cm (1 in) higher than actually occurred, even if there had been no shutdown with the old turbines.

- this was a relatively rare event, about which very little can be done. The variability of inflows provided by nature is much greater than the Companies' (or the Board's) limited ability to regulate them. High levels such as those experienced in 2001 certainly won't occur every year, but even higher levels have occurred in the past and similar or higher levels will occur again periodically in the future. It is important that shorefront property owners be aware of this and take steps to minimize both their risk from such events and their damages when such events do inevitably occur.

- no urgent or major action is deemed necessary in response to this event. However, the work proposed by Boise's consultant to allow their powerhouse to stay operating under similar highwater conditions should proceed, the potential for the new 2000 IJC rule curves to cause more frequent high water events and/or higher peaks on Crane Lake should be assessed, and efforts should continue to have the shoreland hazard land area properly defined and publicised.

Respectfully submitted,

Robert L. Ball, P.E.
Member for the United States

Colonel, U.S. Army Corps of Engineers
District Engineer
St. Paul, Minnesota

Dale R. Kimmett, P.Eng.
Member for Canada

Ottawa, Ontario

REFERENCES

1) "Analysis of Rainy and Namakan Lake Levels During Spring Flood 2001"; August 2001 (cover letter dated August 9, 2001); prepared by KGS Group, Consulting Engineers & Project Managers, Winnipeg, Manitoba; prepared for Boise Cascade Corporation, International Falls, Minnesota

2) "Report of Boise Cascade in response to IRLBC June 11, 2001 Inquiry"; undated (cover letter dated August 2, 2001); prepared by Jay Lofgren, Senior Engineer, Boise Cascade Corporation, International Falls, Minnesota

All precipitation, water level and flow data used herein was taken from the database of the Secretariat of the Lake of the Woods Control Board. At the time of preparation of this report, this data was still provisional and subject to revision.

FIGURES

WINNIPEG RIVER DRAINAGE BASIN

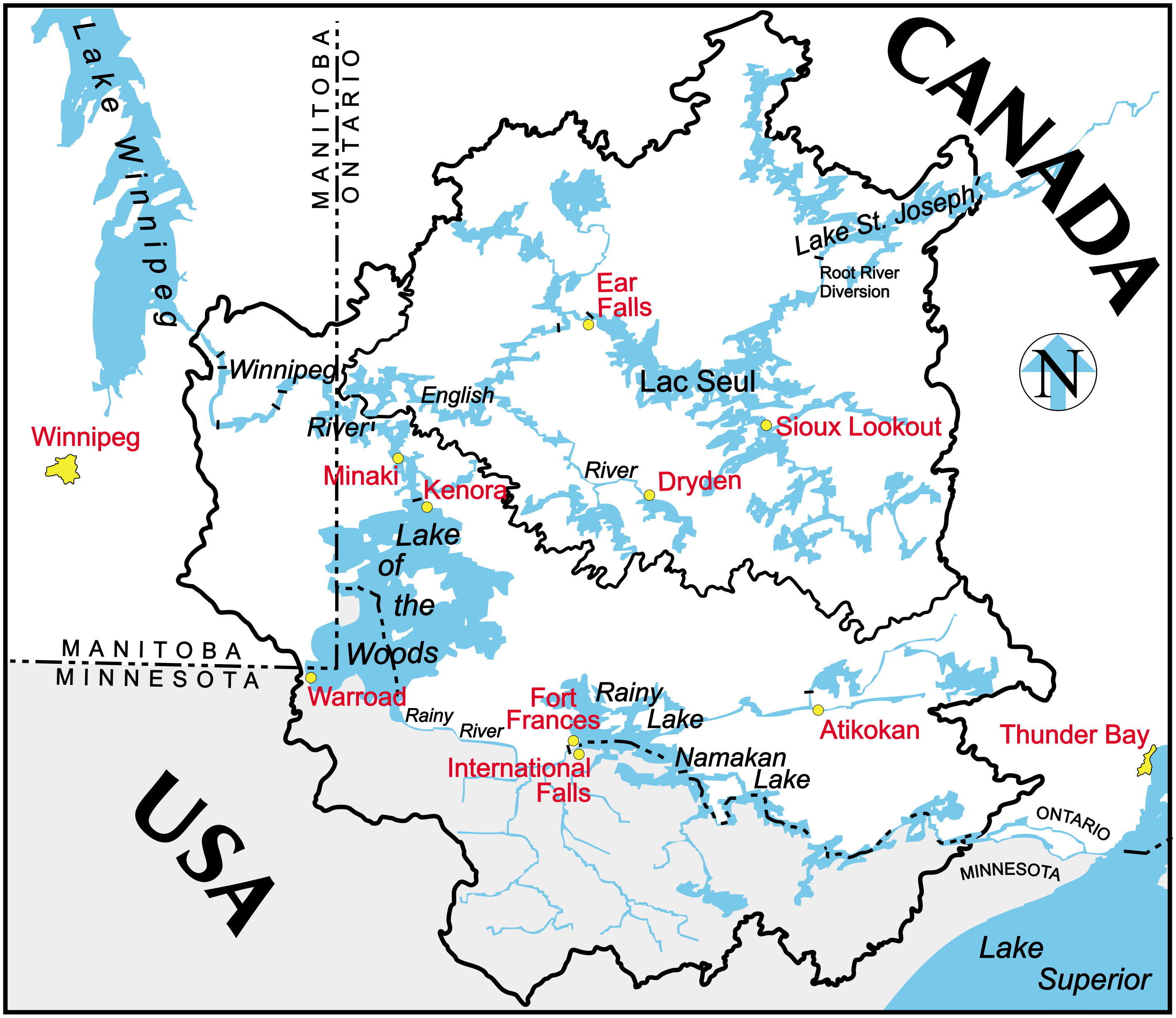
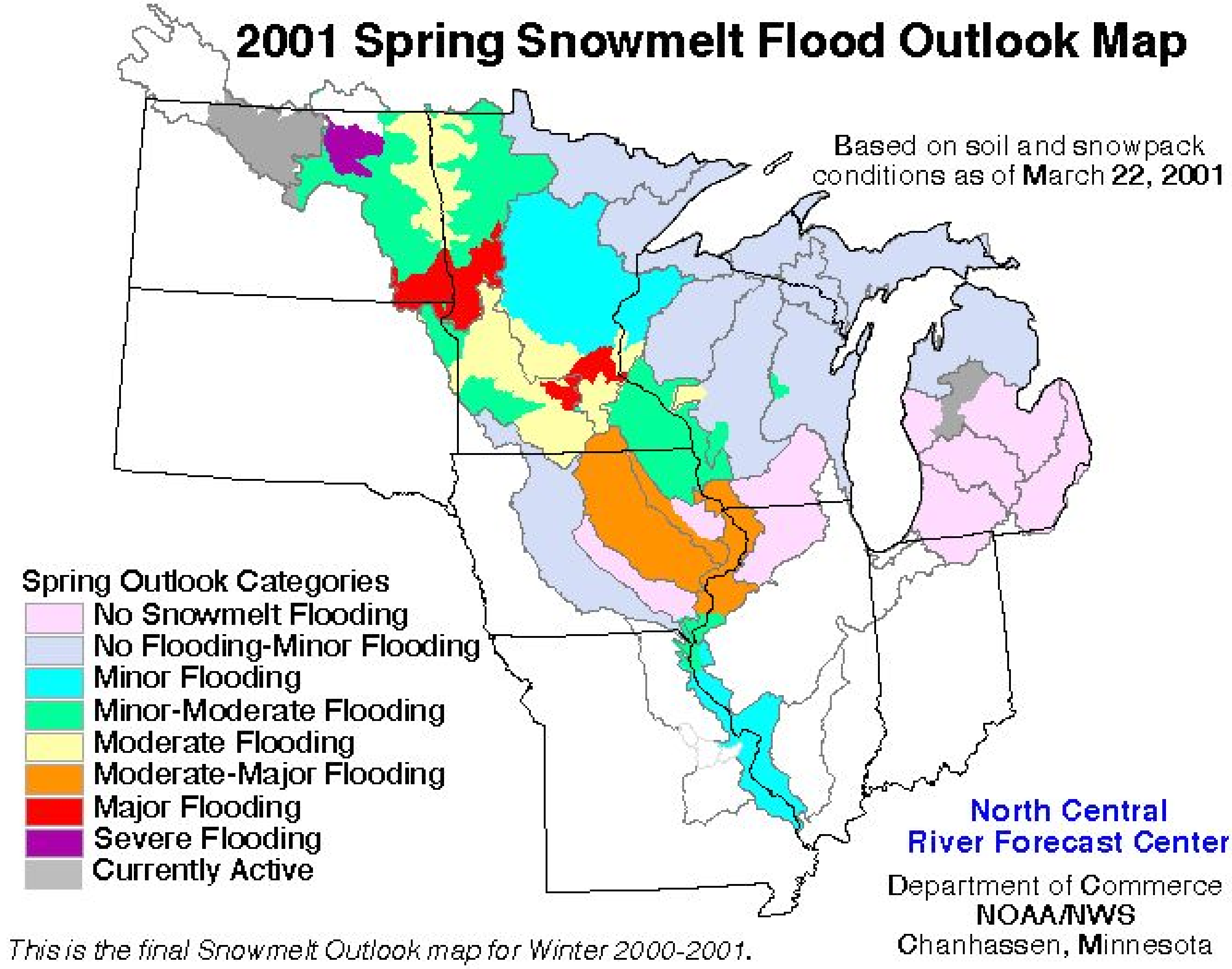


Figure 1



http://www.crh.noaa.gov/ncrfc/flood_outlooks/floodmap.jpg

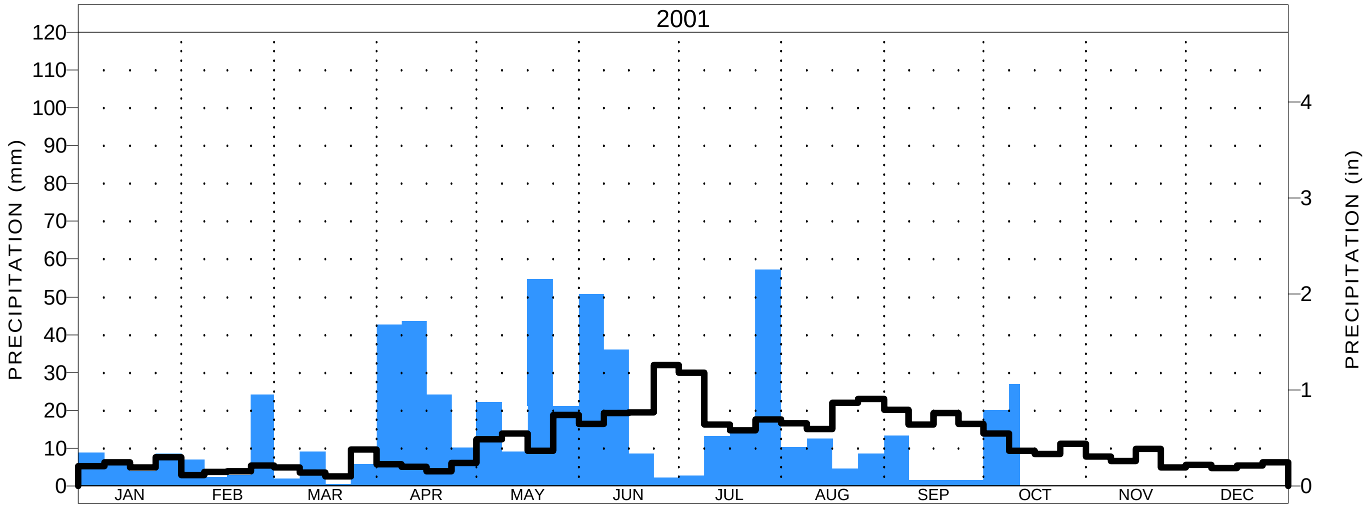
Figure 2

LWCB
Lake of the Woods
Control Board

RAINY BASIN PRECIPITATION

ISSUED: 2001.10.11
** Provisional Data **

LAC LA CROIX BASIN



RAINY-NAMAKAN BASIN

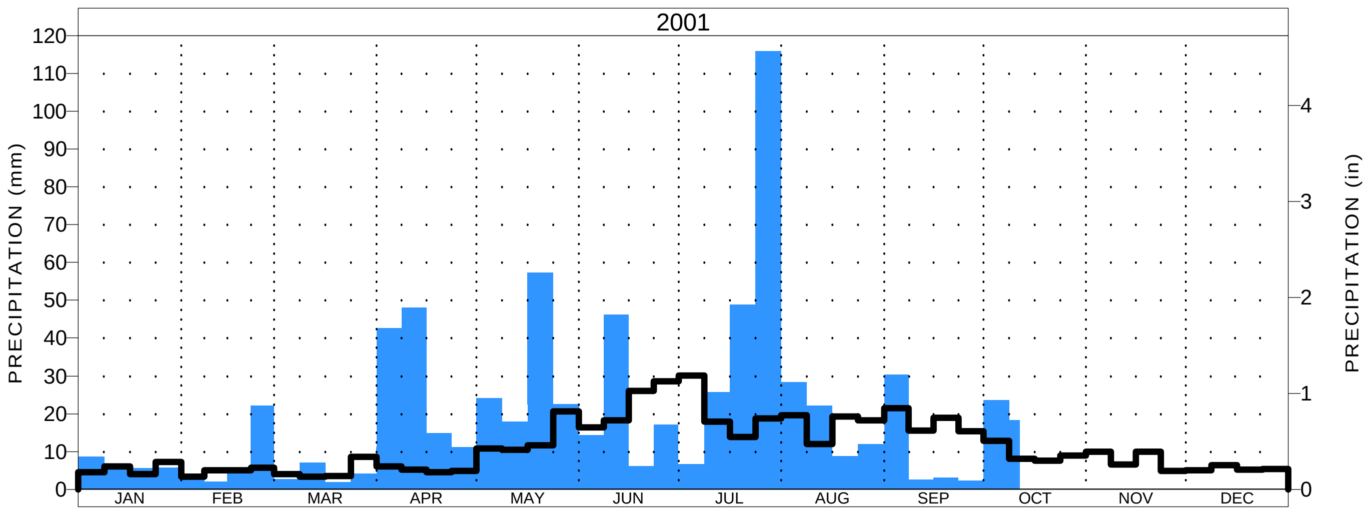


Figure 3

Total Rainfall Ranking

For April Since 1948 (54 years)

	Lac la Croix Basin			Rainy-Namakan Basin		
		Rainfall			Rainfall	
Rank	**Year**	**(mm)**	**(in)**	**Year**	**(mm)**	**(in)**
1	2001	120	4.7	2001	117	4.6
2	1990	107	4.2	1985	104	4.1
3	1994	107	4.2	1967	95	3.7
4	1985	95	3.7	1986	89	3.5
5	1981	91	3.6	1974	84	3.3
6	1967	81	3.2	1968	80	3.1
7	1961	80	3.1	1979	77	3.0
8	1968	73	2.9	1961	71	2.8
9	1970	73	2.9	1957	71	2.8
10	1974	70	2.8	1991	71	2.8
Median		35	1.4		40	1.6

For April-May Since 1948 (54 years)

	Lac la Croix Basin			Rainy-Namakan Basin		
		Rainfall			Rainfall	
Rank	**Year**	**(mm)**	**(in)**	**Year**	**(mm)**	**(in)**
1	1985	241	9.5	1985	245	9.6
2	1970	236	9.3	2001	238	9.4
3	2001	227	8.9	1974	200	7.9
4	1974	193	7.6	1963	192	7.6
5	1994	185	7.3	1977	180	7.1
6	1964	171	6.7	1999	179	7.0
7	1954	167	6.6	1970	177	7.0
8	1981	159	6.3	1962	173	6.8
9	1963	154	6.1	1950	168	6.6
10	1962	152	6.0	1991	148	5.8
Median		113	4.4		105	4.1

For April-July Since 1948 (54 years)

	Lac la Croix Basin			Rainy-Namakan Basin		
		Rainfall			Rainfall	
Rank	**Year**	**(mm)**	**(in)**	**Year**	**(mm)**	**(in)**
1	1970	456	18.0	2001	519	20.4
2	1994	439	17.3	1985	463	18.2
3	1990	436	17.2	1963	458	18.0
4	1985	435	17.1	1950	437	17.2
5	1968	419	16.5	1964	436	17.2
6	1964	418	16.5	1968	427	16.8
7	2001	412	16.2	1999	422	16.6
8	1986	376	14.8	1996	399	15.7
9	1961	373	14.7	1962	369	14.5
10	1999	372	14.6	1969	367	14.4
Median		309	12.2		307	12.1

Figure 4

Average Inflow Ranking

For April-May

		Namakan Lake			Rainy Lake		
	Since	1957	Inflow		1912	Inflow	
Rank		Year	(m^3/s)	(ft^3/s)	Year	(m^3/s)	(ft^3/s)
1		1966	508	17940	2001	875	30900
2		2001	502	17728	1950	875	30900
3		1969	455	16068	1966	865	30547
4		1971	407	14373	1927	860	30370
5		1996	396	13985	1938	789	27863
6		1979	389	13737	1916	760	26839
7		1986	364	12854	1996	709	25038
8		1967	354	12501	1954	697	24614
9		1975	349	12325	1985	694	24508
10		1997	342	12078	1948	679	23979
Median			283	9994		400	14126

Namakan inflow in 1950 estimated to be 466 m^3/s (16457 ft^3/s)

For April-June

		Namakan Lake			Rainy Lake		
	Since	1957	Inflow		1912	Inflow	
Rank		Year	(m^3/s)	(ft^3/s)	Year	(m^3/s)	(ft^3/s)
1		2001	503	17763	1950	1076	37998
2		1966	503	17763	2001	900	31783
3		1969	446	15750	1927	893	31536
4		1996	412	14550	1966	871	30759
5		1979	410	14479	1954	824	29099
6		1970	407	14373	1916	823	29064
7		1971	405	14302	1938	800	28252
8		1974	400	14126	1996	780	27545
9		1968	380	13420	1974	748	26415
10		1965	366	12925	1970	707	24967
Median			303	10700		448	15821

Namakan inflow in 1950 estimated to be 559 m^3/s (19741 ft^3/s)

For April-August

		Namakan Lake			Rainy Lake		
	Since	1957	Inflow		1912	Inflow	
Rank		Year	(m^3/s)	(ft^3/s)	Year	(m^3/s)	(ft^3/s)
1		2001	409	14444	1950	1022	36091
2		1968	408	14408	1927	792	27969
3		1966	368	12996	2001	768	27122
4		1996	355	12537	1968	662	23378
5		1969	348	12289	1996	662	23378
6		1970	340	12007	1944	647	22848
7		1974	322	11371	1916	645	22778
8		1962	307	10842	1966	641	22637
9		1979	304	10736	1985	634	22389
10		1985	302	10665	1954	629	22213
Median			251	8864		406	14338

Namakan inflow in 1950 estimated to be 496 m^3/s (17516 ft^3/s)

Figure 5

Ranking of Annual Peak Water Levels

Namakan Lake (Since 1912)

		Peak Water Level	
Rank	**Year**	**(m)**	**(ft)**
1	1916	342.248	1122.86
2	1950	342.196	1122.69
3	1927	341.970	1121.95
4	1938	341.836	1121.51
5	1968	341.708	1121.09
6	1914	341.538	1120.53
7	1920	341.486	1120.36
8	1944	341.486	1120.36
9	**2001**	**341.445**	**1120.23**
10	1941	341.440	1120.21

Rainy Lake (Since 1911)

		Peak Water Level	
Rank	**Year**	**(m)**	**(ft)**
1	1950	339.233	1112.97
2	1916	339.093	1112.51
3	1941	338.602	1110.90
4	1927	338.438	1110.36
5	1968	338.362	1110.11
6	1938	338.255	1109.76
7	**2001**	**338.240**	**1109.71**
8	1974	338.197	1109.57
9	1954	338.185	1109.53
10	1966	338.157	1109.44

Figure 6

NAMAKAN LAKE

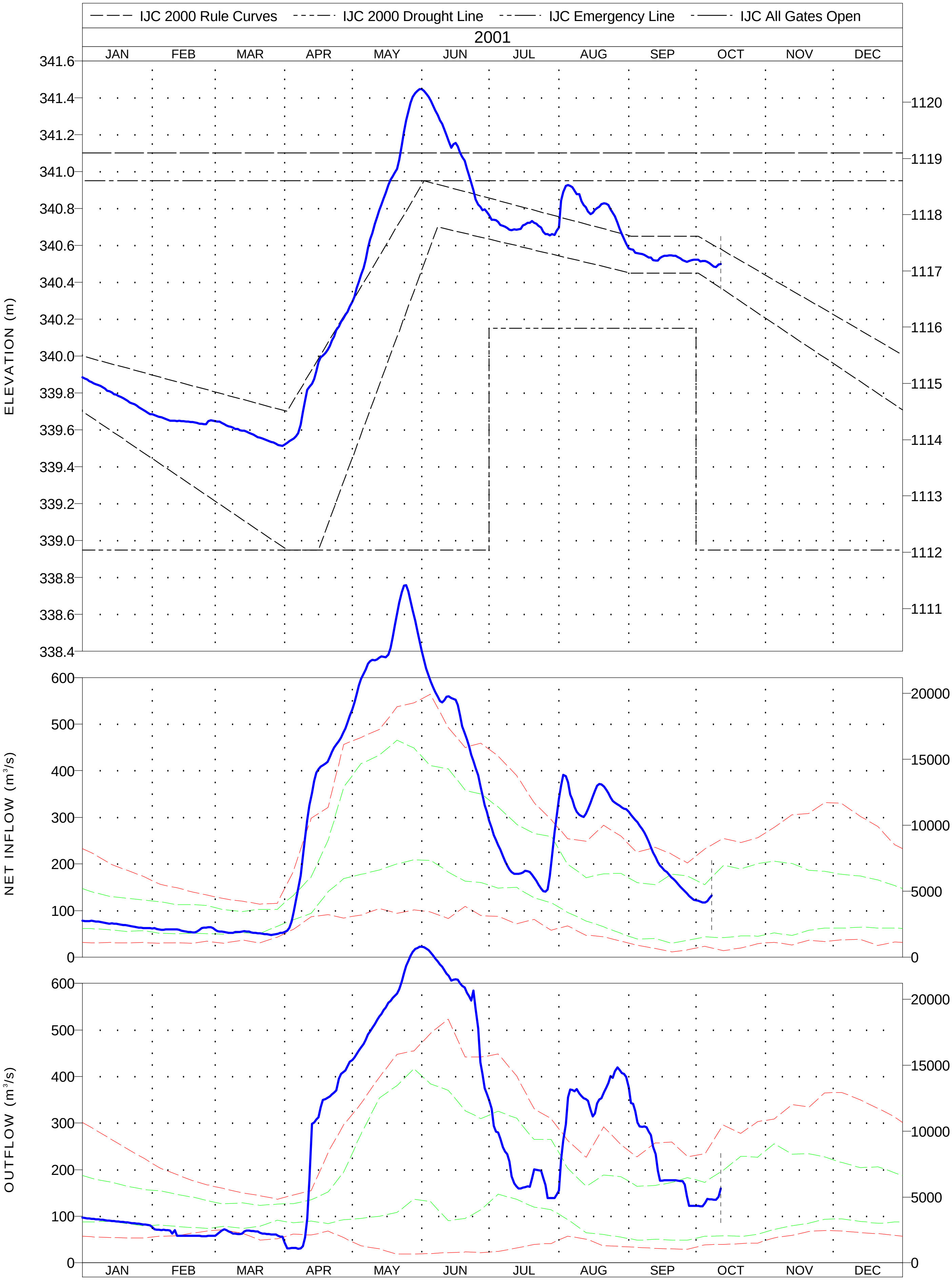


Figure 7

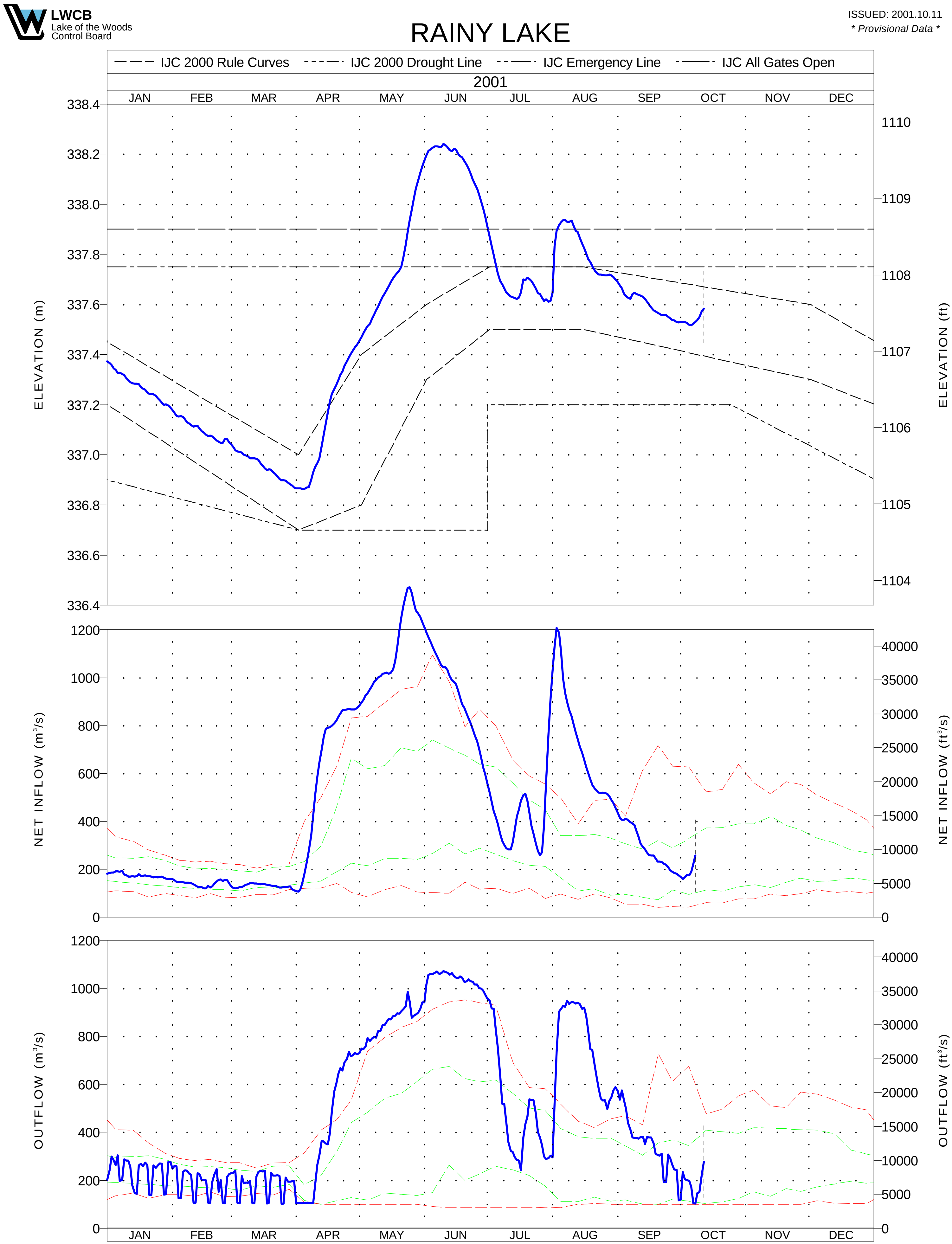

LWCB
Lake of the Woods
Control Board
RAINY LAKE
ISSUED: 2001.10.11
* Provisional Data *
IJC 2000 Rule Curves
IJC 2000 Drought Line
IJC Emergency Line
IJC All Gates Open
2001
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
ELEVATION (m)
ELEVATION (ft)
NET INFLOW (m³/s)
NET INFLOW (ft³/s)
OUTFLOW (m³/s)
OUTFLOW (ft³/s)

Figure 8

LWCB
Lake of the Woods
Control Board

ISSUED: 2001.10.11
Provisional Data

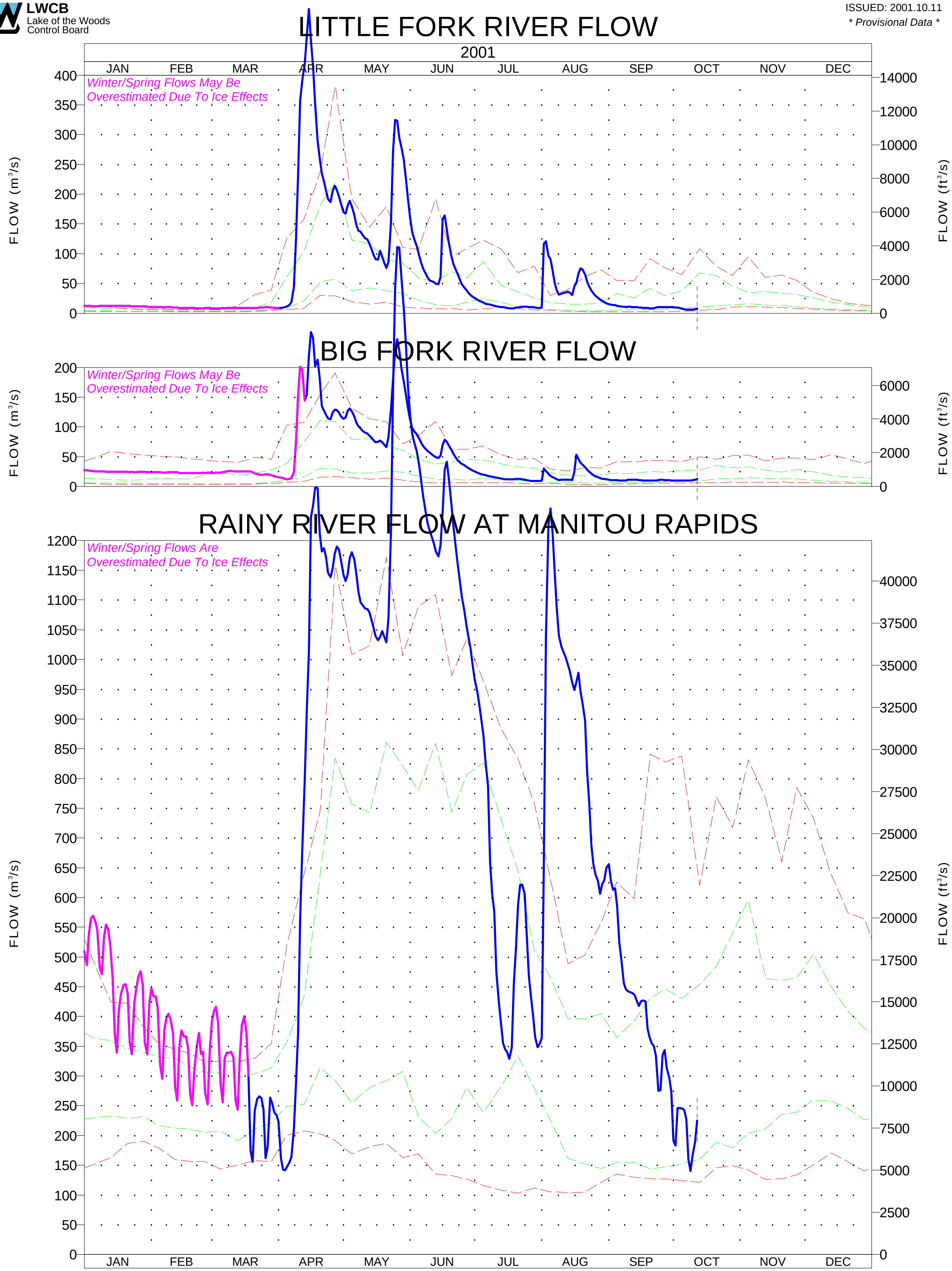
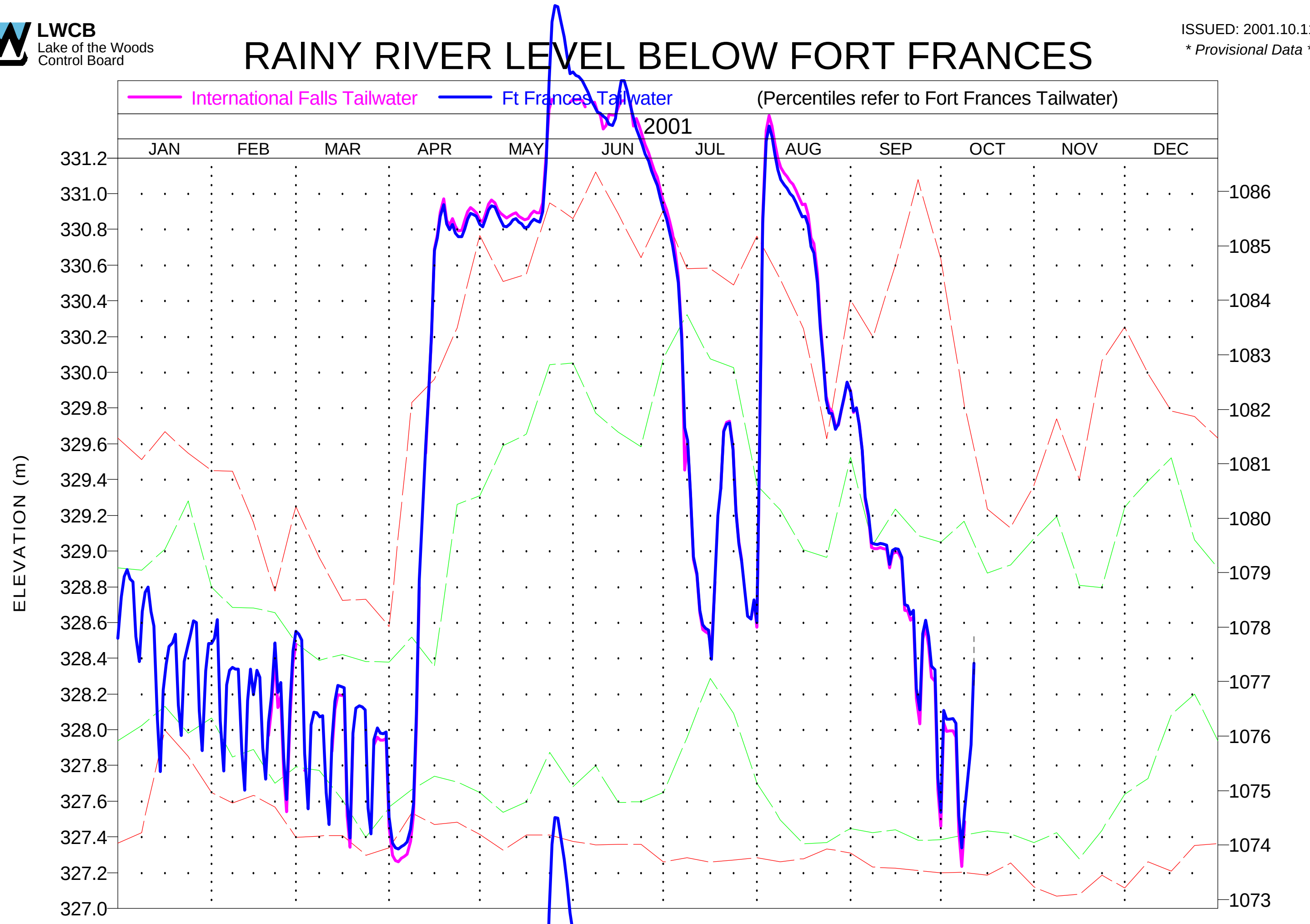


Figure 9

LWCB
Lake of the Woods
Control Board

ISSUED: 2001.10.11
** Provisional Data **



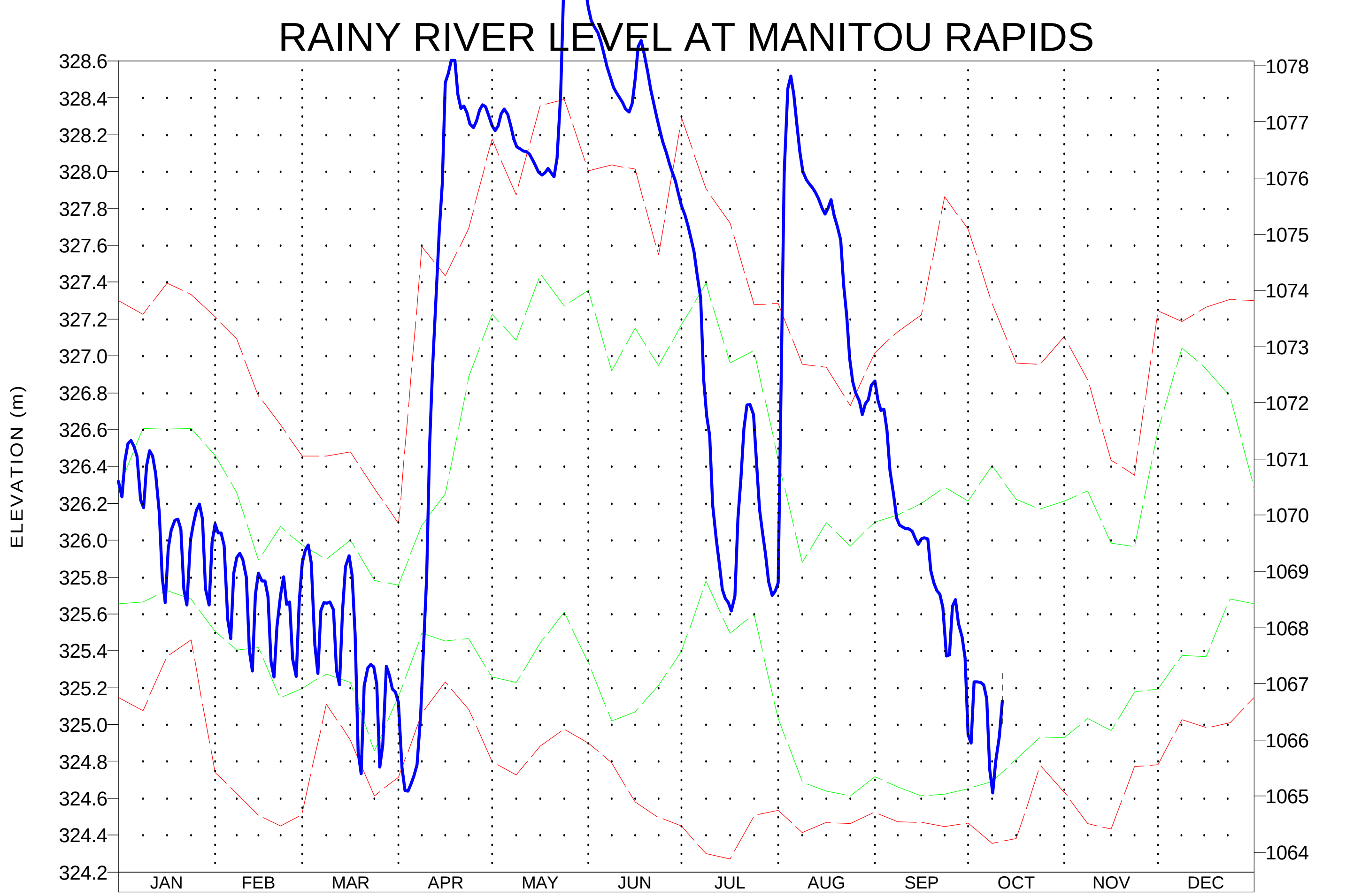


Figure 10

2001 PEAK LEVELS COMPARED TO HISTORIC NORMAL

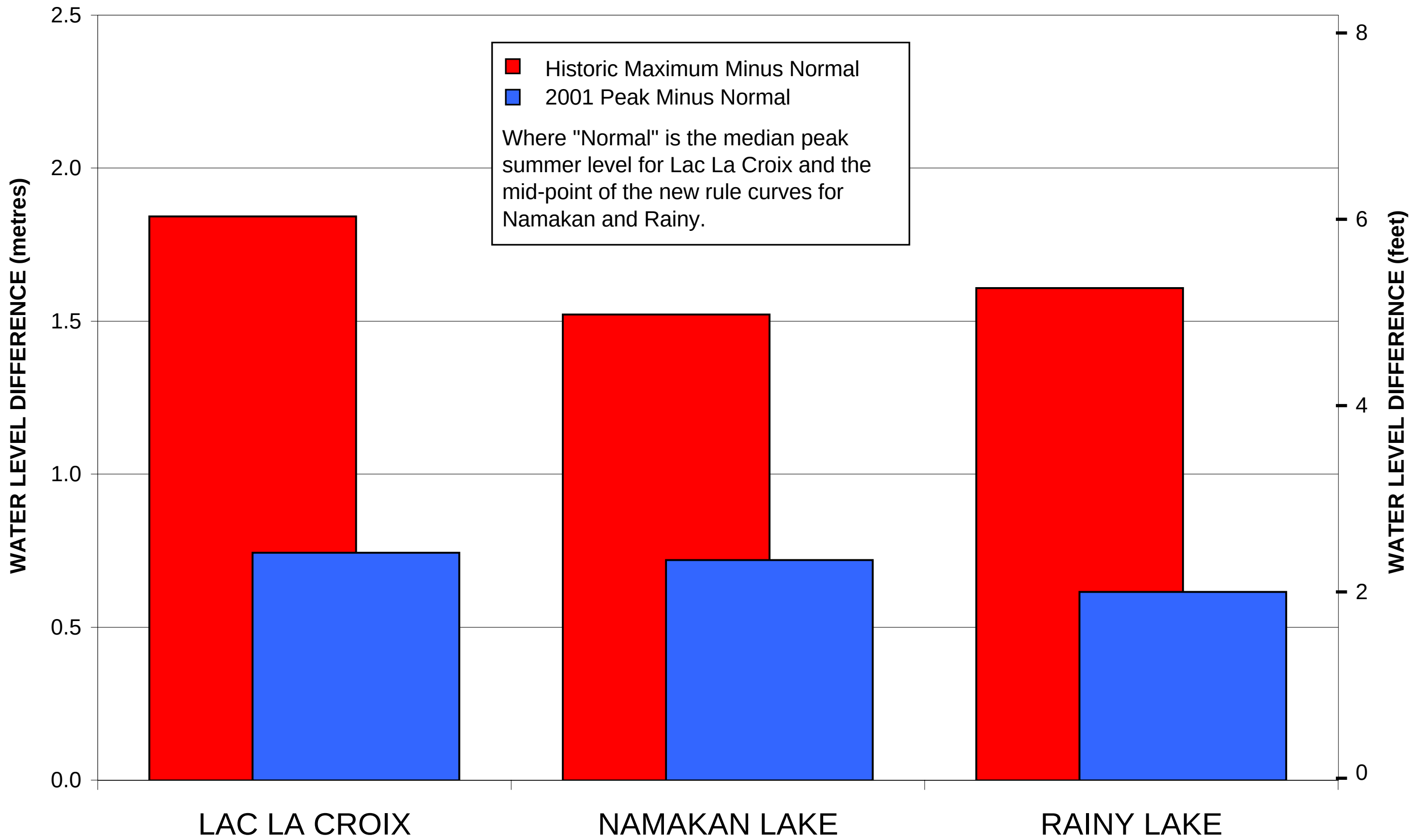


Figure 11

NAMAKAN CHAIN OF LAKES

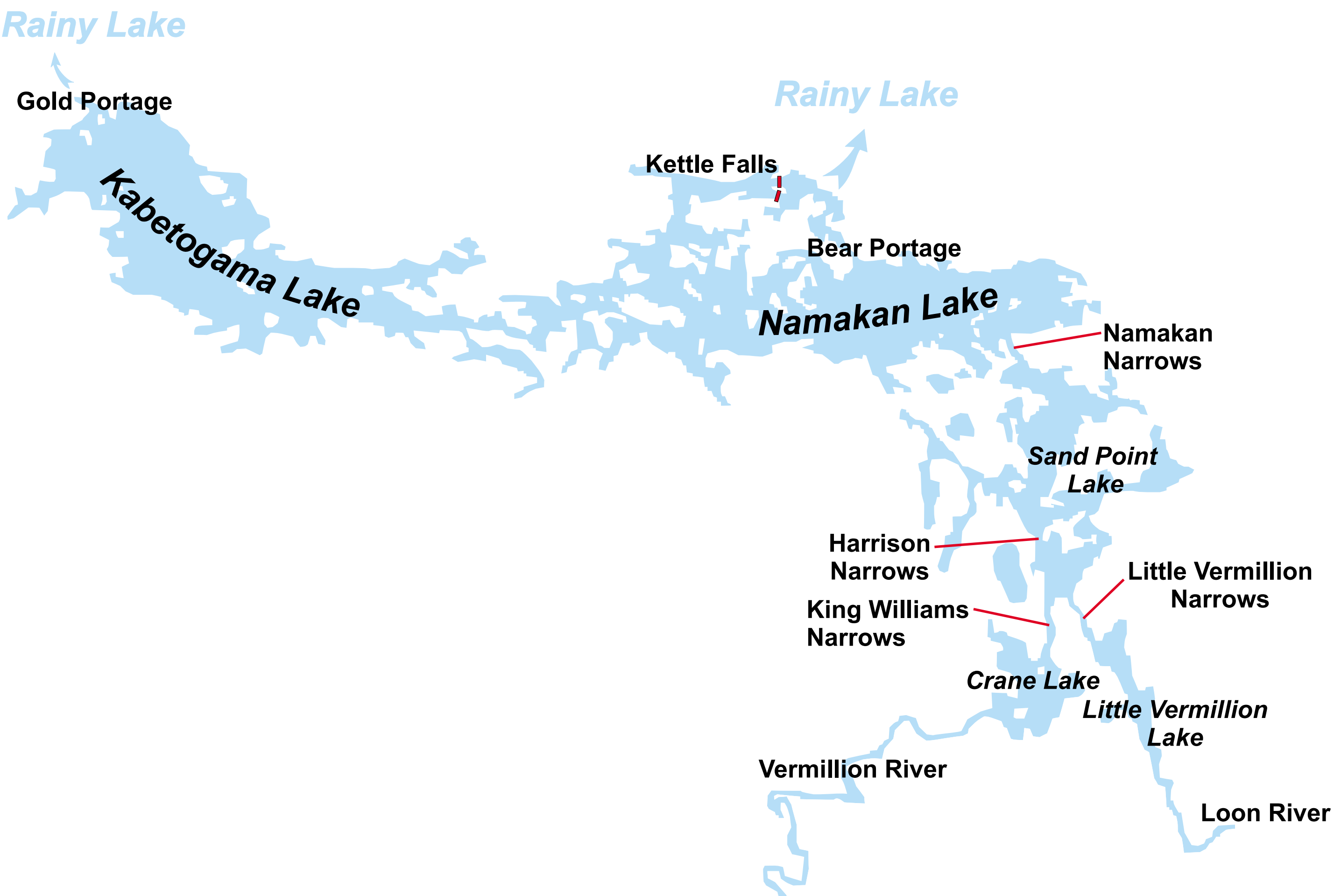


Figure 12

LWCB
Lake of the Woods
Control Board

LEGEND - FOR FIGURES 3 & 7-10

PRECIPITATION

Actual data for year shown, plotted as quarter-month totals
(last quarter-month is usually incomplete)

Statistical Median - precipitation has been below this line 50% of the time

WATER LEVELS & FLOWS

Actual Data

Actual data for year shown
- levels are 1-day main lake means plotted daily
- inflows are 7-day means
- outflows are daily values

- The most recent data is missing if the actual data line does not extend to this vertical line

Rule Curves (Namakan & Rainy Lakes)

IJC 2000 Upper & Lower Rule Curves

IJC 2000 Drought Line

IJC Upper Emergency Level

IJC "All Gates Open" Level

Statistical Data

Level/flow has been above this line 10% of time.

Normal level/flow range
- level/flow has been above this range 25% of time
- level/flow has been within this range 50% of time
- level/flow has been below this range 25% of time

Level/flow has been below this line 10% of time

All statistical levels are based on 3-day means at month quarter points.

All statistical flows are based on quarter-monthly means.

Percent data is based on the period 1970-1999, except for the following:
- Rainy River Level Below Fort Frances 1988-1999
- Rainy River Level at Manitou Rapids 1983-1999

Datums for water levels are:
- Lac la Croix - USC&GS (1912) datum
- Namakan Lake - USC&GS (1912) datum
- Rainy Lake - USC&GS (1912) datum

For other sites, contact the Secretariat