INTERNATIONAL RAINY LAKE BOARD OF CONTROL

IRLBC

REPORT ON YEAR 2002 HIGH WATER LEVELS IN THE RAINY/NAMAKAN BASIN

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TABLE OF CONTENTS

1. INTRODUCTION

In 2002 Rainy and Namakan Lakes experienced high water levels for the second year in a row. The peak level on Namakan Lake was not as high as in 2001, but the peak level on Rainy Lake was 32 cm (12.6 in) above the 2001 peak. Whereas the high levels in 2001 were the result of a series of heavy rainfall events over the whole Rainy-Namakan basin from early April through July, the high levels in 2002 were primarily the result of an extraordinary 2-3 day rainfall event in early June centred on the Rainy basin.

Property owners and visitors to the basin were very frustrated with having to deal with such an occurrence two years in a row, especially when it was understood that the 2001 event was a relatively rare one with a probability of occurrence of, on average, less than once in 50 years. As in 2001, the public questioned the handling of the event by the International Joint Commission (IJC), its International Rainy Lake Board of Control (IRLBC) and the owners of the dams, Boise Cascade Corporation in the United States of America and Abitibi-Consolidated Inc. in Canada. The public also questioned whether the new "rule curves" adopted by the IJC in January 2000 might be worsening the situation, since high levels had now occurred in 2 of the 3 years of their existence.

This report has been prepared for the IJC by the Board to document the event, to explain its cause and the actions taken by the Board and the Companies, to present the results of simulation modelling of the lakes conducted to assess the handling of the event and the impact of the new rule curves, and to draw conclusions and make recommendations as appropriate. The Board suggests that readers of this report also read the Board's report on the 2001 event, as it contains information (such as lake outflow constraints) relevant to both events that is not repeated herein.

2. 2002 HIGH WATER EVENT

Overview

Rainy Lake and the Rainy River experienced very high water levels and flows during the late spring and summer of 2002. This event was driven by extraordinarily heavy rainfall on June 9-10 and additional heavy rainfall on June 22-23. This followed a very dry spring with little snowmelt or rainfall runoff and with Rainy and Namakan Lake outflows at or near their minimums through much of the period. Late June reductions in Namakan Lake outflow, aimed at providing some relief to high Rainy Lake levels, along with localized heavy rainfall on July 4-5 over the Namakan Chain of Lakes, gave rise to concerns on those lakes. Extraordinary runoff from the Canadian tributaries to the Rainy River in response to the June 9-10 rainfall threatened the Town of Rainy River, Ontario and led to a June 12, 2002 IJC Supplementary Order for Rainy Lake. Actions taken by the Board under the June 12 Order allowed time for the Town to complete its emergency flood protection, averting serious flooding of that community. The added runoff from the June 22-23 rainfall event further exacerbated already high Rainy Lake levels, increasing high water concerns on Rainy Lake. Near the end of June, rising tailwater levels in the Rainy River below the Rainy Lake dam caused flooding of the Boise powerhouse at International Falls, Minnesota and led to safety concerns over its continued operation. In response to the high water concerns on Rainy Lake and at the Boise powerhouse, the IJC issued a June 28, 2002 Supplementary Order for Namakan Lake. This Order was aimed at providing some relief to the high water levels on Rainy Lake by reducing Namakan Lake outflows, while Rainy Lake remained significantly in excess of its IJC upper emergency level, taking into account conditions on Namakan Lake and upstream, on Rainy Lake and downstream, and at the Boise powerhouse.

On Rainy Lake the 2002 peak level was the highest since 1950, but the Namakan Lake peak level was only the 24th highest since 1913. Both lakes exceeded their IJC upper emergency levels (the highest point on the upper rule curves) and "all gates open" levels as defined by the IJC. Tributary inflow into Rainy Lake from the unregulated Turtle River to the north and the Seine River to the northeast were the highest of record. Environment Canada has estimated that the 2002 peak flow on the Turtle River near Mine Centre, Ontario had an estimated return period of 500 years and that a return period greater than 500 years would not be unreasonable for the 2002 peak flow on the Atikokan River (tributary to the Seine River) at Atikokan, Ontario. Anecdotal evidence suggests that the 2002 event produced the highest levels and flows ever experienced by anyone now living in the region for the smaller tributaries (the La Vallée, Sturgeon, Pinewood, Rapid and Winter Road Rivers) to the Rainy River. All of these rivers overflowed their banks and flooded vast areas of their floodplains, causing flooding of property and homes. This sudden and heavy tributary runoff resulted in an unprecedented rise in river levels in the lower reaches of the Rainy River at the Town of Rainy River and the City of Baudette, Minnesota, creating a flood threat to those communities. At Fort Frances, Ontario the timing of backwater effects from this runoff, as Rainy Lake outflows were nearing their peak, led to the highest tailwater level at the Rainy Lake dam since the 1950 level, exceeding that level by 3 cm (1.2 in).

Figures in support of the following description of the 2002 high water event can be found in Appendix B. In particular, Figure 1 shows the quarter-monthly precipitation while Figures 2 and 3 show the levels, inflows and outflows for Namakan and Rainy Lakes respectively. A legend for these and other figures can be found after the final figure.

End-of-Winter Conditions

Hydrologic conditions at the beginning of April in the Rainy-Namakan basin consisted of well below normal water content in the little snowpack that remained (snow depths were generally less than 4 inches over most of the basin), below normal soil moisture and well below normal base-flow in the basin's rivers and streams. The northern Minnesota portion of the basin was classified as abnormally dry, according to the US Drought Monitor (see Figure 4), a cooperative effort of a number of US federal agencies including the Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA). As shown on Figures 2 and 3, respectively, water levels on Namakan and Rainy Lakes began April at mid-band. With the continued decline in inflow through March from the very dry conditions, outflow from both lakes was reduced to near minimums by the end of the first week in April in order to maintain lake levels in the middle portion of the IJC rule curve band.

Rainfall

The very dry conditions in the Rainy-Namakan basin continued into early June, although April-May rainfall was only slightly below normal. On June 9-10, the basin received the first of two significant rainfall events in June; the second followed on June 22-23.

The June 9-10 rainfall event was extraordinarily rare in its intensity and geographical extent. A detailed report on this event is currently being prepared by the Meteorological Service of Canada (MSC), part of Environment Canada. According to an early draft of this report (entitled "The 49th Parallel Severe Rainstorm, Floods, and High Water Events of June 2002"), a west to east surface frontal boundary from North Dakota across northern Minnesota and Wisconsin remained nearly stationary through the period and provided the focus for an extended period of elevated convective storms. The frontal system was fed by very warm and moist air from the Gulf of Mexico, which was forced upward over the front by a strong and persistent low-level jetstream flow. The highest rainfall rates occurred on June 9 and 10, associated with intense thunderstorms. MSC analysis referenced in the report support the deduction that training thunderstorm cells resulted in a continuous band of high rainfall from the Red River of the North to just southwest of Upsala, Ontario, with totals of 200-400 mm (8-16 in), and producing significant accumulations along an east-west axis across the Lake of the Woods and Rainy Lake basins. Accumulations diminished to the south and east of Lac La Croix and towards the northerly regions of the Lac Seul basin. The MSC report notes that the one-day rainfall totals from this storm greatly exceeded the storm totals of the previous record days for Atikokan and Mine Centre, the only two Canadian climatological stations in Ontario near the rainfall maxima having a period of record of at least 20 years. The three-day (8-11 June 2002) totals for Atikokan and Mine Centre were 194 mm (7.6 in) and 293 mm (11.5 in) respectively. These new record 24-hr rainfalls also greatly exceeded the record 24-hr rainfalls at nearby Ontario MSC climatological stations at Fort Frances and the Kenora Airport (both long-record climatological stations), which previously had 24-hr record rainfalls of only 128 mm (5.0 in) each. Rainfall records have been kept at the Fort Frances and the Kenora Airport stations since 1892 and 1939, respectively.

Figure 5 gives a clear picture of the widespread nature of the rainfall in the Lake of the Woods and Rainy-Namakan basins from the June 9-10 rainfall event. It also clearly shows that the heaviest rainfall amounts fell over Rainy Lake and its tributaries, particularly the Turtle and Seine Rivers to the north and east, and over Rainy River and its tributaries (primarily the La Vallée, Sturgeon and Pinewood Rivers to the north and the Rapid and Winter Road Rivers to the south). Namakan and Kabetogama Lakes received lesser but significant amounts directly, while their tributaries and the further upstream portion of the basin were not greatly affected.

According to the Minnesota Department of Natural Resources (MDNR), a 48-hour rainfall total of 165 mm (6.5 in) in the northern Minnesota portion of the Rainy-Namakan basin has a one percent probability of occurrence. Historically, rainfall events of similar intensity and spatial extent have occurred only twice in the last 30 years in this region. On June 9 and 10, hundreds of square miles exceeded this threshold, with some communities receiving more than one half of their total normal annual precipitation during this two-day period. The storm had an immediate and significant impact on Rainy Lake and the Rainy River, pushing flow in some of their respective tributaries to record levels.

The June 22-23 rainfall event, while not nearly as heavy as the June 9-10 rainfall, was significant nonetheless. Beginning on Saturday, June 22 and continuing into Sunday June 23, heavy rains of 50 to 100 mm (2-4 in) fell again over the western portion of the basin, exacerbating high water conditions. In addition, localized heavy rainfall on July 4-5 over the Namakan Chain of Lakes gave rise to concerns on those lakes. While not extraordinary by any measure, this rainfall came at a most inopportune time, complicating efforts to provide some relief from the high water levels on Rainy Lake by reducing the outflow from Namakan Lake. The heaviest rainfall of 38 mm to 76 mm (1.5-3.0 in) was concentrated in a very narrow band along the international border, with amounts rapidly diminishing to less than 13 mm (0.5 in) a short distance to the north and south of the border.

For the month of June, the local Rainy-Namakan basin received 238 mm (9.4 in) of rainfall, which was about 2.3 times the normal amount. This number considerably understates how much higher the northern and western portions of the basin were above normal as it is an average for the entire basin; the southern and extreme eastern portions received far less rainfall. By way of contrast, the Lac la Croix basin, upstream of Namakan Lake in the southeastern portion of the Rainy-Namakan basin, received 127 mm (5 in) of rainfall, which was only about 1.2 times the normal amount. Quarter-month rainfall totals for 2002 to date are shown graphically for both basins in Figure 1. The ten highest ranked Lac la Croix and Rainy-Namakan basin monthly rainfall totals for June, since 1948, are tabulated in Figure 6. As shown, the June 2002 Rainy-Namakan basin total was the highest June total since 1948 while the Lac la Croix basin total was only rank 18 for the same period.

For some communities in the northern and western portions of the Rainy-Namakan basin, June 2002 will go down in history as the wettest month ever. June rainfall totals for many locations in this area ranged from

255 to 305 mm (10-12 in), with amounts of up to 428 mm (16.8 in) measured (see Figure 7). June 2002 rainfall totals exceeded historical averages ("normal") by more than 150 mm (6 in) in many locations, by more than 300 mm (10 in) in some locations, and in some locations exceeded one half of the normal annual precipitation. June 2002 precipitation totals ranked at or above the 99th percentile for much of the northern and western portions of the Rainy-Namakan basin.

Namakan Lake

In response to the June 9-10 rainfall, Namakan Lake inflows rose rapidly from 122 m^3/s (4,310 ft^3/s, a 1 in 7 year low value) in early June to a peak of 282 m^3/s (9,960 ft^3/s) on June 16 (see Figure 2). Inflows then fluctuated between 208 m^3/s (7,350 ft^3/s) and 277 m^3/s (9,780 ft^3/s) through the first week in July, when they declined dramatically due to the onset of very dry conditions that persisted through the first week in August. Average inflow to Namakan Lake was quite unremarkable for the month of June, ranking only 33rd since 1957, as shown in Figure 6. This figure compares the highest ranked and 2002 June inflows for Namakan Lake and Rainy Lake respectively (note that Rainy inflow data is available since 1912, while Namakan data is only available since 1957).

Until the very heavy rainfall of June, the level of Namakan Lake remained near the middle portion of its IJC rule curve band, although not without some difficulty. The very dry early spring conditions had required the Companies to reduce lake outflow to near the 30 m^3/s (1,059 ft^3/s) minimum in early April with subsequent outflows remaining low until early June. In response to the June 9-10 rainfall, Namakan Lake levels rose about 15 cm (6 in) in 18 hours from about noon on June 10 to about 6 AM on the June 11, exceeding the IJC upper emergency level (the highest point on the upper rule curve). At the same time, inflow more than doubled from about 122 m^3/s (4,310 ft^3/s) to 282 m^3/s (9,960 ft^3/s). The Companies responded by increasing Namakan Lake outflow, but only moderately, based upon the Board's advice, so as to not further exacerbate the rapidly rising Rainy Lake levels. With this point in mind, Namakan Lake outflow was held nearly steady until June 27, while the Namakan Lake level drifted in a narrow range just above its upper rule curve.

As Rainy Lake levels rose into June 27, many local property owners, local officials and the Companies had called for more water to be stored in Namakan Lake in an attempt to provide some relief for the high water conditions on Rainy Lake. The Board had considered this action on several occasions, but felt it inadvisable to take such an action up to that point in time. This was due to the increased risk of flooding on Namakan Lake that would have resulted from the loss of flood storage for potential storm runoff in light of the very unsettled weather patterns exhibited throughout most of June. Also, with Rainy Lake having roughly four times the storage capacity of Namakan Lake, any increase in Namakan Lake levels would produce only about one-fourth as much in lowered Rainy Lake levels (i.e. 30 cm or 12 in of storage on Namakan Lake is roughly equivalent to 8 cm or 3 in on Rainy Lake). However, concerns over the continued rise of Rainy Lake to levels not seen since 1950, and concerns over flooding of the Boise powerhouse at International Falls from rising tailwater conditions, led to the issuance of an IJC Supplementary Order for Namakan Lake on June 28, 2002. This Order authorized the IRLBC to direct the Companies to deviate from the requirements of the Commission's Consolidated Order of January 18, 2001 for Rainy and Namakan Lakes by limiting the outflows from Namakan Lake while Rainy Lake remained significantly in excess of its IJC upper emergency level, taking into account conditions on Namakan Lake and upstream, on Rainy Lake and downstream, and at the Boise powerhouse.

Under the terms of the June 28 Supplementary Order and with the prior approval of the IJC, the Board directed the Companies on June 27 to take steps to raise the level of Namakan Lake, as soon as possible, to the IJC "all gates open" level of 341.1 m (1119.1 ft). In spite of the requests of some basin interests to intentionally raise Namakan Lake levels as much as 30.5 cm (12.0 in) to provide relief to Rainy Lake, the

Board decided upon a more cautious approach and targeted a rise of about 13.4 cm (5.3 in) above the June 27 level of 340.97 m (1118.6 ft). This action was taken by the Board in view of a dramatic improvement in the weather outlook and a marked decline in the rate of rise of Rainy Lake. Short-term weather projections called for dryer conditions over the following 5-7 days, somewhat reducing the flood risk for Namakan Lake, and the decline in Rainy Lake's rate of rise increased the effectiveness of the Namakan lake outflow reduction to halt any further rise in Rainy Lake. The Board considered the effectiveness of Namakan Lake outflow reductions to relieve the flooding situation at the Boise powerhouse. It was determined that such a reduction would be of little value for that purpose since it would not be possible to reduce Rainy Lake outflows by a similar amount, given that Rainy Lake was still rising. Relief of the powerhouse flooding was dependent on the tailwater levels in the Rainy River, which were known to be peaking on June 27. By June 30 the Namakan Lake level had reached elevation 341.07 m (1119.0 ft), but fluctuations in inflows made it difficult for the Companies to attain the desired level of 341.1 m (1119.1 ft). The lake level hovered just below the "all gates open" level for the next 4 days, until heavy rainfall on July 4-5 caused the lake level to rise sharply.

The July 4-5 rainfall of 38-76 mm (1.5-3.0 in) over the Namakan Chain of Lakes came at the worst possible time, following the intentional increase in Namakan Lake levels to help Rainy Lake. This rainfall pushed Namakan Lake levels up about another 12 cm (4.7 in), peaking on July 6 at 341.19 m (1119.4 ft) or about 9 cm (3.5 in) above the IJC "all gates open" level and 24 cm (9.4 in) above the IJC upper emergency level. This was only the 24th highest level reached since 1913 (see Figure 6, which includes a ranking of the highest and 2002 Namakan Lake levels since 1913). In response, the Board authorized a doubling in the outflow from Namakan Lake on July 5, up from 130 m^3/s to 260 m^3/s (4,590 ft^3/s to 9,180 ft^3/s). On July 6 the Board authorized a further increase in Namakan Lake outflow from 260 m^3/s to 330 m^3/s (9,180 ft^3/s to 11,650 ft^3/s). This action was taken to halt the rise in Namakan Lake levels and initiate a gradual reduction in those levels, without unduly exacerbating already high water levels on Rainy Lake downstream. In response to these outflow increases, Namakan lake levels declined rapidly. By July 16 the lake level had fallen to elevation 340.9 m (1118.4 ft), down 31 cm (12.2 in) from its July 6 peak of 341.19 m (1119.4 ft), 22 cm (8.7 in) below its IJC "all gates open" level, 7 cm (2.8 in) below its IJC upper emergency level, 2 cm (0.8 in) above its upper rule curve and was continuing a downward trend. In light of the continued decline in the level of Namakan Lake, which was nearing the upper end of its normal operating band for the time of year, the Board authorized outflow reductions from the lake on July 16 and 19 to allow for a more gradual tapering of the level of Namakan Lake back into its operating band, while providing an additional small increase in the rate of decline of Rainy Lake. The lake returned to within its rule curve band on July 20, after 5 days above the "all gates open" level, 21 days above the IJC upper emergency level and 38 days above the upper rule curve. On July 22 the Board authorized the Companies to target Namakan Lake levels in the range of 80% to 90% of its rule curve band. This action was taken to allow for a continued gradual decline in the level of Namakan Lake within its rule curve band without unnecessarily discharging added water into the still high Rainy Lake. On August 6, 2002, the IJC revoked its Supplementary Order of June 28, 2002, after being advised by the Board that the conditions requiring the Supplementary Order no longer existed. Subsequently, Namakan Lake levels remained within their IJC operating band.

Rainy Lake

Rainy Lake inflows also rose very dramatically in response to the extraordinary June rainfall. From only 196 m^3/s (6,920 ft^3/s, a 1 in 5 year low value) on June 8, inflows rose to a peak of 1,920 m^3/s (67,700 ft^3/s, maximum of record since 1912) by June 16, just 8 days later (see Figure 3). This led to the most rapid rise in Rainy Lake levels ever experienced by far. Average inflow to Rainy Lake for June was the second highest since 1912, exceeded only by June of 1950, as shown in Figure 6. Prior to the very heavy rainfall of June, the level of Rainy Lake had remained within its normal range near the middle portion of its IJC rule curve band, although, as with Namakan Lake, this was not without some difficulty. Due to the very dry early spring conditions the Companies had reduced lake outflow in early April to its IJC minimum of 100 m^3/s (3,530 ft^3/s) in order to hold Rainy Lake levels near the middle portion of the rule curve band. Rainy Lake outflow remained at its IJC minimum until the very heavy rainfall event of June 9-10, which caused a sharp rise in lake inflows and levels.

Runoff from the unregulated Turtle River (see Figure 8) to the north and the Seine River to the northeast contributed more than a third of the peak inflow to Rainy Lake. Peak flows set records on both rivers, and the flow on the Turtle River was the highest in almost a hundred years of record. Prior to 2002, the highest recorded streamflow for the Turtle River gauge near Mine Centre was 302 m^3/s (10,700 ft^3/s), which occurred on October 2, 1945. The 2002 peak was measured at 407 m^3/s (14,400 ft^3/s) on June 16 and has an estimated return period of at least 500 years, according to Environment Canada. The flow on the Atikokan River at Atikokan (a tributary of the Seine River) was measured on June 11 at twice its previous record flow. Although the period of record for this station is relatively short at 18 years, the magnitude of the flow is indicative of the June 2002 flows on the lower Seine. Environment Canada has indicated that a return period of greater than 500 years would not be unreasonable for the 2002 peak flow on the Atikokan River at Atikokan.

Rainy Lake, from its level on June 9 just below the mid-point of its IJC operating band, rose above the IJC upper emergency level (the highest point on the upper rule curve) of 337.75 m (1,108.1 ft) on June 10, rose above its IJC "all gates open" level of 337.90 m (1,108.6 ft) on June 11, and kept rising, peaking at elevation 338.56 m (1110.8 ft) on June 27. This was the highest level reached since 1950, the fourth highest since 1912, was about 66 cm (26 in) above the IJC "all gates open" level and about 81 cm (32 in) above the upper emergency level. A ranking of the 10 highest Rainy Lake levels since 1912 is shown in Figure 6.

In response to the rapid increase in Rainy Lake inflows, the Companies took immediate action to increase the outflow from the Rainy Lake dam. By late morning on June 11 the Companies had opened all 5 gates on the canal and 2 of the 10 gates on the dam, with all turbines running. This left 8 gates on the dam remaining to be opened. Based upon reports of flooding concerns from rapidly rising downstream Rainy River levels (see Figure 9) at the Town of Rainy River, the Board directed the Companies to delay further gate openings until the situation could be assessed more fully and the IJC advised of the situation. By the afternoon of June 11, local estimates were that another foot of river rise at the Town would begin to flood buildings in the community, including a hospital and retirement home, and so the Town began emergency dike construction.

Following consultations between the Board and IJC, the Commission issued a Supplementary Order on June 12, 2002, authorizing outflow deviations from the Commission's January 2001 Consolidated Order for Rainy and Namakan Lakes until June 20, 2002. The June 12 Supplementary Order directed the IRLBC to endeavour to bring the outflows within the requirements of the Consolidated Order (all gates open) as soon as practicable, taking into account conditions upstream and downstream and at the dam. Over the next 2 days the Board monitored the progress of the dike construction at the Town of Rainy River and increased Rainy Lake outflow as fast as possible without causing undue risk to the Town's flood protection efforts. A total of 6 additional gates were opened on the dam (2 in the morning, 2 in mid-afternoon and 2 in late afternoon) on June 13 and the last 2 gates were opened by noon on June 14, bringing outflows within the requirements of the Commission's January 2001 Consolidated Order.

Declining steadily from June 27, except for a brief 3-day period (July 5-7) due to the July 5 rainfall event, the lake returned to its "all gates open" level on July 24, after 41 days above this point, and declined further to its upper emergency level on July 27, after 44 days above this point and after having been above its upper rule curve for 46 days. Subsequently, Rainy Lake levels remained within their IJC operating band.

Rainy River

Rainy River levels responded very quickly to runoff from smaller tributaries generated by the June 9-10 rainfall and initial outflow increases from Rainy Lake dam. The heaviest rainfall was concentrated over the northern tributaries in Ontario (the La Vallée, Sturgeon and Pinewood Rivers) and two of the smaller southern tributaries in the US (the Rapid and Winter Road Rivers) located in the lower reaches of the river near Baudette. The heaviest rainfall (see Figure 5) remained north of the two major tributaries (the Little Fork and Big Fork Rivers) to the south in the US, which had only a very limited response. Unfortunately, most of the Rainy River tributaries are not gauged with respect to level and flow, except for the Fork Rivers, so very little information exists from which to draw historic comparisons. Anecdotal evidence suggests that this event produced the highest levels and flows ever experienced by anyone now living in the region for the smaller tributaries (the La Vallée, Sturgeon, Pinewood, Rapid and the Winter Road Rivers). All of these rivers overflowed their banks and flooded vast areas of their floodplains, causing flooding of property and homes.

The sudden and heavy tributary runoff resulted in an unprecedented rise in river levels in the lower reaches of the Rainy River at the Town of Rainy River and the City of Baudette, creating a flood threat to those communities. At the Town of Rainy River, the level of the river rose about 2.1 m (7 ft) from the beginning of rainfall on June 9 until peaking some 72 hours later on June 12 (see Figure 9).

Further upstream at Fort Frances and Manitou Rapids, Rainy River levels responded primarily to the rapid increases in outflow from Rainy Lake dam, high runoff from the La Vallée River and moderate runoff from the Big Fork and Little Fork Rivers. Flow hydrographs for the Big and Little Fork Rivers are shown in Figure 10. River levels at Fort Frances and Manitou Rapids (see Figure 11) climbed very sharply, rising about 4.3 m (14 ft) and 4.0 m (13 ft) respectively, from June 9 to June 12, and then remained in narrow range for the next week.

Subsequently, the heavy rainfall of June 22-23 introduced more runoff into the already swollen Rainy River, pushing river levels at Fort Frances and Manitou Rapids to their final peaks for the year on June 27, which were about 5.2 m (17 ft) and 4.9 m (16 ft), respectively, above their levels on June 9. During this further rise in Rainy River levels, backwater effects from the combined peak flow of 476 m^3/s (16,800 ft^3/s) of the Big Fork and Little Fork Rivers from a second June rise (see Figure 10) was a significant factor in raising the level of the river at Fort Frances and Manitou Rapids (see Figure 11). At Fort Frances the timing of these backwater effects, as Rainy Lake outflows were nearing their peak, led to a peak tailwater level of 332.48 m (1,090.8 ft). This was the highest tailwater level since the 1950 level of 332.45 m (1090.7 ft) by 3 cm (1.2 in), which occurred on June 29. At Manitou Rapids the peak flow of 1,784 m^3/s (63,000 ft^3/s), recorded for the June 27 peak, was the highest June mean daily flow and 3rd highest peak annual mean daily flow in the 74 years of record at that gauge. In the lower reaches of the Rainy River, at Baudette and the Town of Rainy River, the level of the Rainy River remained well below its June 12 peak, even with the added runoff from the June 22-23 rainfall event.

3. COMMUNICATIONS

Operational

Throughout the course of the 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. The Board (IRLBC) and its staff also worked closely with the International Rainy River Water Pollution Board (IRRWPB), as directed by the IJC in 2001. Both Boards and staff held several conference calls with

Commissioners and IJC staff at key points in the high water event. Board staff provided frequent updates on conditions in the Rainy-Namakan basin to IJC staff. Under the terms of the June 28 Supplementary Order, Board staff provided daily reports to the Commission on basin conditions from June 28 through August 6, when the Supplementary Order was revoked by the IJC. In their discussions, the Boards utilized hydraulic and hydrologic data from the network of river and lake gauges in the basin, as well as short-term and long-term forecasts of weather and precipitation prepared by a number of state, provincial and federal agencies (including Environment Canada, the Ontario Ministry of Natural Resources and the US National Oceanic and Atmospheric Administration). This data was very thoroughly and closely scrutinized on a daily basis.

Following the very heavy rainfall of June 9-10, the local IRRWPB member visited the Town of Rainy River to view the situation first-hand and also arranged for a temporary staff gauge to be established on the Rainy River at the Town, as readings from the existing gauge were felt to be questionable. A temporary staff gauge was also established on the Rainy River at the Town of Emo, Ontario to allow the Boards to more closely monitor the rising water levels. On June 25-26 US 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 the flooding at the Boise powerhouse.

Public

The Board communicated with the public during the 2002 high water event by a number of means. The Board received literally dozens of phone calls and email messages from individual property owners in the Rainy-Namakan basin requesting information on hydrologic conditions in the basin and dam operations or to express their concerns that action be taken to bring relief from rising lake levels. Board staff spent many hours responding to each and every request.

Additionally, the IRLBC issued 3 news releases concerning gate openings at the Rainy Lake dam under the Commission's June 12 Supplementary Order for Rainy Lake and 7 news releases concerning outflow from Namakan Lake under the Commission's June 28 Supplementary Order for Namakan Lake. These releases were provided by fax and electronic mail to the key media outlets in the region, both in the United States and Canada and were also posted to the IRLBC web site. Board staff also gave a number of interviews concerning the high water situation to local and regional newspapers and radio stations.

The Board made extensive use of the Internet as a tool for conveying information to the public. The web sites maintained by the Lake of the Woods Control Board at www.lwcb.ca and the St. Paul District Corps of Engineers at www.mvp-wc.usace.army.mil played key roles in providing the public with current information on water levels and flows in the basin as well as other hydrologic conditions. The IRLBC's web site at www.mvp-wc.usace.army.mil/ijc/rainylake.html played an important role in allowing wide distribution of posted news releases in addition to providing access to informational reports such as the IRLBC's report on the 2001 high water event in the Rainy-Namakan basin.

In addition to the public communication efforts of the Board during the 2002 high water event, 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. Abitibi-Consolidated's toll-free Lake Level Information Line (1-800-509-LAKE or 1-800-509-5253) provided daily-recorded messages with information on lake elevations and outflows for Rainy and Namakan Lakes, precipitation levels and spillway gate operations for the dams at International Falls/Fort Frances and Kettle Falls. In addition to the toll-free number, lake level graphs for Rainy and Namakan Lakes were published weekly in the Fort Frances Times and International Falls Daily Journal.

Finally, the IRLBC's US Section staff met on June 25 in International Falls with the Koochiching County Commissioners to provide an update on the high water situation and to hear their concerns first-hand. The IRLBC and IRRWPB also held a joint annual open house and public meeting in the basin on August 20 to provide a summary of the high water event and to hear the concerns of basin residents. In response to local perceptions that not everyone had an ample opportunity to voice their concerns at the August 20 meeting, IRLBC Members and IJC staff attended a second public meeting hosted by Koochiching County on November 28 in International Falls.

4. HIGH WATER IMPACTS AND CONCERNS RAISED

High water conditions and flooding resulting from the very heavy rainfall in June 2002, in particular the extraordinary rainfall event of June 9-10, caused widespread damage over portions of southeastern Manitoba, northwestern Ontario and northern Minnesota, including the Rainy-Namakan basin. Outside the Rainy-Namakan basin, in Manitoba, flooding forced hundreds of people out of their homes and several businesses to temporarily close. Hundreds of properties were left underwater, farms inundated, and roads washed out as ditches, creeks and streams overflowed. The Province of Manitoba declared states of emergency in ten municipalities, and announced CAN$6.7 million in disaster relief to help southeastern Manitobans rebuild from flash-flood damage, with early damage estimates in excess of CAN$7M. Other areas outside the Rainy-Namakan basin severely impacted by the rainfall and resultant flooding included the northwestern Minnesota town of Roseau, where most residences and the business district were affected. According to the Minnesota Division of Emergency Management (DEM), total damages in Roseau County and the City of Roseau were estimated at about US$50M. In Canada, claims for damages totalling CAN$7.5M were made to the Northwestern Ontario Disaster Relief Assistance Program (ODRAP). In northwestern Ontario, Highway 71 connecting Kenora and Fort Frances down the east side of Lake of the Woods was impassable in places for several days, while Highway 11 between Baudette and Warroad in Minnesota was closed briefly. Both within and outside the Rainy-Namakan basin, the Canadian National Railway (CN) rail line between Winnipeg, Manitoba and Thunder Bay, Ontario (via Warroad and Fort Frances) was washed out in approximately thirty places, with one of the washouts measuring almost a kilometre in length. Rail service between Winnipeg and Fort Frances was restored by June 12 but service between Fort Frances and Thunder Bay was out for several weeks due to three large washouts west of Atikokan. About 150,000 m^3 (196,200 yd^3) of rock were placed to refill the washed out sections. Thirteen Ontario First Nation communities were deemed eligible for disaster relief. An initial estimate of total damages in Ontario was CAN$31M, of which approximately CAN$3M would be attributed to damages to infrastructure (source: Thunder Bay Chronicle Journal, Fort Frances Times and Rainy River Record).

Within the Rainy-Namakan basin, numerous major and secondary highways and roads were closed for periods from a few days to a week or more, due to culvert and bridge washouts, and many rural areas in Ontario were rendered inaccessible, thus requiring use of air ambulance service for non-flood related emergencies. In northwestern Ontario, Highway 11 between Fort Frances and Emo and Highway 622 between Atikokan and Highway 17 were closed for several days, while Highway 502 from Fort Frances to Dryden was closed for nearly a week and Highway 11 between Fort Frances and Atikokan was closed for more than a week until a temporary bridge replacement could be put in place at Price Creek. Repair of many of the gravel secondary and logging roads in northwestern Ontario took several months. Two northern Minnesota counties and a number of northwestern Ontario municipalities and townships declared states of emergency and were later declared disaster areas by the US Federal Emergency Management Agency and the Ontario Ministry of Municipal Affairs and Housing, respectively. Figures obtained from the Town of Rainy River estimate the total damages, including flood fight and clean-up costs, at CAN$979,300. In Koochiching and Lake of the Woods Counties in Minnesota, total summer 2002 flood damages were estimated at US$3.9M and US$15.7M, respectively, according to the Minnesota DEM. The bulk of these damages (about 95%) in both of these counties was concentrated in agricultural crop and livestock losses and damages to agriculture-related structures, primarily from tributary and overland flooding, away from Rainy Lake. Within the Rainy-Namakan basin, nearly all of the US portion of Rainy Lake is located within Koochiching County, while the lower reaches of the Rainy River, from just upstream of Baudette to the mouth of the river where it empties into Lake of the Woods, is located within Lake of the Woods County.

In Fort Frances, high Rainy River flows and levels cost Abitibi-Consolidated an un-quantified amount in lost hydroelectric generation, plus CAN$78,000 in lost paper production and CAN$69,000 to build a dyke to protect the lower mill yard from the high tailwater levels. Abitibi reported that, if this dyke had failed, the mill basement would have flooded, leading to possibly millions of dollars in damages and lost production. Construction of a permanent dyke is under consideration by Abitibi. Damages from the rainfall event itself were even more costly to Abitibi than were the high water impacts in the Fort Frances area. Damages to Abitibi's woodlands road network totalled CAN$4M with nearly every bridge and culvert in the storm area being washed out.

In International Falls, high tailwater levels flooded Boise Cascade's powerhouse, necessitating the construction of temporary dikes and the purchase, rental or borrowing of approximately 40 emergency sump pumps. Temporary piping was constructed and mill labourers worked around the clock stopping leaks and keeping pumps fuelled and operating. The total cost of these emergency measures was US$182,000. To reduce the threat of future flooding, an additional US$400,000 will be spent to engineer, purchase and install permanent diking and sump pumping capacity in this facility and to upgrade road access to other low lying buildings along the river, which were also flooded and inaccessible.

The remainder of this Section summarizes, by area, the impacts of the high water in 2002 on Namakan Lake, Rainy Lake and the Rainy River, based on information available to the Board. Also summarized are the concerns and comments expressed by many people, either by phone or electronic mail to Board Members and Board staff or directly during damage inspections, public meetings and tours. Board responses to public concerns that are not addressed by other sections of this report can also be found here. Photographs of high water impacts in a number of areas can be found in Appendix C.

Namakan Lake

As discussed in Section 2, the level of Namakan Lake remained in the middle of its IJC rule curve throughout the spring, until the June 9-10 rainfall event. The Boards had received little expression of concern from basin residents up to that point in time.

Following the reduction in Namakan Lake outflow under the terms of the June 28 IJC Supplementary Order and the lake's rise to near the IJC "all gates open" level on June 30, the Board received many calls from property owners in the Namakan Chain of Lakes. Most sought further clarification of the Board's future intentions with regard to Namakan Lake outflows. Nearly all expressed concern that their property was being placed at risk of flooding for the sake of providing only minimal relief to Rainy Lake. A number of these property owners questioned the fairness of this approach, inasmuch as the Namakan Chain of Lakes had only experienced inflows in the normal range for which flooding would not be expected to occur. At this point the Boards had received only a few reports of minor impacts to crib docks and their usability on Kabetogama Lake and one Crane Lake resident reported the increased water levels there were causing shoreline erosion problems and limiting access to a boathouse.

The 38-76 mm (1.5-3.0 in) of rainfall on July 5 over the Namakan Chain of Lakes caused a sudden, albeit short-lived, rise in lake levels. Namakan Lake rose about 9 cm (3.5 in) from the early morning hours of July 5, until peaking about 9 hours later. Fortunately, the rainfall magnitude was not widespread, falling mostly on the lake surfaces and missing the upstream areas. In addition, the rainfall was moderate in magnitude and the basin weather conditions had been relatively dry, since the earlier rainfall events in June. The potential for the occurrence of this situation was exactly why the Boards had not sought to reduce Namakan Lake outflow earlier in June to provide some relief to the high water conditions downstream on Rainy Lake. It was also why the IRLBC proceeded cautiously with only a modest increase in Namakan Lake levels to help Rainy Lake, when the risks involved seemed more acceptable.

Reaction from property owners on the Namakan Chain of Lakes was immediate. Board staff were inundated with calls on July 5 and 6 expressing concerns over dock flooding and potential for damage from the pounding submerged crib docks were receiving from wind-driven waves. Most expressed the view that the Namakan Chain of Lakes had done what it could to help Rainy Lake, was now experiencing minor flooding and was on the brink of significant flooding and demanded immediate action to bring Namakan Lake levels down. Outflow increases from the lake on July 5 and 6 halted the rise in Namakan Lake levels and caused a rapid decline in those levels, without increasing water levels on Rainy Lake, which were by then declining. Once Namakan Lake levels began their decline on July 6, the Board received no further concerns. By all accounts, the high water damage on the Namakan Chain of Lakes was limited and relatively minor in nature. There were no disaster declarations for St. Louis County, which encompasses most of the US portion of the Namakan basin, and the Board is not aware of any disaster declarations in the Canadian portion of the Namakan basin.

Rainy Lake

Because of the high Rainy Lake levels a large number of fixed docks and shoreline facilities were rendered difficult or impossible to use. A number of fixed docks received damage after floating off their cribs or being pushed by wind-generated waves, while buoyant from being submerged. Business at a number of local marinas was impacted to varying degrees with at least one marina completely out of operation and having to relocate stored boats. Several houseboat operations were impacted by reduced operations from dock flooding. Dock flooding and basement flooding impacted several area resort operations on the lake. Problems were reported with flooding of home basements and crawl spaces, home furnaces and water heaters, yards and landscaping and septic systems. In Canada, an entire subdivision at Couchiching First Nation suffered damages as a result of back-ups through the sewer system. Severe flooding caused extensive washouts of roads, highways and rail lines near the Atikokan, Seine and Turtle Rivers and their tributaries. Within Koochiching County in the United States, the Minnesota DEM reported US$3M in agricultural crop losses, US$763,000 in agricultural structure/livestock losses, US$60,000 in public damage, US$78,300 in housing grants dispersed, and US$3,200 in individual family grants, plus significant basement structural damage in the City of International Falls.

The major concerns expressed by Rainy Lake interests included the following:

- That this was the second consecutive year of flooding on the lake and that the 2000 rule curve change was the primary cause.
- That the Rainy Lake dam should have been fully opened sooner and that the delay in opening the last 8 gates to provide time for construction of a flood levee at the Town of Rainy River resulted in more damage on Rainy Lake.
- That storage capacity existed in the Namakan Chain of Lakes to store more water (up to a foot according to some), and should be utilized to provide some relief to high Rainy Lake levels and a more equitable sharing of high water impacts among the lakes (seen as a fairness issue by Rainy Lake interests).
- That Namakan Lake outflows should be reduced to help alleviate safety concerns over the flooding of the Boise powerhouse from high tailwater levels in late June.
- That Namakan Lake outflows should have been reduced earlier in the high water event and to a greater degree than authorized by the IRLBC on June 27.

- That more discretion should be given back to the Companies to manage water levels within the rule curve band.
- That the Board and IJC need to streamline the overall regulation process and communicate better with each other and the public, particularly with respect to helping the public understand the regulation process.
- That more opportunity for public input to the regulation of Rainy and Namakan Lakes should be available to stakeholders in the Rainy-Namakan basin.

A number of these concerns are addressed elsewhere in this report. In particular, the effect of the new IJC year 2000 rule curves, the effect of the delayed opening of the Rainy Lake dam, and the effect of using additional storage on Namakan Lake were assessed with a simulation model and are addressed in Section 5. However, a general response to the storage issue and responses to the concerns not addressed elsewhere are provided below.

Quite apart from assessing the direct impact on lake levels of storing additional water in Namakan Lake to provide some relief to Rainy Lake, it is noted that such a transference of impacts raises philosophical or ethical questions. In 2001 both Namakan and Rainy Lakes experienced high inflows due to heavy rains and neither lake could be prevented from rising above its upper rule curve as a result. However, in 2002, the Namakan Lake basin did not receive nearly the rainfall that the Rainy Lake basin did and, apart from temporary effects due to direct rainfall on the lake surface, it would have been easily possible to maintain the level of Namakan Lake within its IJC operating band. This then raises the question: to what extent, if any, should high water levels or flooding be deliberately caused on a lake when none or little would have otherwise occurred? Is it "fair" to do so? It is also noted that, once a lake has been deliberately raised above the level where it otherwise would have been, the risk is increased of it going even higher, perhaps with significant damage, if heavy rains should then subsequently occur in its own basin.

Further, the process of trying to distribute excess water "equitably" among several lakes may well be more complex than it at first would appear. For example, how many lakes should be involved? Rainy Lake residents proposed that some of their excess water should be stored in Namakan Lake, but some Lake of the Woods residents felt that some of their excess water should be stored upstream on Rainy Lake while property owners along the Winnipeg River (downstream of Lake of the Woods), who suffered both the largest increases in water level and the longest duration of excessive levels, felt that water should be stored anywhere upstream of them. Of course, as the area of sharing excess water increases, so do attendant management problems due to the travel time of water from one area to another, the possibility of getting subsequent heavy rains that affect one area but not another, and so on. Also, do you attempt to distribute the excess water by raising each lake by the same amount, or by some other means? A smaller increase on one lake may have a greater adverse impact compared to another due to the presence of flatter shoreline, more erodible shoreline or more susceptibility to damaging wave action due to larger open areas. Finally, there remains the point that, due to the differing volumes or storage capacity of the lakes, a smaller lake such as Namakan may have to be raised significantly (and perhaps excessively) in order to provide only a small saving in peak water level on a larger lake, such as Rainy.

Regarding the belief that Namakan Lake outflows should have been reduced in June to help alleviate safety concerns over the flooding of the Boise powerhouse by high tailwater levels, it is noted that such action would have had no effect on the powerhouse flooding issue. The flooding was due to high Rainy River levels downstream of the powerhouse, which in turn were due to high inflows to the Rainy River from its various tributaries and from Rainy Lake. The only effective measure available to the Board and the Companies was reducing Rainy Lake outflows, which could not be done (unless the situation became much more serious) due to the high and rising level of Rainy Lake. Reducing Namakan Lake outflows (into Rainy Lake) would not have been sufficient to permit a corresponding reduction in Rainy Lake outflows because the maximum Namakan Lake outflow at the time was only about 250 m^3/s (8,830 ft^3/s), whereas the total inflow to Rainy Lake at the time reached nearly 1,920 m^3/s (67,800 ft^3/s).

Regarding the belief that more discretion should be given back to the Companies to manage water levels within the rule curve band, it is noted that the Companies currently have considerably more operational discretion than they had in the late 1980's and 1990's. With the 1970 rule curves and accompanying IJC Order, the Companies originally had full discretion within the rule curve band, subject to the IJC or the Board on its behalf being able to provide advice or direction if deemed necessary. However, this range was initially narrowed for Boise in 1987 when Article 403 of their FERC operating licence required them to be near or at the upper rule curve on Rainy Lake in the springtime. The operating range was narrowed much further for Boise in 1996 when a US federal act required them to try to operate in the area of the IJC band either common to or closest to the proposed "Steering Committee" rule curves. This greatly limited the operational flexibility originally intended by the IJC, and led to conflicting operations by Boise and Abitibi. The Board, in its draft report recommending new rule curves, first recommended a clause restoring full discretion to the Companies within the rule curve band. However, in response to strong adverse public reaction, this was modified in the final report such that the Companies were to target the "middle portion" of the operating band unless directed to target elsewhere by the Board. In the three years with the new rule curves in place, the Board has stressed repeatedly to the Companies that they need not rigidly follow the exact middle of the operating band, that the Board intends to interpret the "middle portion" as being fairly wide most of the time, and that the Board is open to (and encourages) operational proposals from the Companies and discussion with them at any time. In other words, the Board intends that there be as much operational flexibility as possible available to the Companies, subject to due regard for other interests. However, the Companies have advised the Board that, due to liability concerns, they intend to operate the lakes as close to the middle of the band as possible.

Regarding communications and streamlining the regulation process, information has already been presented in Section 3. However, regarding the public, it is worth noting here that, while the Board will continue to frequently provide information to the media and callers during significant events, the Board is also reviewing changes and potential additions to its web site and is considering the preparation of an information pamphlet on the regulation process. As to streamlining the regulation process, it is noted that the Board already takes action when and as needed, regardless of the fairly rigid rules that are normally in place. For example, in June 2002 the Board directed the Companies to stop increasing Rainy Lake outflows immediately upon learning of the threat to the Town of Rainy River downstream, and then followed up with the IJC after the fact. The IJC not only approved the action taken by the Board at that time, but has recently confirmed that the Board should continue to act in this manner in the future.

Finally, regarding the desire for more opportunity for public input to the regulation of Rainy and Namakan Lakes, several preliminary ideas have been discussed by the IRLBC, the IRRWPB and the IJC, including periodic informal stakeholder round-table discussions and establishment of a public advisory group to the IRLBC. By definition, an advisory group would not possess decision-making authority, which would continue to rest with the IJC and the IRLBC. However, such a group could provide an on-going forum for discussion of regulation and information issues. Such a group, or members of the public at round-table discussions, might participate in discussion of potential regulation guidelines and communication mechanisms, and add to the Board's information base about water resource users in the basin and their concerns. Further, the people involved in such processes could facilitate true 2-way communications between the Board and the public, by being additional sources of information in the community and possibly by helping to explain regulation actions. The participants might be members of the public at large or might be drawn to represent local interest groups or municipal bodies and other agencies.

Rainy River

The major impacts and concerns of the high Rainy River levels were focussed on the Town of Rainy River and high tailwater levels at the Boise powerhouse at International Falls. The Town narrowly avoided significant flooding by a delay in the opening of the last 8 gates on the Rainy Lake dam and the construction of a protective dike along its riverfront. Nonetheless, the Town incurred significant expenses in flood-fight and clean-up costs and repair of damages to some of the Town's infrastructure. Based upon information obtained from the Town Administrator, these costs included about CAN$90,000 for flood-fight and clean-up (including CAN$53,000 for related road repair), CAN$343,300 for repair/replacement of culverts, CAN$18,300 for repairs to the Town's riverfront park and CAN$527,700 in contract costs for road repair and to repair extensive damage to the Town's sewer system. In addition, there were reports of basement flooding and foundation damage to private homes in the area, mostly due to interior drainage problems related to overloading and damage to the city's culverts and sewers from the excessive runoff. The inability of the Town's sewer system to handle the surge of storm runoff and infiltration flow resulted in discharges of raw sewage into the Rainy River. Also, according to local accounts, eleven homes in Nelles Township north of Pinewood, Ontario were inundated by as much as 0.6 m (2 ft) of water, sustaining significant damage, due to overland flooding from the Pinewood River and local runoff. Highway 11 (Trans-Canada highway) near La Vallée was closed for a brief period due to high runoff on the La Vallée River. At International Falls, high Rainy River levels in the tailwater of the Rainy Lake dam caused flooding of the Boise powerhouse, creating safety concerns over the continued operation of the powerhouse.

The Board received other reports that several homes in low-lying areas along the Rainy River (near the mouth of the Little Fork River) and at the City of Baudette were being flooded, and that protective measures were being taken for several Baudette area businesses. According to the Minnesota DEM, a number of basements in the city were affected by sewer backup, with an estimated average water depth of 0.3 m (1 ft), and there were 13 bridge washouts in Lake of the Woods County. The City proper was not threatened, as it sits well above the river. There were also some reports of bank erosion in the lower reaches of the Rainy River.

5. MODELLING

Both during and following the high water event on Rainy Lake, there was public concern regarding the way the dams were being operated and regarding the effect of the new rule curves for Rainy and Namakan Lakes, which were adopted by the IJC in 2000. In particular, people felt that the peak Rainy Lake level would have been lower if there hadn't been a delay in opening all of the Rainy Lake dam gates (to protect the Town of Rainy River from flooding), and if more water had been held back in Namakan Lake. There was also a very strong belief that the adoption of the new rule curves had contributed significantly to the high levels reached on Rainy Lake.

To assess these concerns, the IRLBC conducted simulation modelling of the operation of Rainy and Namakan Lakes, using a relatively simple "spreadsheet model". The model used 2002 inflow data, volume-elevation and discharge-elevation characteristics of the two lakes and their dams, and operating policies reflecting typical operations within the IJC rule curves and specific operations in 2002. The model was operated with a daily time step and generally used the previous day's inflow as an estimate for the current day inflow, to more closely represent the information typically available to the dam operators. Calibration runs with only Rainy Lake simulated and with both lakes simulated produced peak levels on Rainy Lake differing from the actual peak level reached in 2002 by only 4-7 mm (0.2-0.3 in). The results for the various cases modelled are addressed in the following sub-sections and are tabulated and compared graphically in Figure 12.

Effect of Delayed Opening of the Rainy Lake Dam

As reported in Section 2, the Companies had opened 7 of the 15 sluice gates in the Rainy Lake dam by late morning on June 11 in response to the June 9-10 rainfall. At that point the Board received word of potential flooding in the Town of Rainy River (placing the local hospital and senior's home at risk) and, in response, directed the Companies not to open any more sluice gates. The IJC subsequently issued a Supplementary Order so that the full opening of the dam might be delayed to allow time for the Town of Rainy River to build a protective dike. Consequently, more dam gates were not opened until June 13, when 6 were opened over the course of the day, and the final two gates were opened by noon on June 14.

The simulation model was used to determine to what degree the high water level situation on Rainy Lake was exacerbated by this delay in opening all the gates. As tabulated in Figure 12 (Run B1) and plotted in Figure 13, the model showed that the peak level on Rainy Lake would have been about 5 cm (2 in) lower than it was if this delay had not occurred. The actual reduction in peak level without the delay in gate opening would likely have been somewhat less than this, since the model assumed all gates were opened on June 11 and also did not account for the timing of the within-day gate operations.

Effect of Using Additional Storage on Namakan Lake

In response to the June 9-10 rainfall, the level of Namakan Lake rose rapidly from about mid-band on the 10^{th} to just above its upper emergency level (340.95 m or 1118.6 ft, the highest point on the upper rule curve) on the 11^{th}. The Companies responded by increasing outflow, but only moderately (at the Board's request) so as to limit its impact on the much worse situation developing on Rainy Lake. The level of Namakan Lake was held just above its upper rule curve into the 4^{th} week of June. However, as the level continued to rise on Rainy Lake, pressure grew from several quarters to store more water in Namakan Lake. On June 28, the IJC issued a Supplementary Order to permit raising the level of Namakan Lake. As reported previously, the Board targeted for a moderate rise to 341.1 m (1119.1 ft), and then rainfall in early July took Namakan Lake to a peak level of 341.19 m (1119.4 ft).

The impact on Rainy Lake of the additional storage used on Namakan, both before and after the Supplementary Order, was assessed with the simulation model. Due to the much lower rainfall over the local Namakan basin compared to the local Rainy basin, inflows to Namakan Lake were not extreme. Thus, with Namakan Lake and unlike the situation on Rainy Lake, it would have been possible, apart from the immediate rise in level due to rainfall directly on the lake surface, to maintain Namakan's level within the IJC operating band. Several operational alternatives for Namakan Lake were modelled. The first run assumed that the lake would be managed so that the level would follow the middle of the IJC 2000 rule curves, the second followed the IJC 2000 upper rule curve and the third allowed Namakan Lake to rise to 340.95 m (1118.6 ft, the highest point on the upper rule curve) and stay at that level. Results for these runs, C1 to C3 respectively, are tabulated in Figure 12 and plotted in Figure 14.

Of the alternatives tested, Run C1 (following mid-band on Namakan Lake) would have released the most water downstream into Rainy Lake, and so the additional storage actually used in 2002 would be expected to give the most relief to Rainy Lake when compared against this run, of the three alternatives tested. When compared against the next two runs, which used more storage on Namakan, the actual amount of Namakan storage used in 2002 would be expected to provide successively less relief to Rainy Lake. The results show this. The Rainy Lake peak level in 2002 was nearly 5 cm (2 in) lower than it would have been if Namakan had been held to its mid-band level, nearly 3 cm (1 in) lower than if Namakan had followed it upper rule curve, and nearly 1 cm (0.3 in) lower than if Namakan had been held at the high point of its upper rule curve. In contrast, Namakan Lake ultimately rose 24 cm (9.4 in) above its emergency level in the attempt to provide relief to Rainy Lake. Also, of the 1-5 cm (0.3-2.0 in) reduction in peak level on Rainy Lake, most of the relief was due to the additional water stored on Namakan Lake prior to the June 28 Supplementary Order. Since Rainy Lake inflows were declining sharply and the lake was close to peaking when the Order was issued, only a small portion of the total relief, in the order of 5-6 mm (about 0.2 in), resulted from the additional storage used after the Supplementary Order was issued. Storing more water earlier in Namakan Lake would have provided somewhat more relief to Rainy but, as stated previously, the risk to Namakan Lake from additional rainfall was deemed to be too great given the relatively small benefit gained on Rainy Lake.

Effect of the New Rule Curves Versus the Old

A fairly common view of the public in the watershed both during and following the 2001 and 2002 high water events was that the adoption of the new rule curves by the IJC in 2000 (replacing the previous rule curves adopted in 1970) had contributed significantly to the high levels reached on Rainy Lake. Again, the simulation model was used to assess this, by determining what the peak levels might have been if the 1970 rule curves on both lakes had been in place in 2002 instead of the new 2000 rule curves. A similar assessment regarding the 2001 event was reported on in the 2001 high water level report.

The previous model runs described above all started with actual 2002 lake levels on June 8, just prior to the main rainfall event of 2002. For the first set of runs with the 1970 rule curves, an earlier start was deemed necessary in order to determine where the lake levels would have been by June 8 when operating under different rules. January 1 was used for the start date, commencing with the actual water levels recorded for both lakes on January 1, 2002. The two sets of rule curves are not too different at this point in time, and levels quickly adjust in the first few days of the simulation to follow the set of rules in place, either 1970 or 2000. As to operating policy, it was acknowledged that many different variations might have been followed, and that it was virtually impossible to say, after the fact, how the lakes would have actually been operated if the 1970 rule curves were still in place in 2002. Again, for the first set of runs, it was decided to follow the current policy of targeting lake levels for the middle portion of the band. If the decision at the conclusion of the rule curve study in 2000 had been to keep the 1970 rule curves instead of revising them, the new clauses in the Order to normally follow the middle portion of the band, with provision for other targets to be set by the Board, might well still have been adopted since these clauses were put in place to avoid the apparent conflict with the FERC (United States Federal Energy Regulatory Commission) requirements imposed on Boise Cascade during the 1990s. Further, the Companies have recently stated that, when free to do so, they now intend to target the mid-level of the IJC bands and would do so even if the 1970 rules were still in place. Finally, it was noted that operations by the Board and the Companies were likely to be influenced by the high water event of 2001, resulting in mid-band levels being targeted rather than higher levels within the band. This was in fact the case in early 2002, when mid-band levels were targeted, whereas higher levels had been targeted in early 2001 under similar hydrologic conditions. In the simple model being used, targeting the middle portion of the band meant targeting the exact mid-level. This was done on Rainy Lake for the whole simulation and on Namakan Lake up to June 8, after which several alternatives were used (as done with the “additional Namakan storage” case, Runs C1-C3 above), from following the actual level on Namakan Lake that occurred after June 8 in 2002 to following the mid-point of the rule curve bands.

The earlier starting date for the first runs with the 1970 rule curves, coupled with the mid-band operating policy, proved to have a major impact on the results of the runs. This was due to the fact that inflows were well below normal in the spring of 2002, up to the point of the exceptional June 9-10 rainfall. In spite of these low inflows, it was possible to stay within the operating band with the 2000 rule curves. However, with the 1970 rule curves, it was not possible to keep the level of Rainy Lake within its operating band and, as a result, Rainy Lake was significantly lower with the 1970 rule curves than with the 2000 rule curves by

June 8, just prior to the June 9-10 rainfall event. The different starting water levels for this rainfall event accounted for most of the difference in peak level between the two rule curve sets.

Results for these 1970 rule curve model runs are tabulated in Figure 12 (Set "i", Runs D1-D3) and plotted in Figure 15. As shown, with the 1970 rule curves, the level of Rainy Lake on June 8 was 337.26 m (1106.5 ft), 22 cm (8.7 in) below the actual June 8, 2002 level operating with the 2000 rule curves. With the 1970 rule curves, the level on Rainy Lake could have peaked at about 15 to 20 cm (6-8 in) lower than the actual level reached in 2002.

Acknowledging that 2002 was an atypical year, hydrologically speaking, going suddenly from sustained well below normal inflows to record high inflows, a second set of model runs was performed to determine what the impact of the rule curves might be in a more typical year. In a "normal" year, with inflows neither too high nor too low compared to the median inflow, it is possible for both lakes to track near or at the mid-point of their operating bands, whether they be the 1970 rules or the 2000 rules. Thus, to test a more typical year, in which it is possible to remain within the IJC bands, it was assumed that Rainy Lake would be at its mid-band position when hit by the June 9-10, 2002 rainfall. Rainy Lake was close to this point on June 8 in 2002. Results from these runs (Set "ii", Runs E1-E3) are tabulated in Figure 12 and plotted in Figure 16. As shown, with the 1970 rule curves and Rainy Lake at mid-band when the heavy rains came, the level on Rainy Lake could have peaked at about 4 to 8 cm (1.5-3.0 in) lower than the actual level reached in 2002. Thus, comparing run sets D and E, about 11-12 cm (about 4.5 in) of the lower peak with 1970 rule curves and 2002 inflows was due to the combination of early drought with the 1970 rule curves (which resulted in the lake level just prior to the rainfall event being well below the operating band) rather than being due to the 1970 rule curves alone.

In assessing the results for Set "i", it was observed that, in mid-April when more inflow became available from the minimal freshet received in 2002, the modelled outflows from both Namakan and Rainy Lakes had been increased to keep the lake levels at mid-band. As noted previously, the simple model forces the lake levels to remain exactly at the target level whenever possible, which in these runs was the mid-band level. This effect is shown for Run D3 in Figure 17, which is the same as Figure 15 except that only Run D3 is shown, not Runs D1 and D2, and the lake outflows for Run D3 are added. The main effect of the increased outflows in April, in order to keep the lakes at mid-band, is that water leaves the Rainy-Namakan system (down the Rainy River), which subsequently results in a lower Rainy Lake level on June 8. This in turn results in a lower peak level from the rainfall after June 8.

Observing this effect drew attention to the operating policy that was being assumed in the model and lead to the question of what would the Companies have actually done under these circumstances. Would the Companies have held the lakes to exactly mid-band and used the extra water to generate more power at International Falls / Fort Frances, or would they have remained at the near minimum allowable outflow (100 m^3/s or 3,530 ft^3/s) used in the model and allowed the level of Rainy Lake to rise somewhat above the mid-point of the IJC operating band? More runs were performed to assess the impact of this choice on the ultimate peak level on Rainy Lake. The results for the run equivalent to Run D3 are tabulated as Set "iii", Run F3, in Figure 12 and are plotted in Figure 18. As can be seen by comparing the outflows in Figure 17 (Run D3) with those in Figure 18 (Run F3), in Run F3 the outflow from Namakan Lake in April has been capped at the actual maximum released in 2002 in this period, and the outflow from Rainy Lake in April has been held constant at 100 m^3/s rather than being allowed to increase. This results in the level of Rainy Lake rising above the mid-band target level from mid-April through early May, which in turn results in a higher Rainy Lake level on June 8, when compared to Run D3. It is noted that, in Run F3, the modelled level of Rainy Lake tracks a little higher than the actual 2002 level during this period. The net effect of this relatively minor change in operating policy was a difference of about 6 cm (2.5 in) in the resultant peak level on Rainy Lake. The peak level from the model run F3 is 13 cm (5.3 in) less than actual in 2002, instead of the 20 cm (7.8 in) less for the original Run D3. If the Companies rigidly followed the 1970 rule curve mid-band level and generated extra power (D runs), the peak level would have been about 15-20 cm (6-8 in) lower than the actual 2002 peak (range depending on Namakan operations), but if they had allowed the lake level to rise a little above the mid-band target and not generated the extra power, the peak would have been only about 9-13 cm (3.5-5 in) lower than the actual 2002 peak. Reasonable arguments can be made to support either mode of operation, and although it is noted that the Companies typically operated above the 1970 rule curve mid-point in the 1990s, in truth it is impossible to say now, after the fact, which mode of operation would have been followed in 2002 with the 1970 rule curves still in place.

Following the examination of operating policy effects one step further, it was decided to simulate operations with the 1970 rule curves as closely as possible to typical operations in the 1990s. During this period, Boise (but not Abitibi) was required by Article 403 of its FERC operating licence (December 1987) for the International Falls powerhouse to operate its facilities to achieve the maximum allowable lake level (the 1970 upper rule curve) on Rainy Lake from ice-out to 15 days thereafter, and then to allow the level to rise gradually to summer levels. In addition, from November 1995 through to January 2000, under a portion (the so-called "Wellstone Amendment") of the US Energy and Water Development Appropriations Act of 1996, Boise was required to operate both lakes in the coincident area of the IJC 1970 operating band and the band proposed by the Rainy Lake and Namakan Reservoir Water Level International Steering Committee. This essentially required Boise to try to operate both lakes high within or at the upper limit of the IJC 1970 operating band during the April to June period.

An examination was made of typical lake levels and flows for the April through early June period for the years 1970 to 1999, the years during which the 1970 rule curves were in place. A summary of this examination is presented in Figure 19. Based on this data for the last decade with the 1970 rule curves, 1990-99, target levels were established for both lakes to guide model operations. For Rainy Lake, the target ran from 50% of the IJC 1970 operating band on January 1 to 60% on March 31, to 90% on April 30 and through to May 31, and then to 50% on June 30. For Namakan Lake, the target ran from 50% of the IJC 1970 operating band on January 1 to 90% on March 31, to 100% on April 30 and through to May 22, and then to 50% on June 15.

The simulation model was run with 2002 inflows and the target levels described above. Results are tabulated in Figure 12 (Set "iv", Run G1) and plotted in Figure 20. As shown, with the 1970 rule curves in place and an operating policy typical of the 1990s, the model predicted that the peak level of Rainy Lake would have been only 2.5 cm (1 in) lower than the peak that actually occurred in 2002. It can be strongly argued that, even if the 1970 rule curves had remained in place through to 2002, the operating policy within these bands likely would have changed. The requirements of the "Wellstone amendment" were to terminate upon a decision by the IJC at the conclusion of its rule curve study, and the adoption of the clauses in the new IJC Order specifying a "middle portion of the band" target might well still have been implemented, negating FERC Article 403. This would have reduced the motivation to operate above mid-point in the band, especially if the study had concluded that the 1970 rule curves (generally lower levels in the springtime compared to the 2000 rule curves) were better and should be retained. In addition, the high water level event of 2001 would likely have influenced operations in 2002, toward targeting somewhat lower levels, as already noted previously. Nevertheless, it cannot be stated with certainty now, after the fact, what operating policy would have prevailed in 2002 if the 1970 rule curves had still been in place. It can, however, be stated that if the 2002 inflow had occurred in, say, year 1998, the 1970 rule curves and the related policy of that time would have been in place and, as a result, the peak level on Rainy Lake would likely have been only 2.5 cm or 1 in lower than that experienced in 2002.

Drawdown Needed to Avoid High Water Levels

Finally, model runs were done to determine how low the level of Rainy Lake would have had to be on June 8 in order to manage the runoff from the June 9-10 and subsequent rainfall without exceeding the upper rule curve. These runs assumed that the Rainy Lake dam was opened as quickly as possible, starting on June 11, but of course discharge was still limited by the level-discharge relationship for the dam. This constraint is significant because the discharge capacity increases with lake level; it is much lower at low lake levels (even with the dam fully open) than it is at typical summer lake levels. In these runs Namakan Lake was operated at the mid-band point of its rule curves.

Results are tabulated in Figure 12 (Runs H1-H2) and plotted in Figure 21. As shown, it was found that Rainy Lake would need to be at a very low level indeed to manage the volume of the 2002 June rainfall. The runs shown for both sets of rule curves were both started with Rainy Lake at elevation 335.40 m (1100.4 ft) on June 8, this being the lowest level for which operational relationships were available to run the model. With this starting level, Rainy Lake could have peaked at 337.74 m (1108.1 ft) with the 1970 rule curves, and at 337.81 m (1108.3 ft) with the 2000 rule curves. These peak levels are 1 cm (0.4 in) below the upper rule curve with the 1970 curves and 6 cm (2.2 in) above the upper rule curve with the 2000 curves, both upper rule curves being at the same level at the time of peak. Thus, with this start level, the 1970 rule curves could have given a 7 cm (2.5 in) lower peak than the 2000 rule curves. However, the start level is 1.3 m (4.3 ft) below the lowest point on both the 1970 and 2000 lower rule curves. Drawing the level of Rainy Lake this low every year for flood management purposes, in case the 2002 rainfall event was repeated, would be clearly devastating for all other uses and interests on the lake. Further, the actual peaks with either rule curve set would actually be higher than those achieved here because, with such a low start level, the dam gates would not be fully opened immediately, as they were in these runs.

6. FLOODPLAIN MANAGEMENT, ZONING AND HAZARD LAND UTILIZATION

In light of rare back-to-back high water events in 2001 and 2002, the Board would like to again reiterate its message on floodplain management, zoning and hazard land utilization, conveyed in its October 26, 2001 report to the Commission on Year 2001 high water levels in the Rainy-Namakan basin.

Although rare, the high water events of the last two years have very effectively driven home the point that higher levels have occurred in the past and will almost certainly occur again at some point in the future. In its contacts and dealings with the various affected interests in the Rainy-Namakan basin concerning the high water events of the past two years, the Board endeavoured 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 US and Canada, and to point out the need for wise and prudent planning of property developments to accommodate periodic high water events. The Board in its October 26th report stated that "Although floodplain and hazard land delineations exist to one extent or another in both the US 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". Based upon the many public contacts between the Board and basin interests during the 2002 high water event, this view has only been reinforced.

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. SUMMARY AND CONCLUSIONS

The high water levels experienced in the Rainy-Namakan basin in 2002 were due to a very large amount of rainfall in June, which primarily resulted from an extraordinary rainfall event on June 9-10 but was augmented by another significant rainfall event on June 22-23. Total rainfall during this period was the highest since 1948 (55 years). As a result, inflows to Rainy Lake for the month of June were the 2nd highest since 1912. The resultant peak water level on Rainy Lake was 338.56 m (1110.8 ft) on June 27, the highest level reached since 1950 and 2nd highest since 1912. The June 27 peak was 66 cm (26 in) above the IJC "all gates open" level and 81 cm (32 in) above the upper emergency level. Although inflows to Namakan Lake were in the median range through most of June and July, efforts to provide some relief to high Rainy Lake levels by reducing Namakan Lake outflow in late June resulted in higher levels than would have otherwise occurred and some minor high water impacts on the Namakan Chain of Lakes. On the Rainy River the response to the June 9-10 rainfall event produced (based upon anecdotal evidence) the highest levels and flows ever experienced by anyone now living in the region on the smaller tributaries in the lower reaches of the Rainy River, creating a flood threat to the Town of Rainy River. Subsequently, the timing of tributary runoff from the June 22-23 rainfall event with peak outflows from Rainy Lake produced the highest tailwater levels at the Boise powerhouse since 1950, causing flooding of the powerhouse and creating concerns about the safety of its continued operation.

Simulation modelling was conducted by the Board to address some of the public concerns regarding lake management during this event. It was found that the delay in the full opening of the Rainy Lake dam, in order to protect the Town of Rainy River from flooding, caused the peak on Rainy Lake to be at most 5 cm (2 in) higher than it might otherwise have been. Similarly, it was found that the use of additional storage on Namakan Lake during the event had lowered the Rainy Lake peak level by 5 cm (2 in) at most, while causing the level of Namakan Lake to rise 24 cm (9.4 in) above its emergency level. Regarding the effects of rule curves, it was found that, had the 1970 rule curves still been in place in 2002 but operations within them been to current day stated policy, the peak level on Rainy Lake might have been 9-20 cm (3.5-8 in) lower than it was, depending on assumptions made within that policy (policy variants). However, most of the difference (with each policy variant) was due to the drought period preceding the heavy rain period, which resulted in the lake level being below normal (by differing amounts, dependent on policy variant) when the rains came. In a more typical year, with lake levels remaining near mid-band through the spring, the June 2002 rains with the 1970 rule curves would likely have resulted in a peak level on Rainy Lake only 4-8 cm (1.5-3.0 in) lower than it was, depending on Namakan operations. Further, it was found that, if the 2002 June rains had occurred in the 1990s, when both the 1970 rule curves and all operating requirements and policies related to them were in place, then the peak level on Rainy Lake would likely have been only 2.5 cm (1 in) lower than the actual peak in 2002. Finally, it was found that, if the peak level on Rainy Lake was to be limited to, or kept close to, the IJC upper emergency level (highest point on either the 1970 or 2000 upper rule curve), the level of Rainy Lake would have had to be drawn down to about 335.4 m (1100.4 ft), or 1.3 m (4.3 ft) below the lowest point on both the 1970 and 2000 lower rule curves, prior to the June rainfall event. Such a drawdown, to provide flood protection, would prove devastating to most uses of the resource in most years.

Overall, the differences between the actual 2002 peak level and the modelled results with the 1970 rule curves generally fell within the range predicted during the rule curve study conducted by the IRLBC and reported upon in 1999. It was recognized in that study that somewhat higher levels were likely to occur with the revised rule curves under above-normal inflow conditions. This was recognized as the cost for attempting to achieve environmental benefits, and was deemed to be an acceptable tradeoff at that time. Where the difference is larger at the upper end of the range of results, it is clearly due to the 2002 event being a more extreme event than those tested during the study, and it appears to fall well within what would be expected. As with the 2001 event, the high water levels that occurred in 2002 were due to abnormally high rainfall and do not appear to be unduly worsened by the adoption of the new rule curves. In the Board's view it is simply fate that 2 of the 3 years since the adoption of the new rule curves have proven to be high water years.

The high water conditions and flooding resulting from the very heavy rainfall in June 2002 caused widespread damage over portions of southeastern Manitoba, northwestern Ontario and northern Minnesota, including the Rainy-Namakan basin. Within the Rainy-Namakan basin, severe flooding caused extensive washouts of roads, highways and rail lines and damage to homes near the Atikokan, Seine and Turtle Rivers and their tributaries to the northeast of Rainy Lake. Extensive damage to some homes and farms along with road washouts were also experienced near the Pinewood, Sturgeon and La Vallee River tributaries to the Rainy River in Canada, between Fort Frances and the Town of Rainy River. The Town of Rainy River experienced significant damage to roads, culverts and in particular its sewer infrastructure. In the United States, in Koochiching County away from Rainy Lake, major damages were concentrated in agricultural crop and livestock losses and damages to agriculture-related structures, primarily from tributary and overland flooding. On Rainy Lake, the high levels damaged a large number of fixed docks and shoreline facilities or rendered them difficult or impossible to use, with business at a number of local marinas and several resort and houseboat operations impacted to varying degrees. Other problems reported around Rainy Lake included flooding of home basements and crawl spaces, home furnaces and water heaters, yards and landscaping, septic systems and sewers. Abitibi-Consolidated in Canada reported losses in hydroelectric generation, paper production, flood fight and clean up costs, and extensive damage to its woodlands road network, with nearly every bridge and culvert in the storm area being washed out. In the United States, Boise Cascade incurred significant flood fight and clean up costs associated with the flooding of its International Falls powerhouse. Flood fight and clean up costs were incurred to one degree or another by most of the communities and individuals directly affected by the June 2002 rainfall. In contrast, high water damage on the Namakan Chain of Lakes was limited and relatively minor in nature.

Due to the high water events in the basin in 2001 and 2002, stakeholders have requested more explanation of regulation processes and trade-offs, more information during significant events and more public input to the regulation of Rainy and Namakan Lakes. In response, a number of preliminary ideas are being considered by the Board which would hopefully improve 2-way communications, addressing both input from the public to the Board and information from the Board to the public. The Board intends to explore these ideas further, with the hope of fostering greater public involvement and better understanding by basin residents of the regulation process.

In conclusion, the extraordinary June 2002 rainfall was bound to result in high lake and river levels. This was a relatively rare event, about which little can be done. The Companies and the Board responded to the rapidly increasing inflows in a timely and appropriate manner, increasing outflow over time as quickly as was prudent. The variability of inflows provided by nature is simply much greater than the Board's limited ability to regulate them. High levels such as those experienced in 2002 certainly won't occur every year, but even higher levels have occurred in the past and will occur again in the future. Property owners must be aware of this and take appropriate steps. These include: being aware of the range of water levels likely to occur, being aware of hazard land and floodplain zones, limiting incursion into the floodplain and hazard land zone to only docks and boathouses and recognizing that these structures are at risk, and preserving natural vegetation as much as possible to limit erosion.

8. RECOMMENDATIONS

Based on its assessment of the 2002 high water event, the Board recommends:

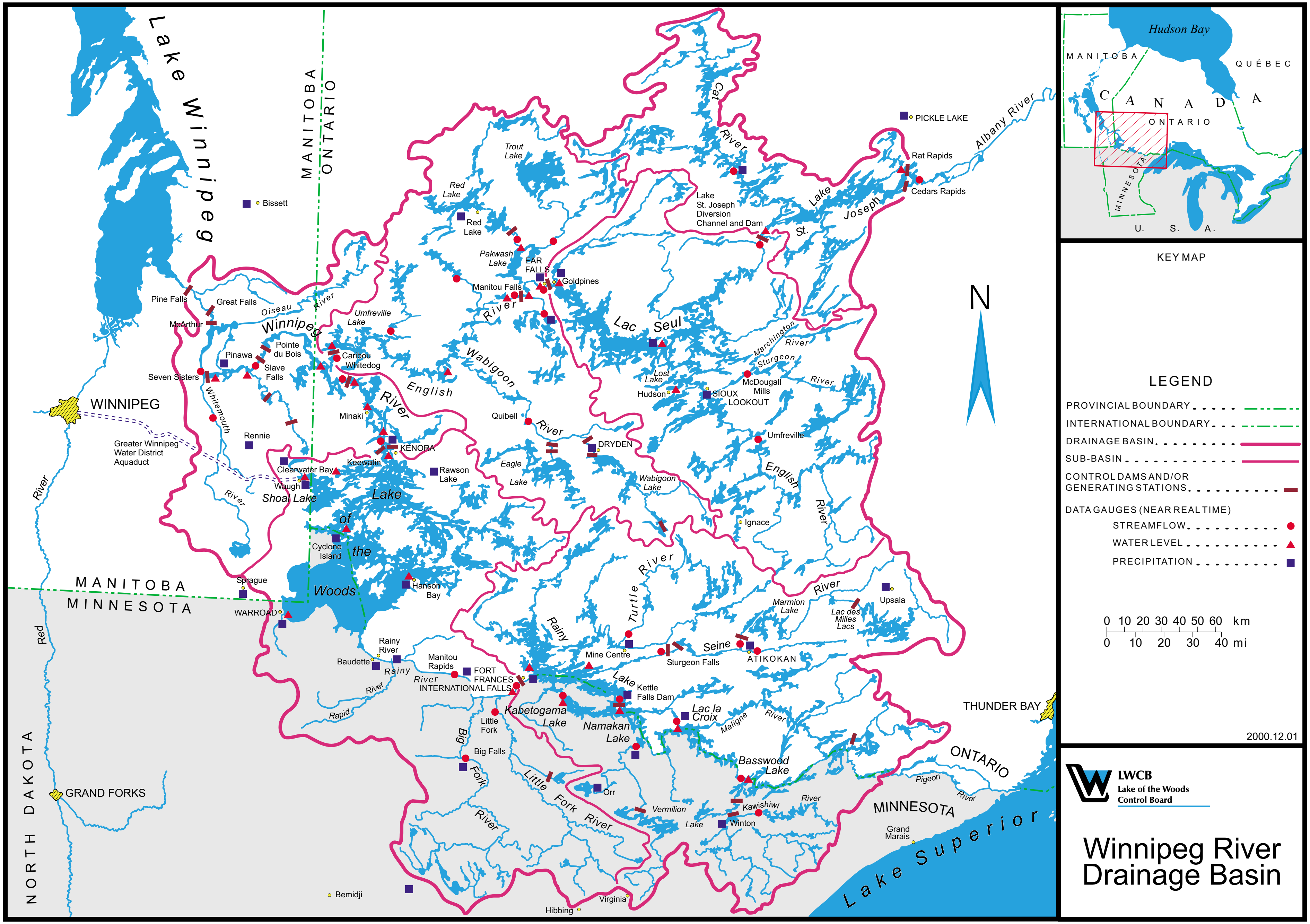
- that the IJC Year 2000 rule curves for Rainy and Namakan Lakes not be reviewed further at this time. The IJC should continue with its plans for review in 2015, with an earlier review only if warranted by new information in the future. The high water events in 2001 and 2002 were the result of unusually heavy rainfall and were not unduly worsened, beyond what was anticipated, by the new rule curves adopted in 2000. The peak level reached in 2002 on Rainy Lake, while 0.81 m (2.7 ft) above the IJC upper emergency level, was 0.67 m (2.2 ft) below the 1950 flood peak of record, and therefore was well within the shore zone area that should be considered hazard land around the lake.

- that more effort be made: to raise public awareness of the water levels that can occur, to educate the public about the shoreline hazard land area and how it should be used, and to encourage local governments to adopt and enforce hazard land zones around the lakes with appropriate development restrictions. After the events of 2001 and 2002, it is apparent that many people do not realize the risks associated with living and building near the water's edge and do not realize the height to which the lakes have risen in the past and are likely to rise to again, and even higher, in the future. As a result, appropriate planning has not occurred, nor have safeguards and measures to minimize damage been put in place. In light of the events of 2001 and 2002, it would be irresponsible not to try to rectify this situation.

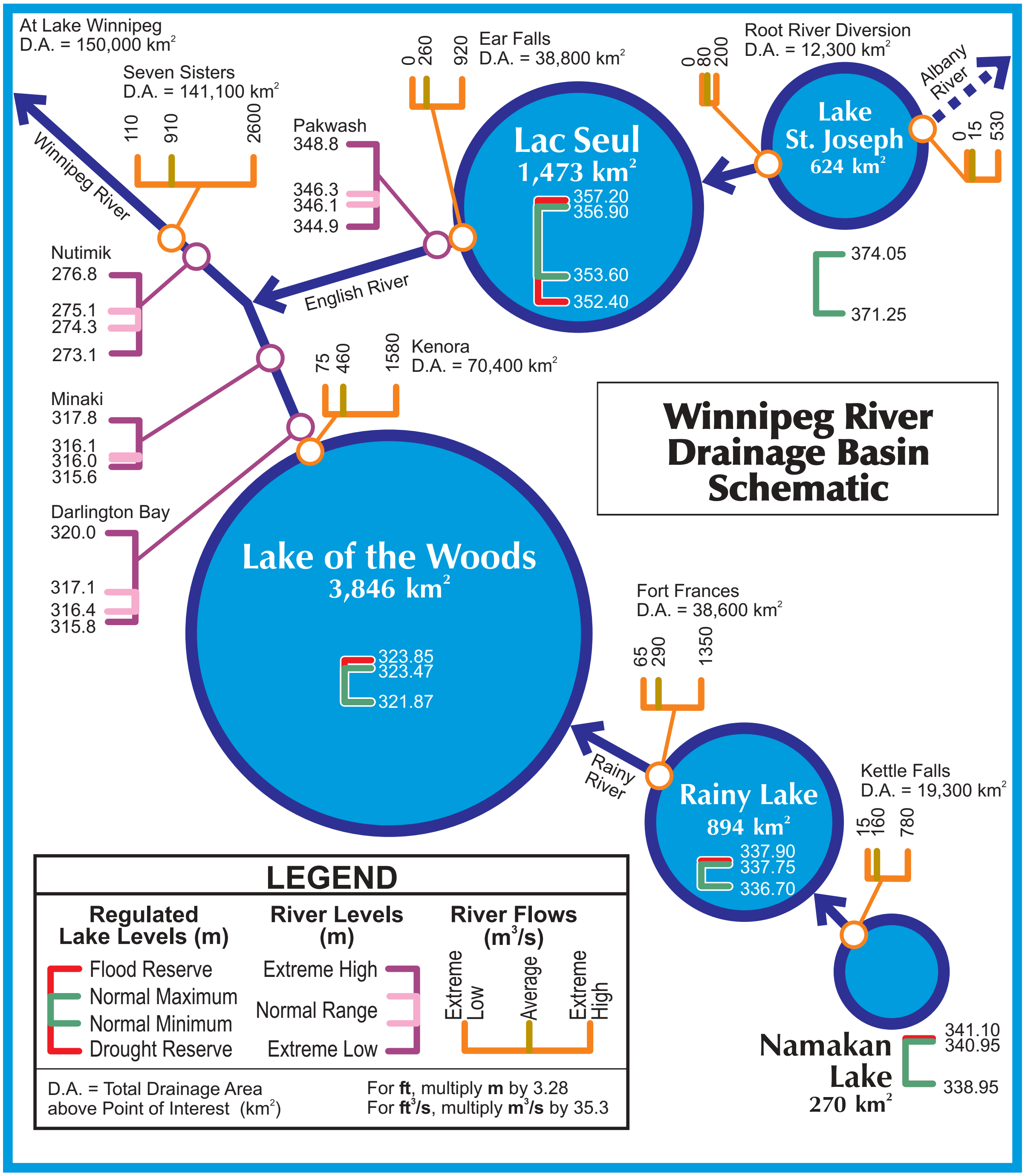
- that steps be taken to improve communications with the public, and to explore potential means of increased public involvement, regarding water level and flow regulation. Stakeholders in the basin have requested more explanation of regulation processes and trade-offs, more information during significant events and more public input to the regulation of Rainy and Namakan Lakes. In response, a number of preliminary ideas have been discussed by the IRLBC, the IRRWPB and the IJC, including information pamphlets, periodic informal stakeholder round-table discussions and establishment of a public advisory group to the IRLBC. These preliminary ideas should be investigated further and discussed by the Boards and the IJC with the dam operators and other stakeholders, seeking their views, comments and additional ideas.

APPENDIX A

MAP AND SCHEMATIC OF BASIN



Winnipeg River Drainage Basin
LWCB
Lake of the Woods Control Board
2000.12.01
KEY MAP
Hudson Bay
MANITOBA
QUÉBEC
CANADA
ONTARIO
MINNESOTA
U. S. A.
LEGEND
PROVINCIAL BOUNDARY
INTERNATIONAL BOUNDARY
DRAINAGE BASIN
SUB-BASIN
CONTROL DAMS AND/OR GENERATING STATIONS
DATA GAUGES (NEAR REAL TIME)
STREAMFLOW
WATER LEVEL
PRECIPITATION
0 10 20 30 40 50 60 km
0 10 20 30 40 mi
N
Lake Winnipeg
MANITOBA
ONTARIO
MINNESOTA
NORTH DAKOTA
WINNIPEG
GRAND FORKS
THUNDER BAY
Lake Superior
Greater Winnipeg Water District Aquaduct
Red River
Bissett
Pine Falls
Great Falls
McArthur
Pinawa
Seven Sisters
Pointe du Bois
Slave Falls
Whitemouth River
Rennie
Oiseau River
Winnipeg River
Umfreville Lake
Caribou
Whitedog
Minaki
English River
KENORA
Keewatin
Clearwater Bay
Waugh
Shoal Lake
Lake of the Woods
Cyclone Island
Sprague
WARROAD
Hanson Bay
Rawson Lake
Trout Lake
Red Lake
Pakwash Lake
EAR FALLS
Goldpines
Manitou Falls
Lac Seul
Wabigoon River
Quibell
Eagle Lake
DRYDEN
Wabigoon Lake
Lost Lake
Hudson
SIOUX LOOKOUT
McDougall Mills
Marchington River
Sturgeon River
Umfreville
English River
Ignace
Cat River
Lake St. Joseph Diversion Channel and Dam
Lake St. Joseph
PICKLE LAKE
Rat Rapids
Cedars Rapids
Albany River
Turtle River
Rainy Lake
Marmion Lake
Lac des Milles Lacs
Upsala
Seine River
Mine Centre
Sturgeon Falls
ATIKOKAN
Rainy River
Baudette
Manitou Rapids
FORT FRANCES
INTERNATIONAL FALLS
Rapid River
Kabetogama Lake
Namakan Lake
Kettle Falls Dam
Lac la Croix
Maligne River
Basswood Lake
Little Fork
Big Falls
Big Fork River
Little Fork River
Orr
Vermilion Lake
Kawishiwi River
Winton
Pigeon River
ONTARIO
MINNESOTA
Grand Marais
Bemidji
Hibbing
Virginia



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APPENDIX B

FIGURES

<u>NOTE</u>

All precipitation, water level and flow data used in the text and figures of this report were 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.

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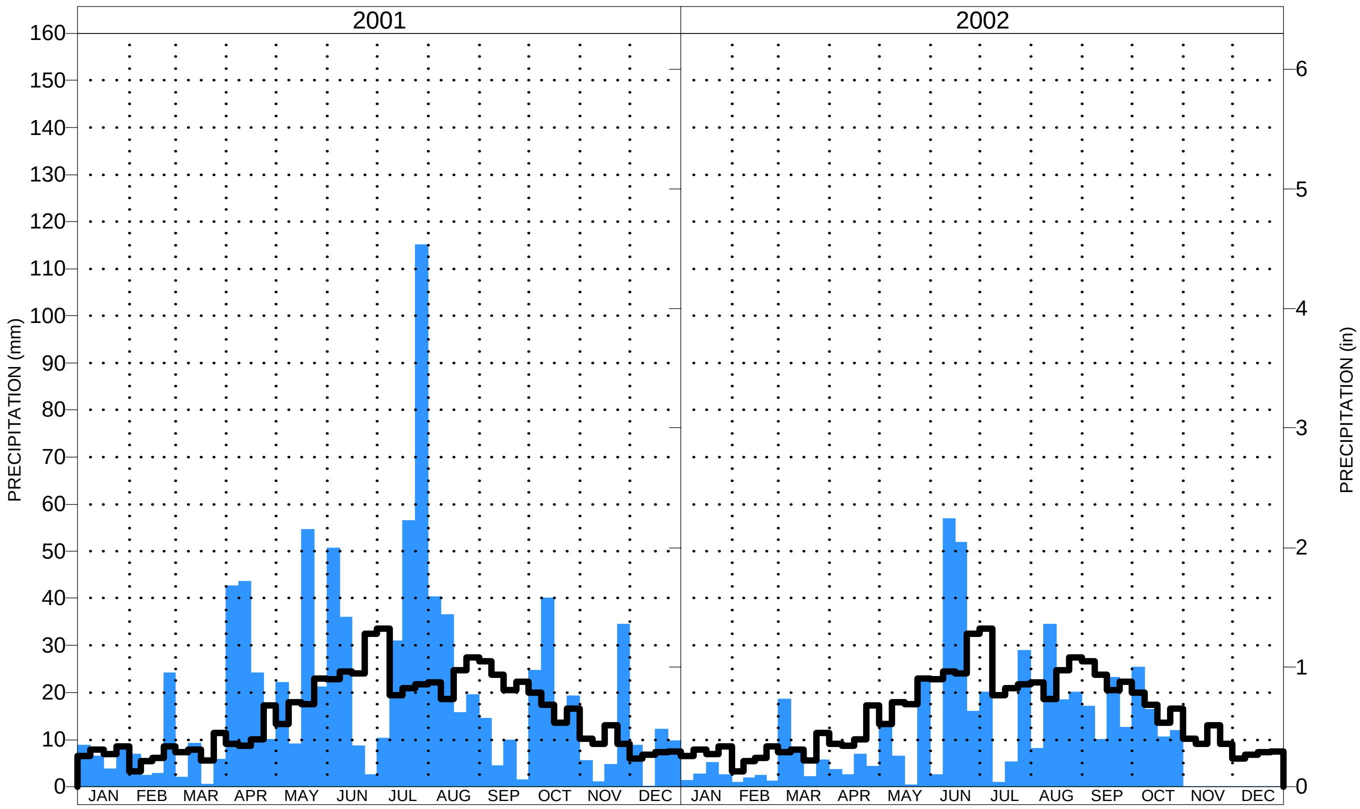
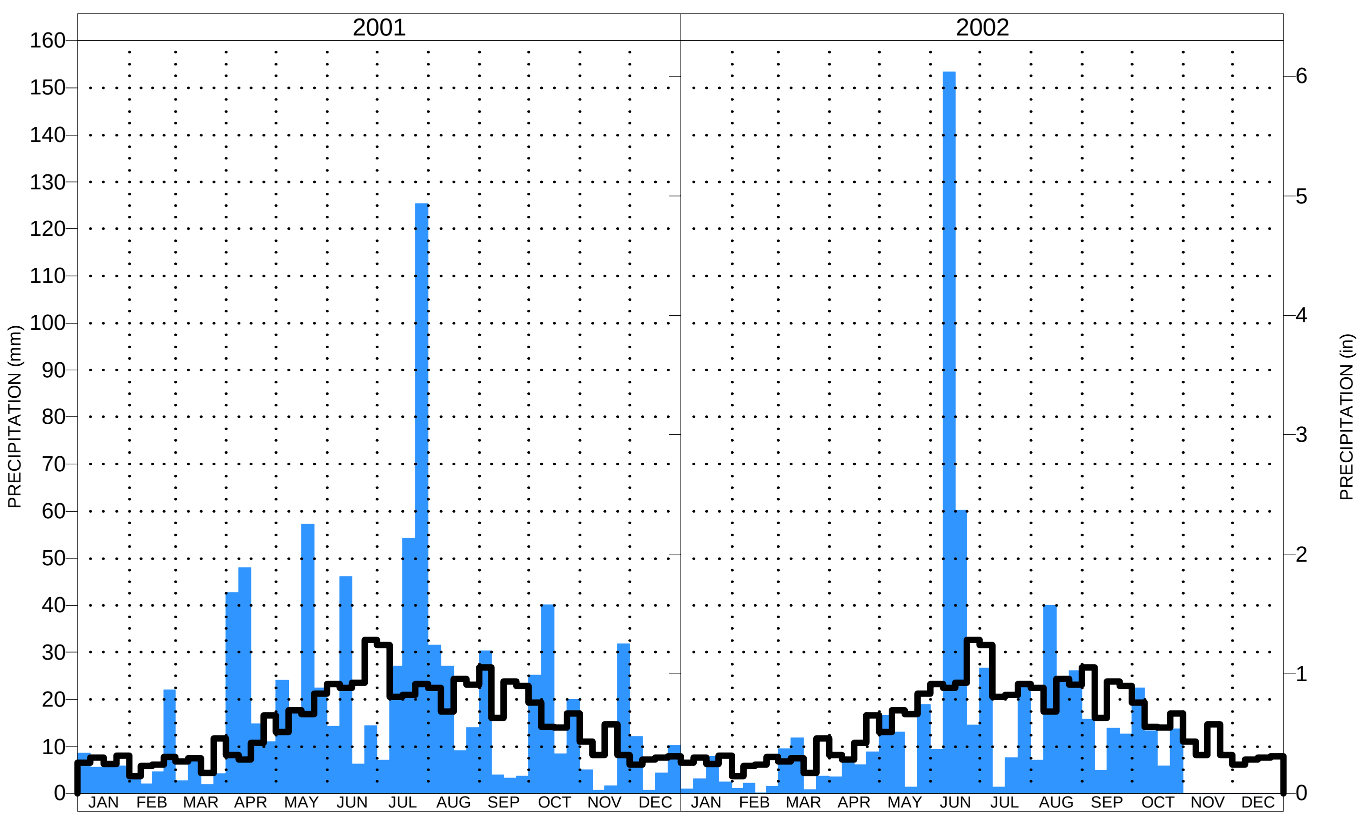
RAINY RIVER SYSTEM PRECIPITATION

Figure 1

LAC LA CROIX BASIN



RAINY-NAMAKAN BASIN



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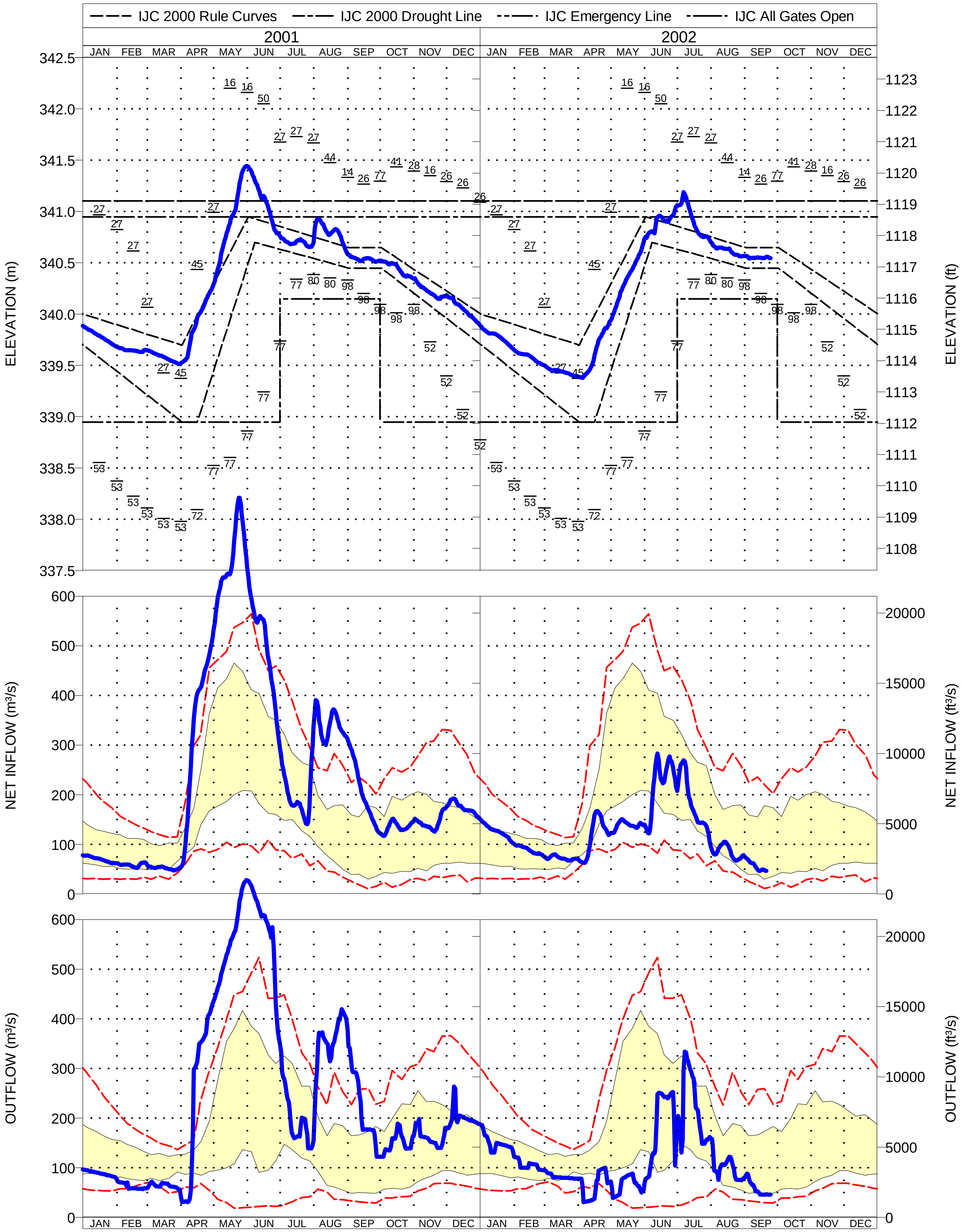
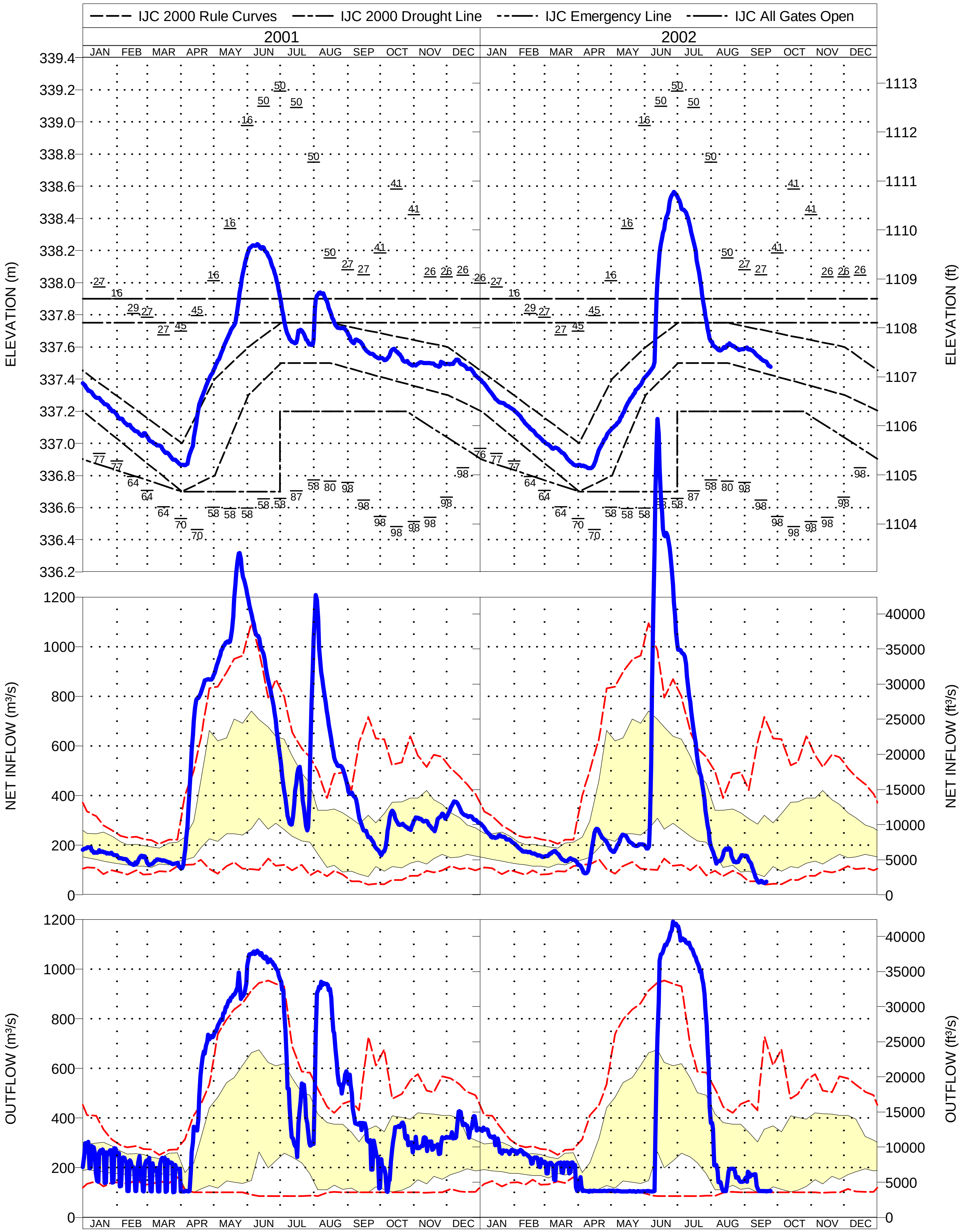
NAMAKAN LAKE

Figure 2



RAINY LAKE

Figure 3



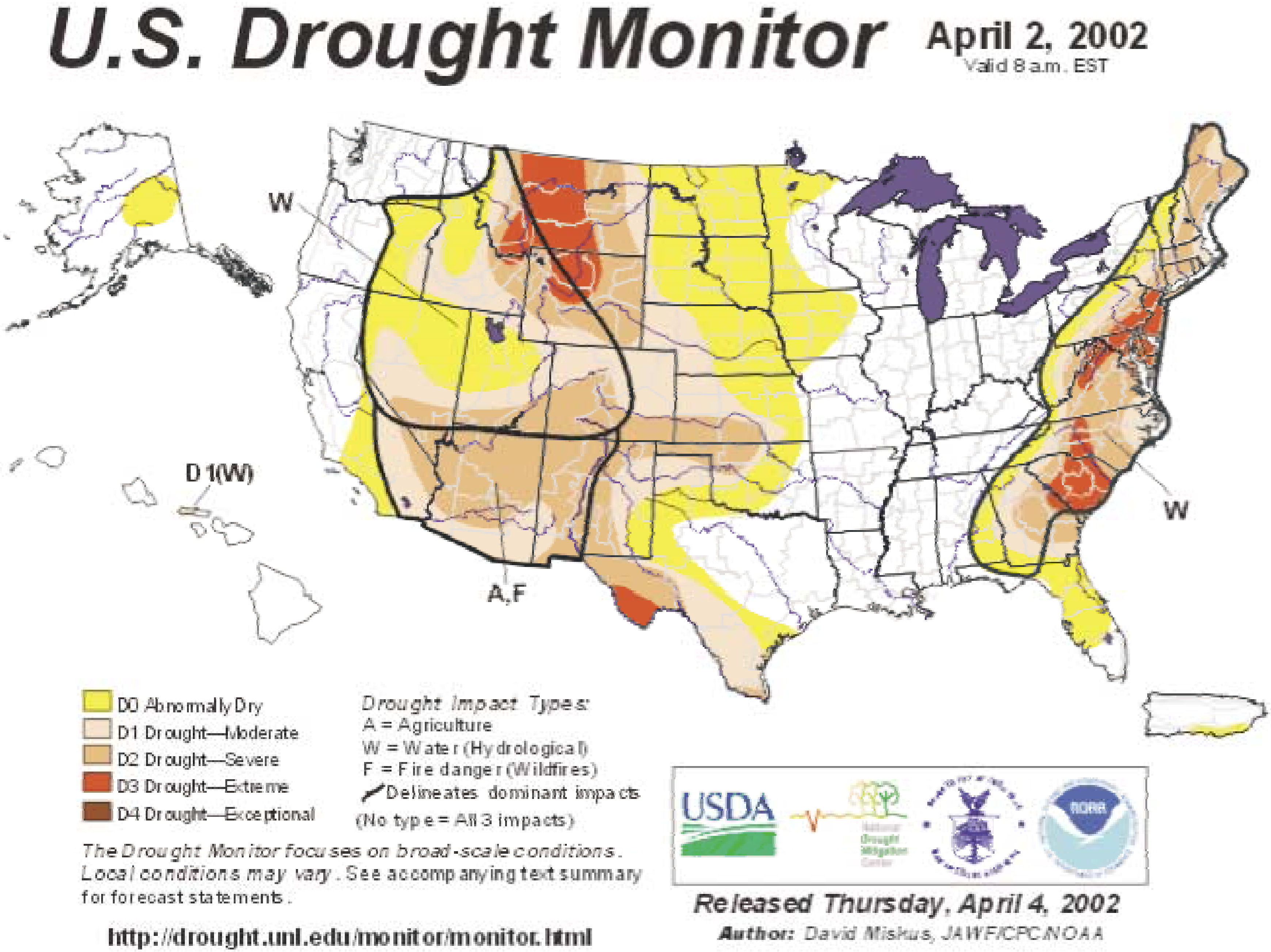
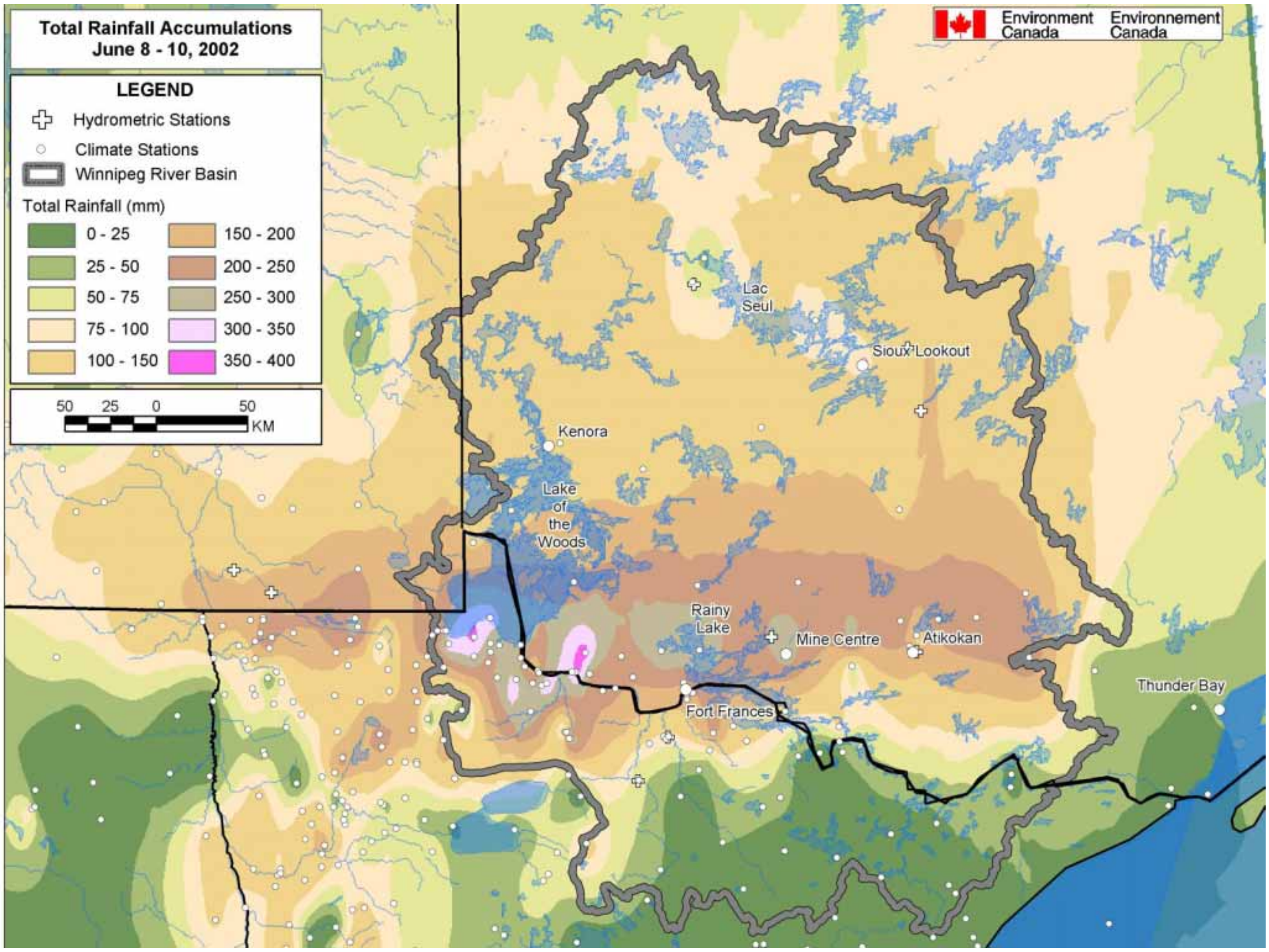

U.S. Drought Monitor
April 2, 2002
Valid 8 a.m. EST
W
D1(W)
A,F
W
D0 Abnormally Dry
D1 Drought—Moderate
D2 Drought—Severe
D3 Drought—Extreme
D4 Drought—Exceptional
Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
Delineates dominant impacts
(No type = All 3 impacts)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/monitor/monitor.html
USDA
Released Thursday, April 4, 2002
Author: David Miskus, JAWF/CPC/NOAA

Figure 4

Figure 5

Winnipeg River Basin: Rainfall Distribution June 8-10, 2002



Source: Meteorological Service of Canada, Environment Canada

Note: Multiply millimeters by 0.0394 to obtain inches

Figure 6

Total Rainfall Ranking

Lac La Croix					Rainy-Namakan				
Since 1948			June Rainfall		Since 1948			June Rainfall	
Rank		**Year**	**(mm)**	**(in)**	**Rank**		**Year**	**(mm)**	**(in)**
1		1990	214	8.4	**1**		**2002**	**238**	**9.4**
2		1964	187	7.4	**2**		1964	191	7.5
3		1968	173	6.8	**3**		1990	175	6.9
4		1986	161	6.3	**4**		1968	172	6.8
5		1976	160	6.3	**5**		1955	171	6.7
6		1943	153	6.0	**6**		1976	166	6.5
7		1981	152	6.0	**7**		1989	165	6.5
8		1926	146	5.7	**8**		1950	157	6.2
9		1994	146	5.7	**9**		1985	154	6.1
10		1941	144	5.7	**10**		1984	147	5.8
18		**2002**	**127**	**5.0**					
Median			91	3.6	**Median**			94	3.7

Average Inflow Ranking

Namakan Lake					Rainy Lake				
Since 1957			June Inflow		Since 1912			June Inflow	
Rank		**Year**	**(m^3/s)**	**(ft^3/s)**	**Rank**		**Year**	**(m^3/s)**	**(ft^3/s)**
1		1968	578	20400	**1**		1950	1490	52500
2		1970	578	20400	**2**		**2002**	**1150**	**40800**
3		1974	535	18900	**3**		1954	1080	38200
4		2001	506	17900	**4**		1974	1040	36900
5		1966	492	17400	**5**		1943	1020	36100
6		1964	462	16300	**6**		1968	1010	35700
7		1979	453	16000	**7**		1970	1010	35600
8		1978	451	15900	**8**		1927	958	33800
9		1996	446	15700	**9**		1916	950	33600
10		1965	445	15700	**10**		2001	944	33300
33		**2002**	**219**	**7720**					
Median			393	13900	**Median**			433	15300

Annual Peak Water Level Ranking

Namakan Lake					Rainy Lake				
Since 1913			Peak Level		Since 1912			Peak Level	
Rank		**Year**	**(m)**	**(ft)**	**Rank**		**Year**	**(m)**	**(ft)**
1		1916	342.25	1122.9	**1**		1950	339.23	1113.0
2		1950	342.20	1122.7	**2**		1916	339.09	1112.5
3		1927	341.97	1121.9	**3**		1941	338.60	1110.9
4		1938	341.84	1121.5	**4**		**2002**	**338.56**	**1110.8**
5		1968	341.71	1121.1	**5**		1927	338.44	1110.4
6		1914	341.54	1120.5	**6**		1968	338.36	1110.1
7		1920	341.49	1120.4	**7**		1938	338.26	1109.8
8		1944	341.49	1120.4	**8**		2001	338.24	1109.7
9		2001	341.45	1120.2	**9**		1974	338.20	1109.6
10		1941	341.44	1120.2	**10**		1954	338.19	1109.5
24		**2002**	**341.19**	**1119.4**					
Median			341.02	1118.8	**Median**			337.84	1108.4

Lake of the Woods and Rainy-Namakan Basins: Rainfall Distribution June 1-30 2002

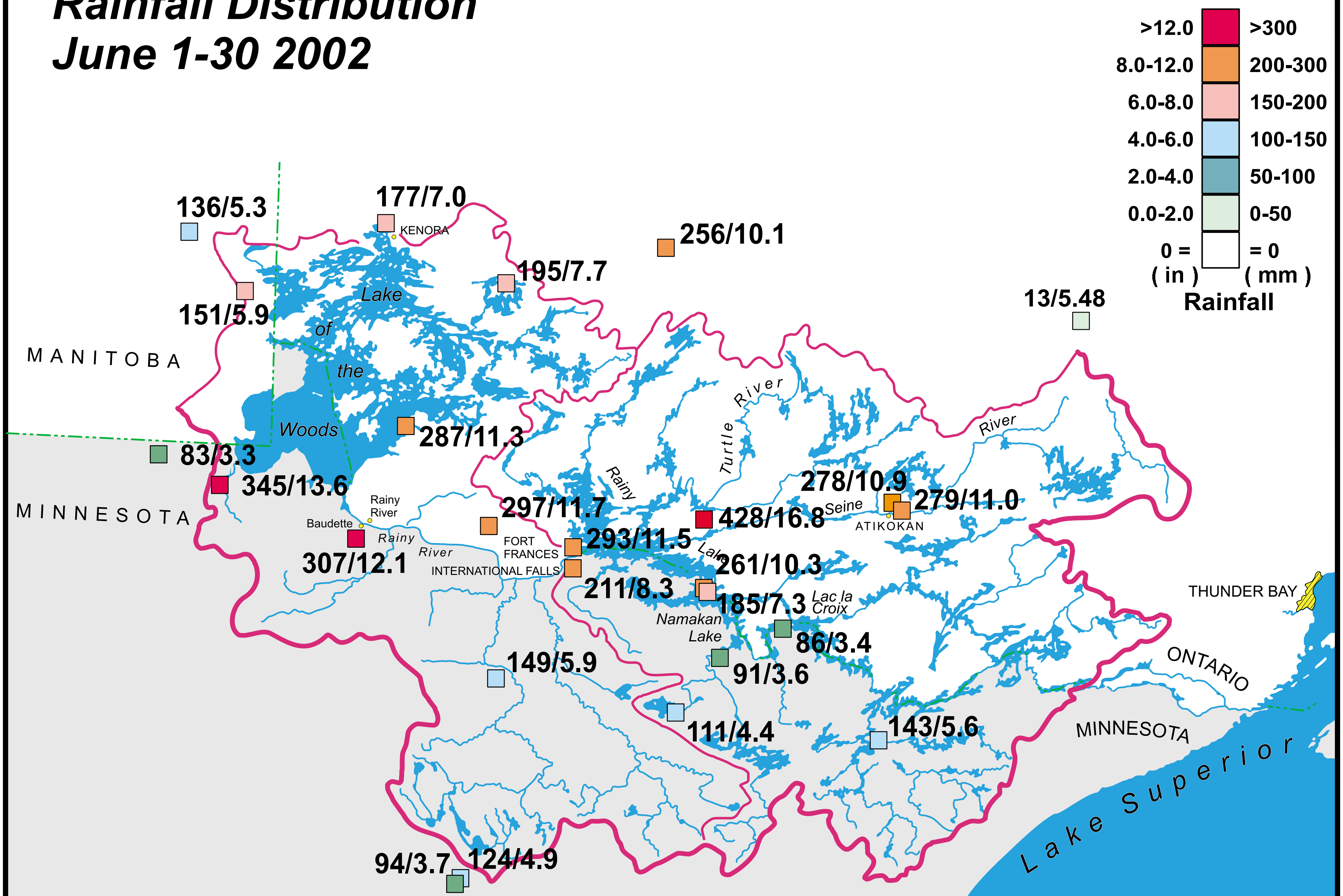


Figure 7

LWCB
Lake of the Woods
Control Board

TURTLE RIVER FLOW

Figure 8

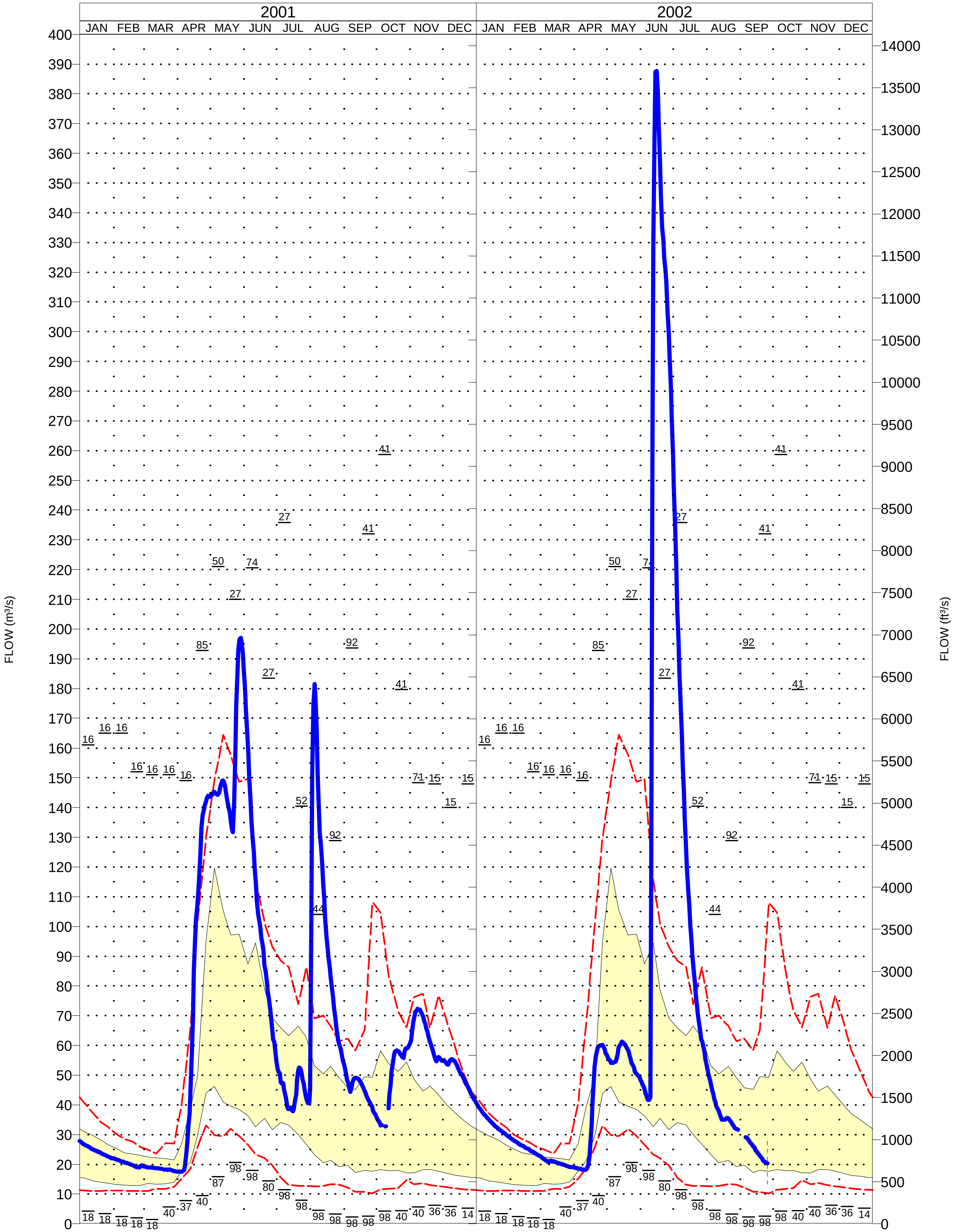
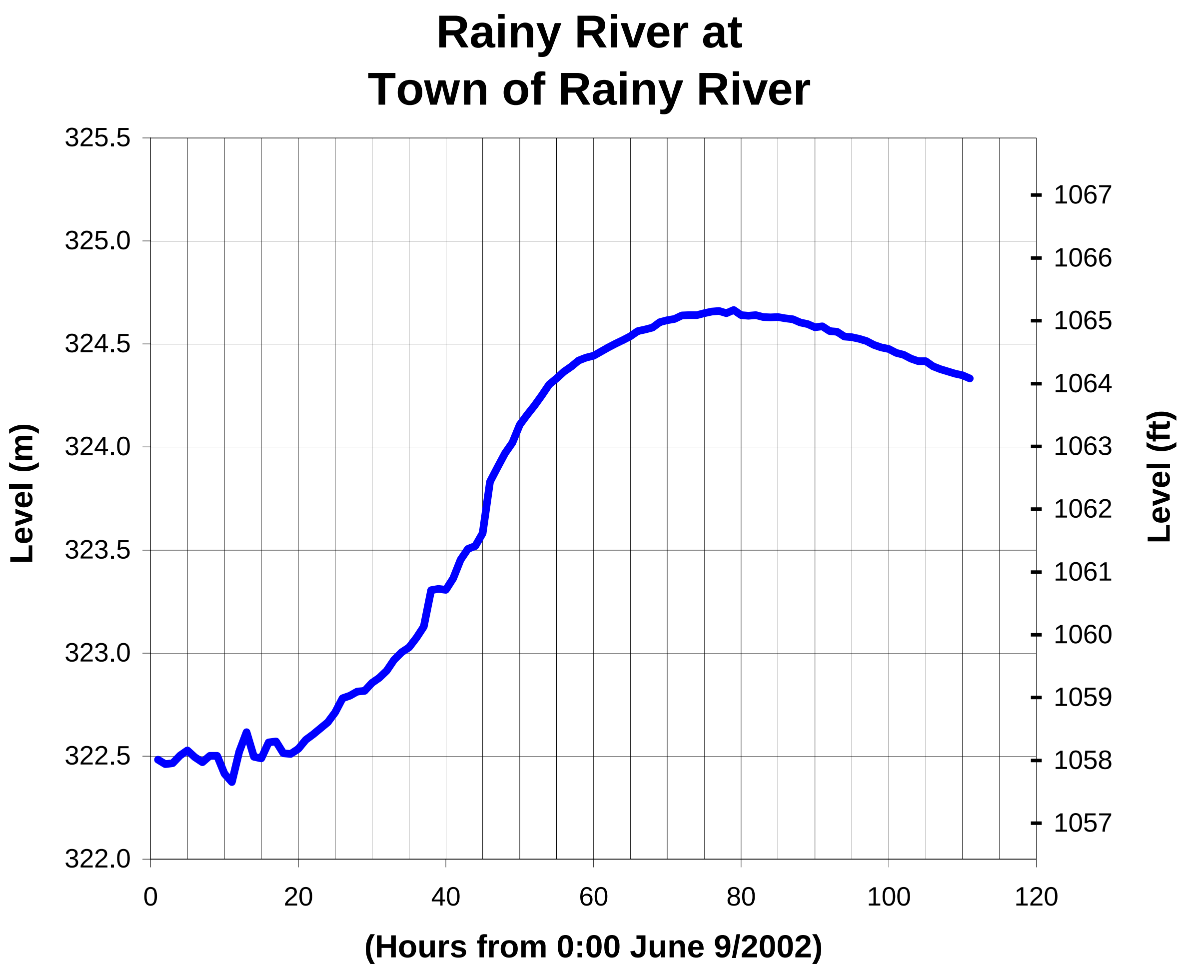


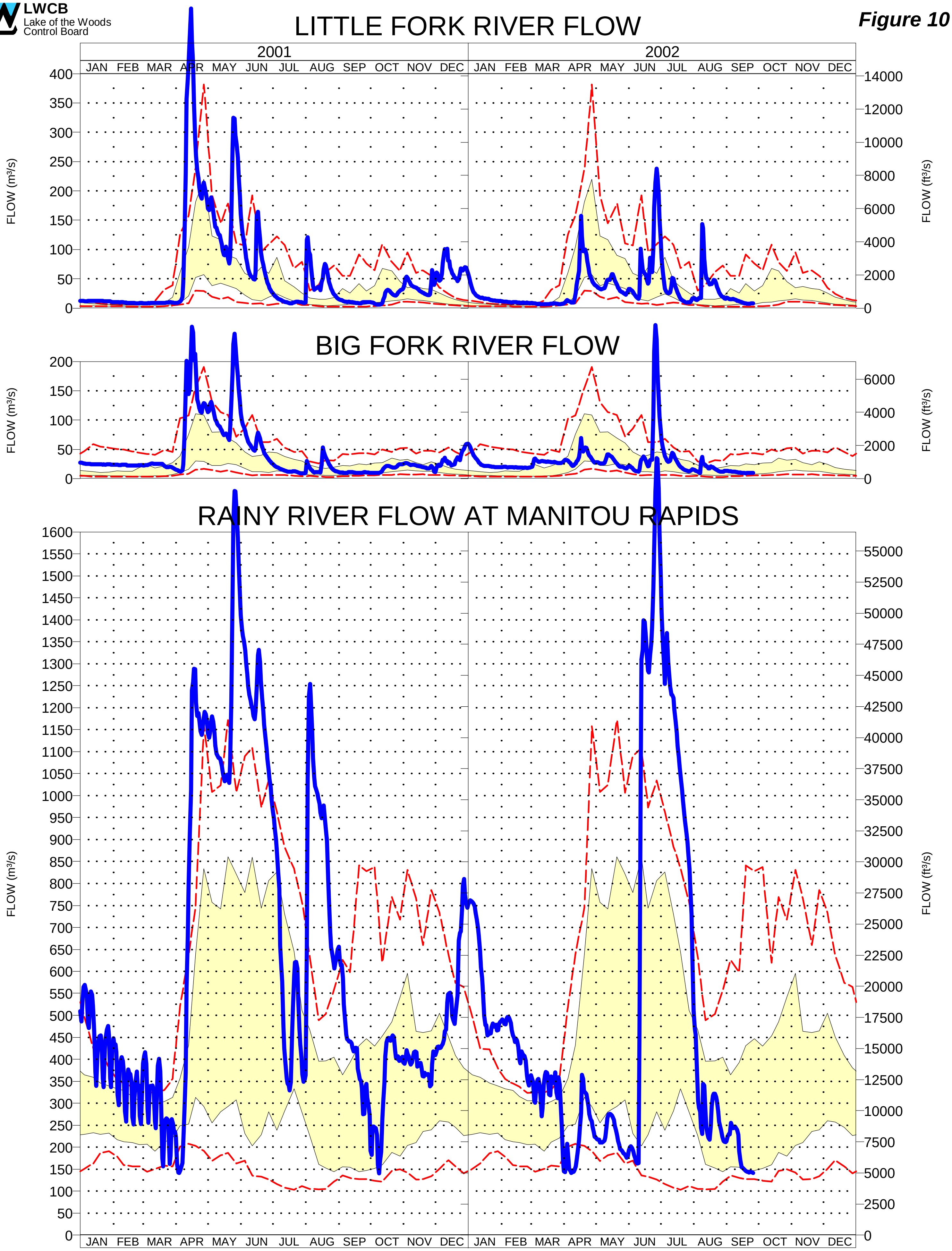
Figure 9



Rainy River at
Town of Rainy River
Level (m)
Level (ft)
325.5
325.0
324.5
324.0
323.5
323.0
322.5
322.0
1067
1066
1065
1064
1063
1062
1061
1060
1059
1058
1057
0
20
40
60
80
100
120
(Hours from 0:00 June 9/2002)

LWCB
Lake of the Woods Control Board

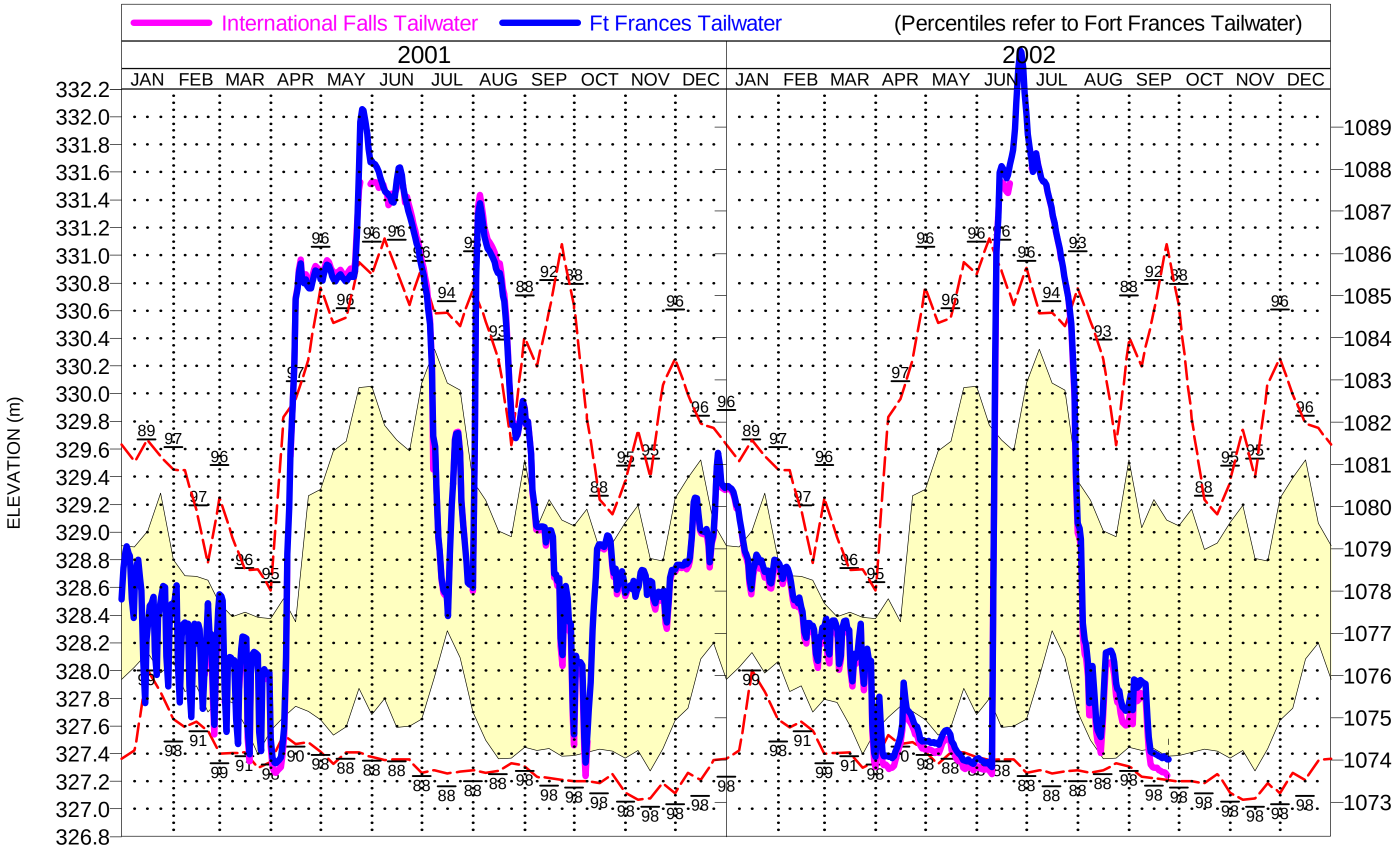
Figure 10



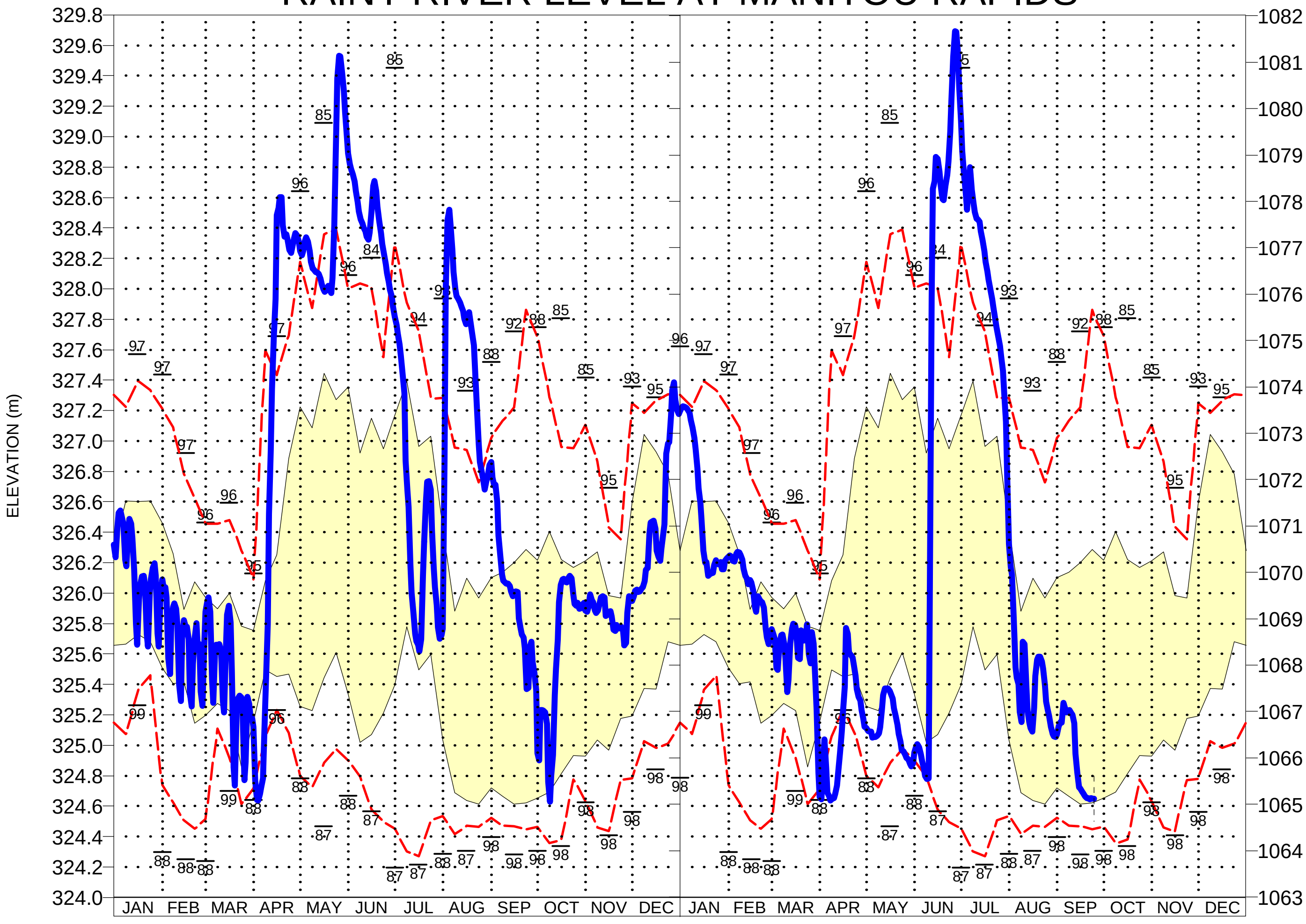
LWCB
Lake of the Woods Control Board

RAINY RIVER LEVEL BELOW FORT FRANCES

Figure 11



RAINY RIVER LEVEL AT MANITOU RAPIDS



Simulation Model Results for Rainy Lake

Run #	Rule Curve	Lakes Modeled	Start Date/Level	Namakan Lake Level Followed	Rainy Lake Peak Level	Difference in Rainy Lake Peak Level (-ve = lower)	
					m	cm	in
Actual	2000			2002	338.564		
Calibration							
A1	2000	RL	June 8 / actual 2002		338.557	-0.7	-0.3
A2	2000	NL, RL	June 8 / actual 2002	Actual June 8 on	338.560	-0.4	-0.2
A3	2000	NL, RL	January 1 / actual 2002	Actual June 8 on	338.558	-0.6	-0.2
Effect of Delayed Opening of the Rainy Lake Dam							
B1	2000	RL	June 8 / actual 2002		338.513	-5.1	-2.0
Effect of Using Additional Storage on Namakan Lake							
C1	2000	NL, RL	June 8 / actual 2002	Mid-band	338.610	4.6	1.8
C2	2000	NL, RL	June 8 / actual 2002	URC	338.590	2.6	1.0
C3	2000	NL, RL	June 8 / actual 2002	340.95 m	338.572	0.8	0.3
Effect of the New Rule Curves Versus the Old							
i) With current operations and 2002 spring drought through June 8							
D1	1970	NL, RL	January 1 / actual 2002	Mid-band	338.410	-15.4	-6.1
D2	1970	NL, RL	January 1 / actual 2002	URC	338.381	-18.3	-7.2
D3	1970	NL, RL	January 1 / actual 2002	Actual June 8 on	338.367	-19.7	-7.8
ii) With "normal" inflows through June 8 (no spring drought)							
E1	1970	NL, RL	June 8 / mid-band	Mid-band	338.528	-3.6	-1.4
E2	1970	NL, RL	June 8 / mid-band	URC	338.498	-6.6	-2.6
E3	1970	NL, RL	June 8 / mid-band	Actual June 8 on	338.486	-7.8	-3.1
iii) With current operations, 2002 spring drought and Rainy outflows at minimum							
F1	1970	NL, RL	January 1 / actual 2002	Mid-band	338.473	-9.1	-3.6
F2	1970	NL, RL	January 1 / actual 2002	URC	338.444	-12.0	-4.7
F3	1970	NL, RL	January 1 / actual 2002	Actual June 8 on	338.430	-13.4	-5.3
iv) With operations typical of 1990-1999							
G1	1970	NL, RL	January 1 / actual 2002	Fishery target	338.539	-2.5	-1.0
Drawdown Needed to Avoid High Water Levels							
H1	1970	NL, RL	June 8 / RL at 335.40	Mid-band	337.740	-82.4	-32.4
H2	2000	NL, RL	June 8 / RL at 335.40	Mid-band	337.805	-75.9	-29.9

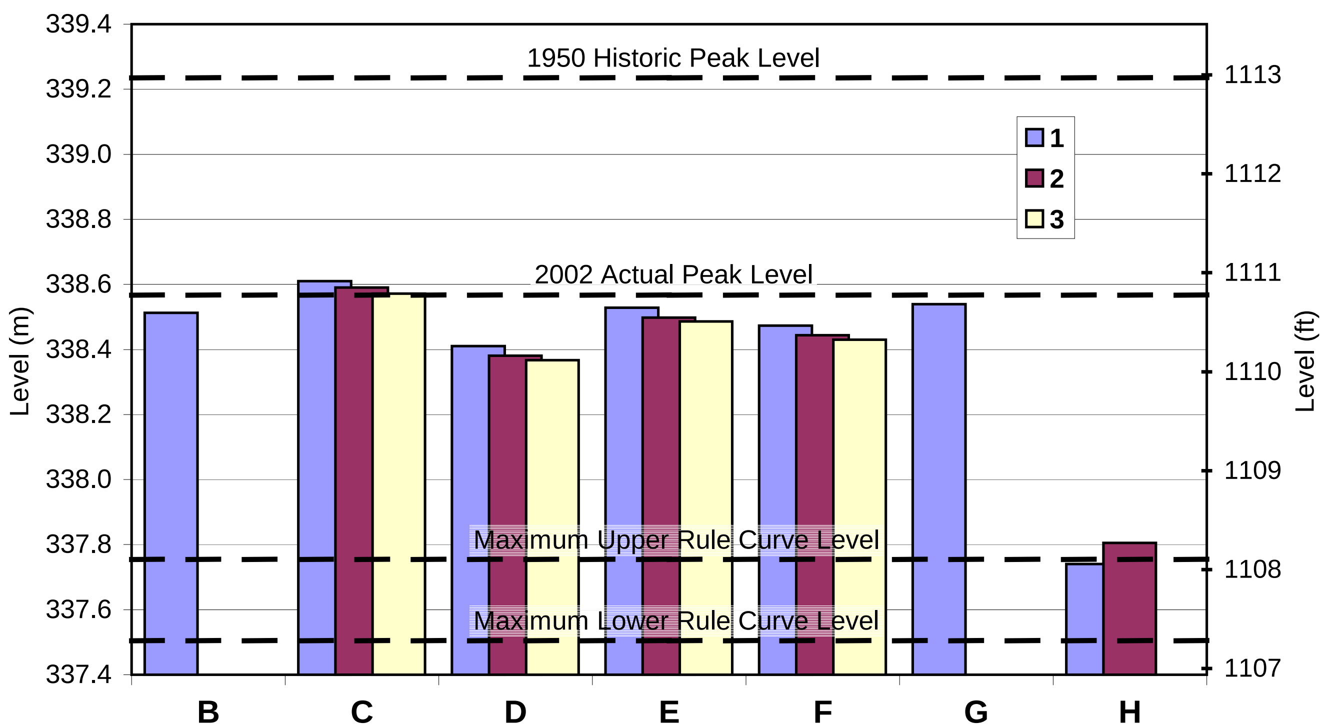
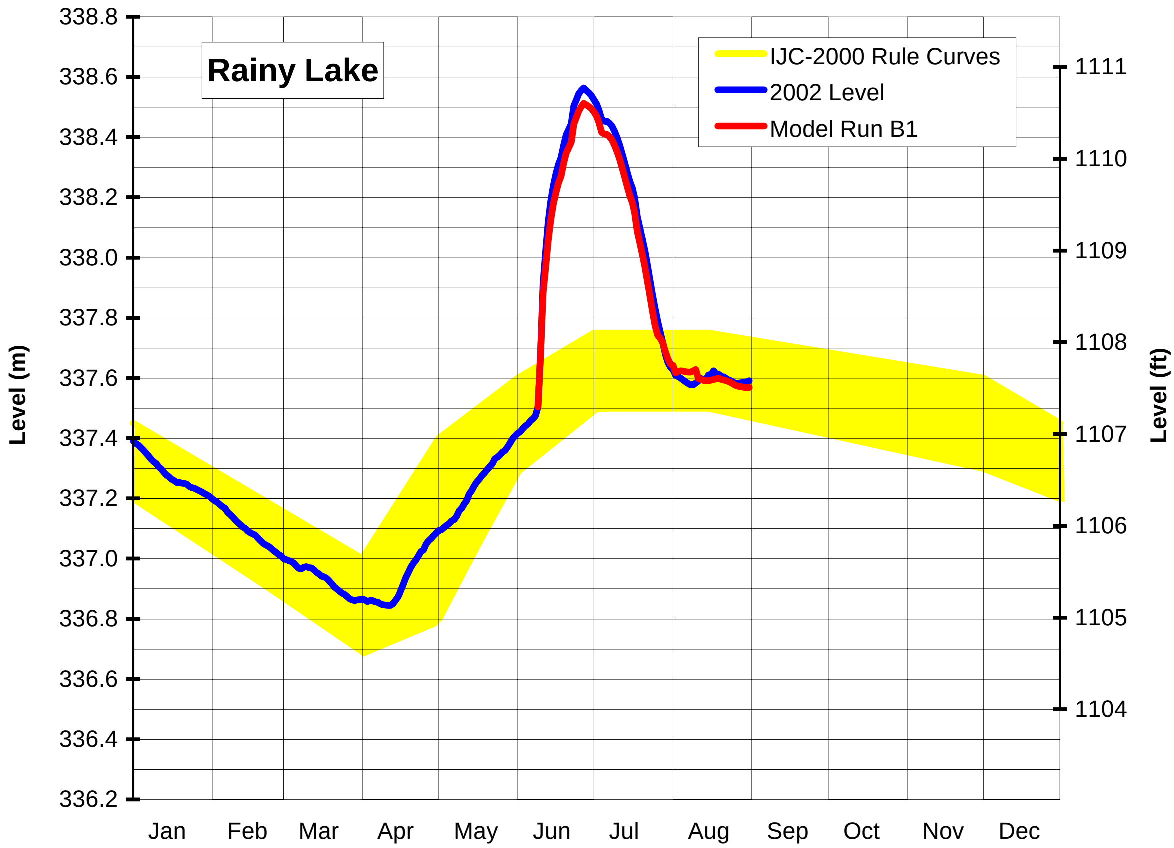
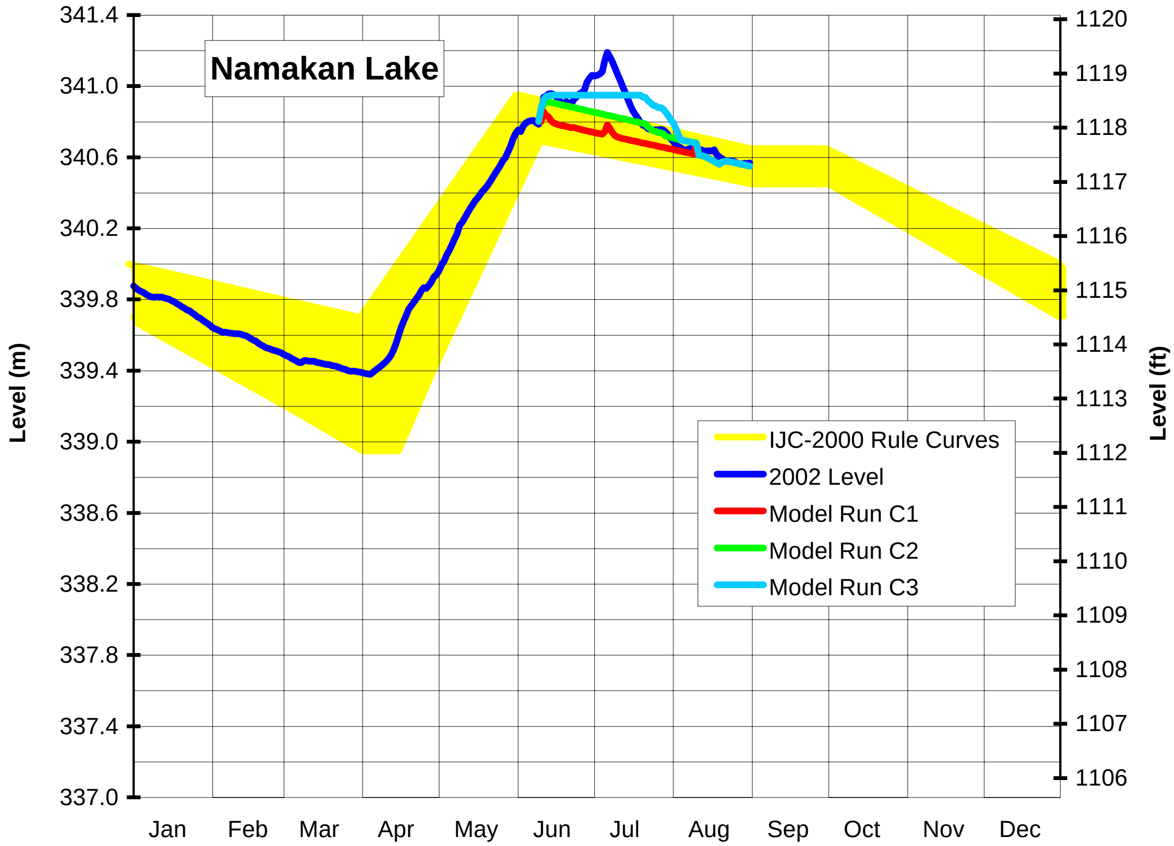


Figure 13

Model Results - Effect of Delayed Opening of the Rainy Lake Dam



Model Results - Effect of Using Additional Storage on Namakan Lake



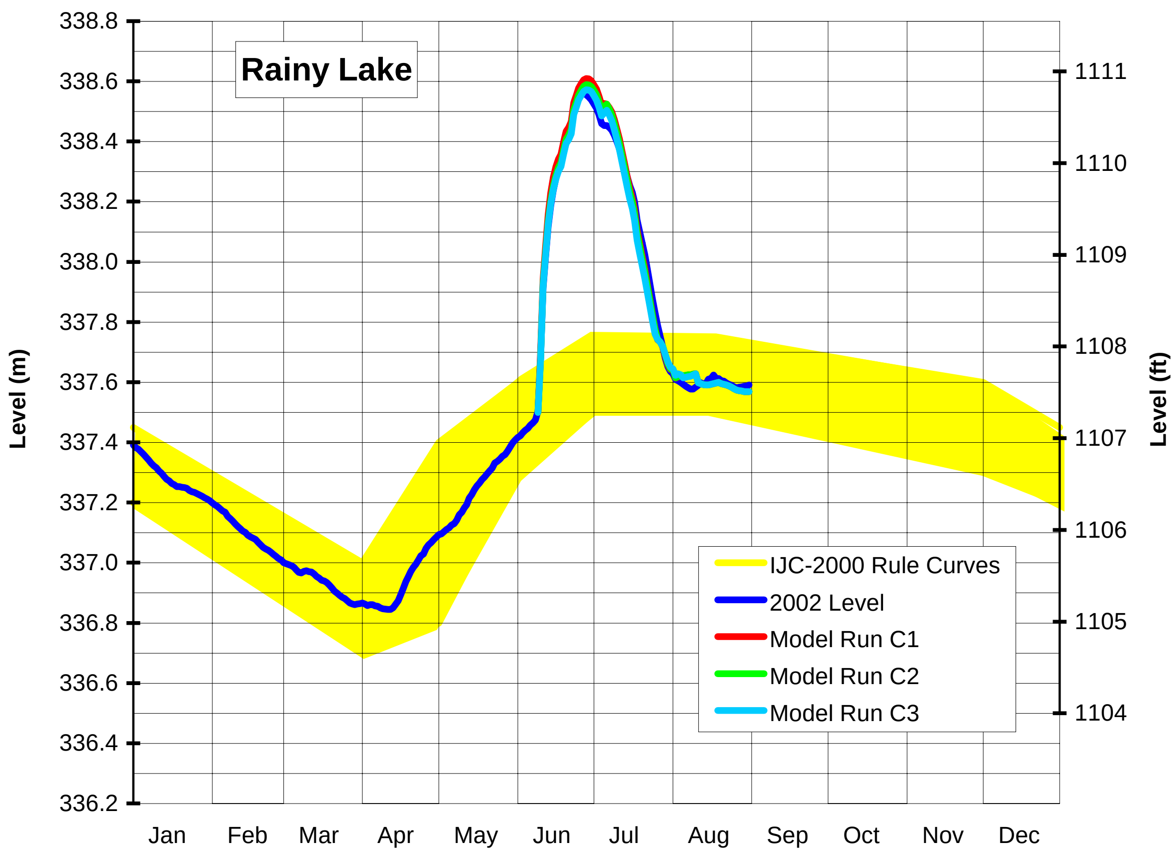
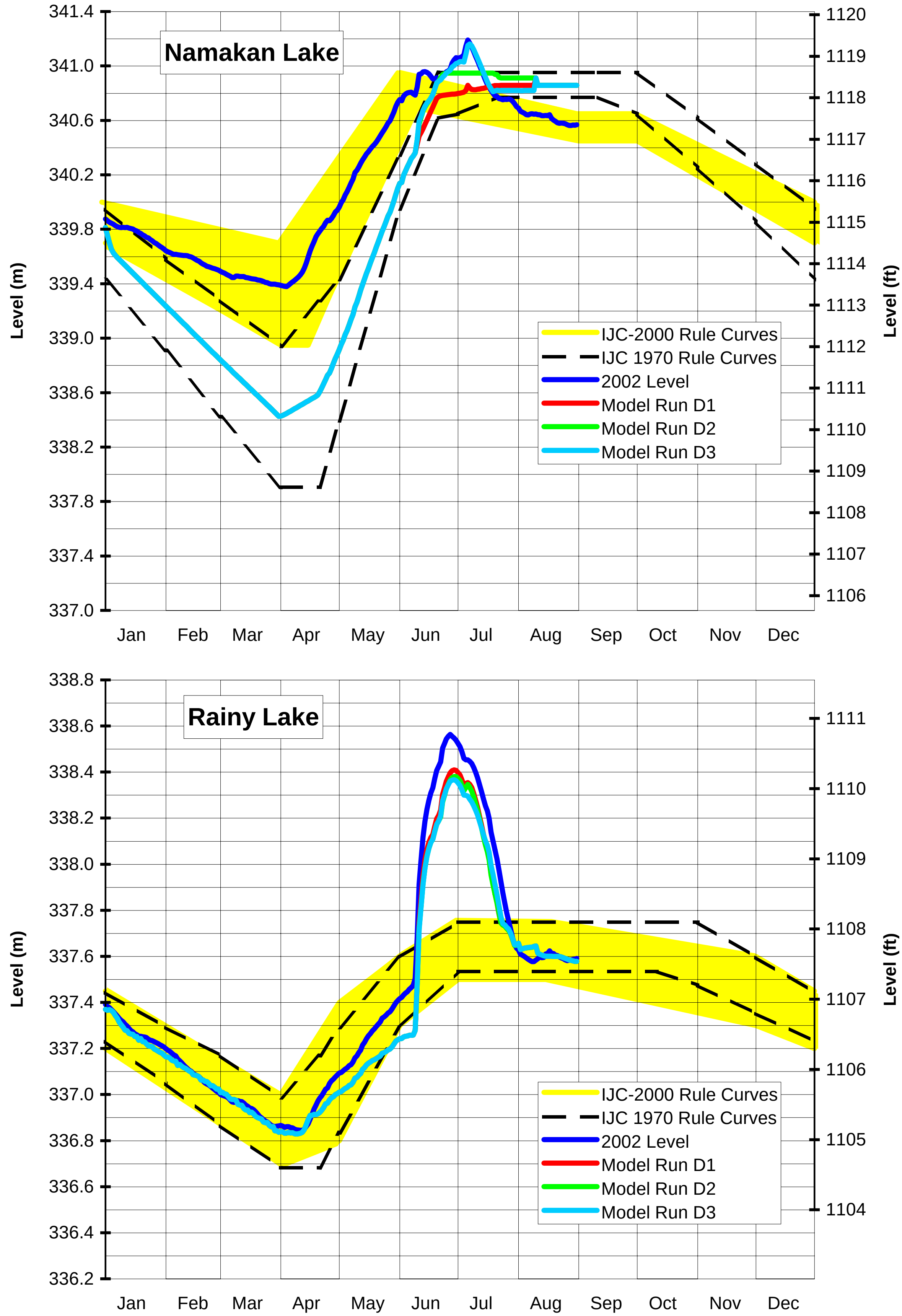
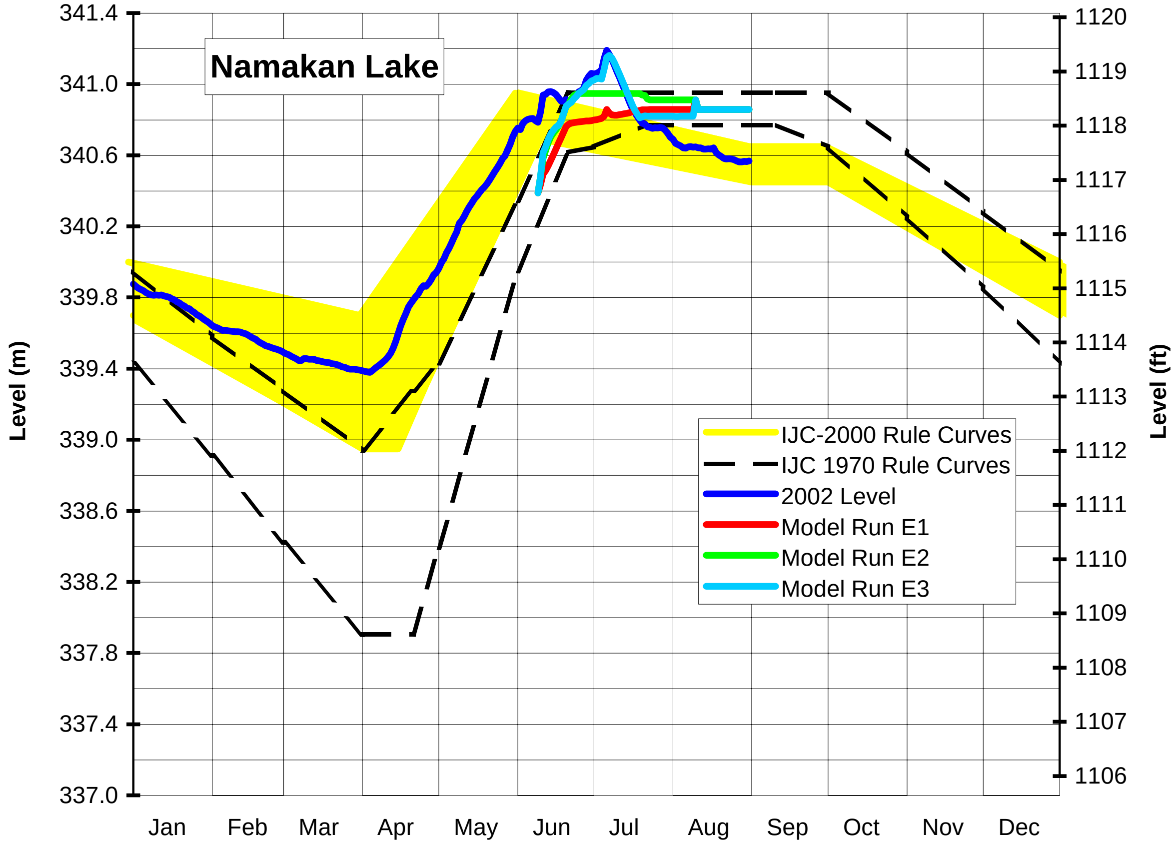


Figure 15

Model Results - Effect of Rule Curves
Current Operating Policy and Spring Drought



Model Results - Effect of Rule Curves
"Normal" Spring Inflows (No Spring Drought)



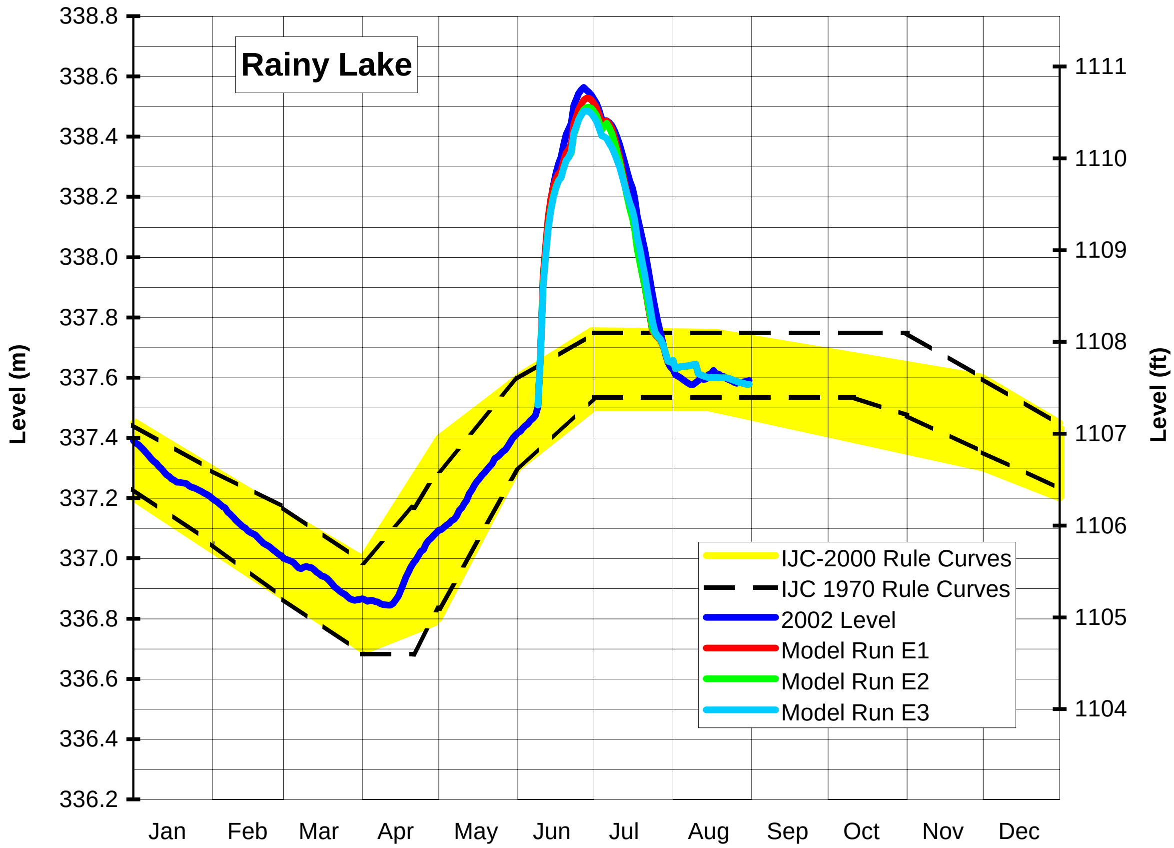
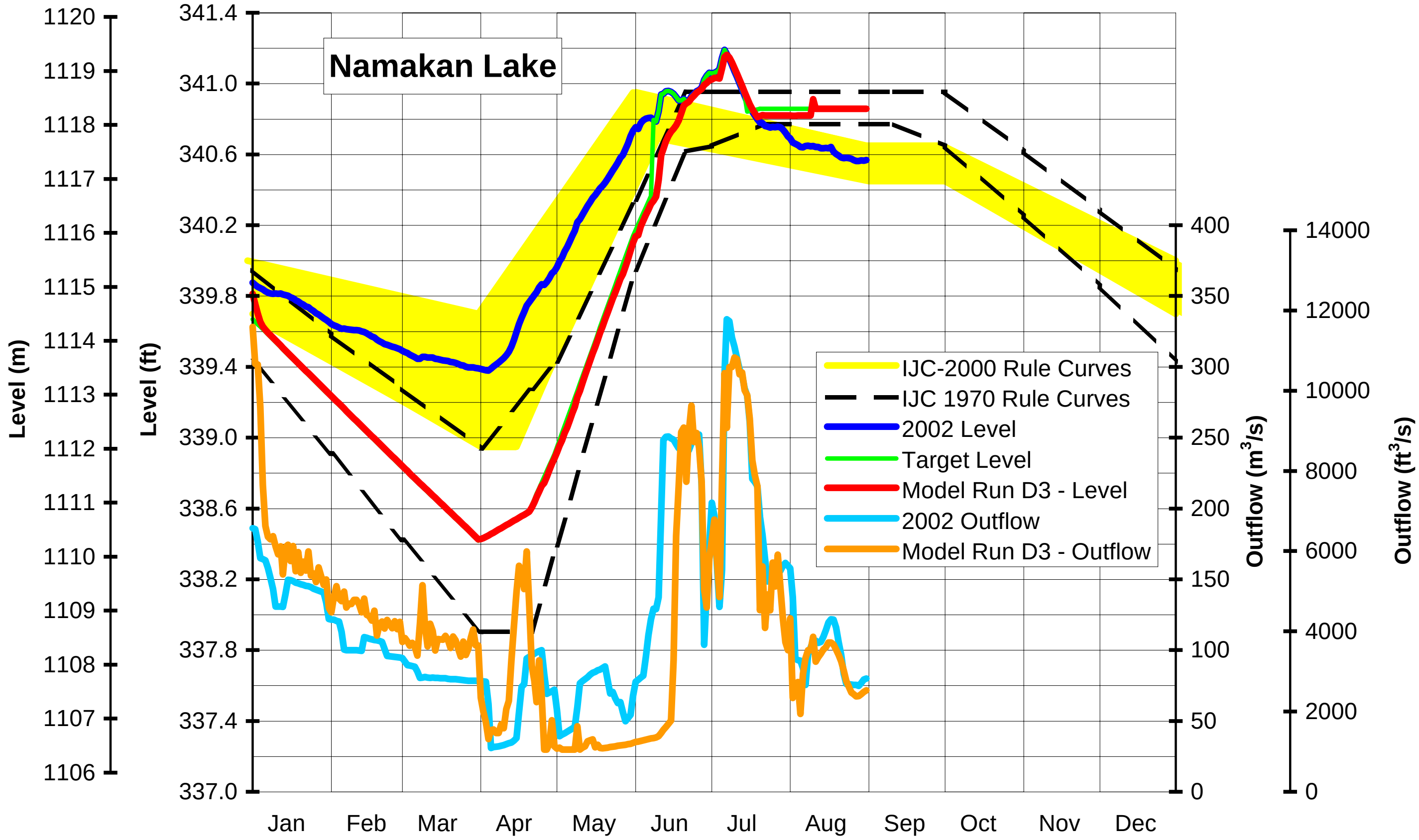
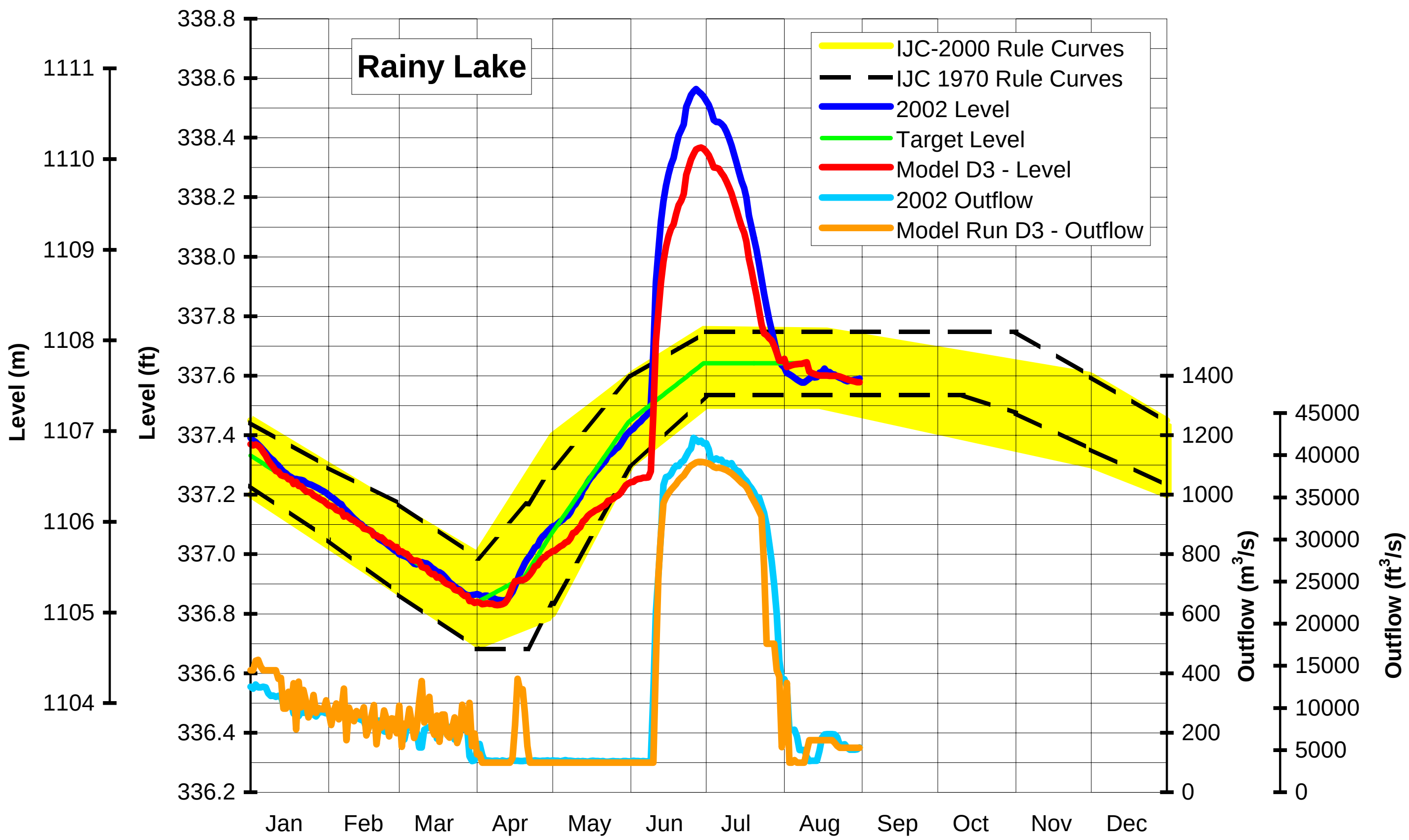


Figure 17

Model Results - Effect of Rule Curves
Current Operations and Spring Drought, Run D3 Only

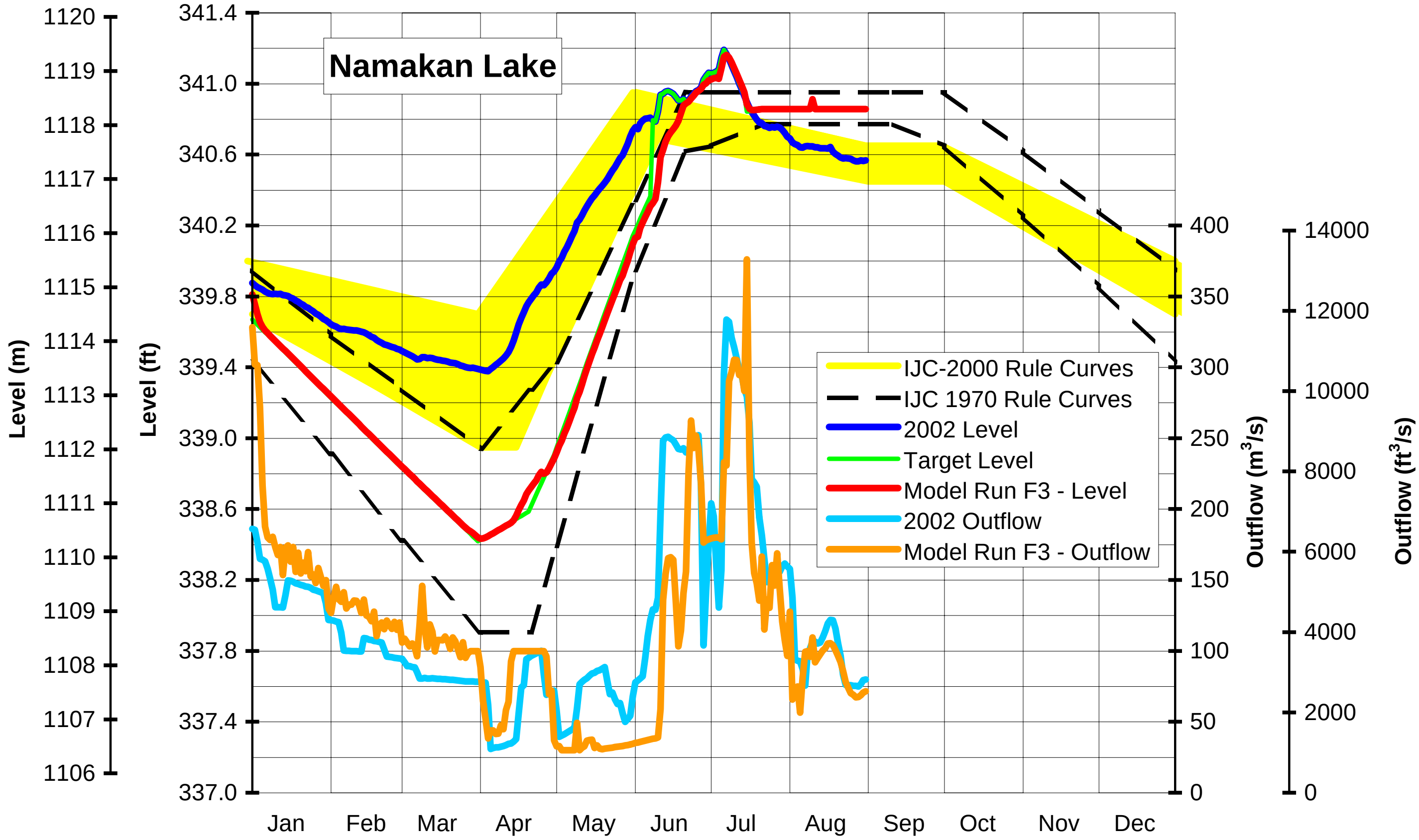


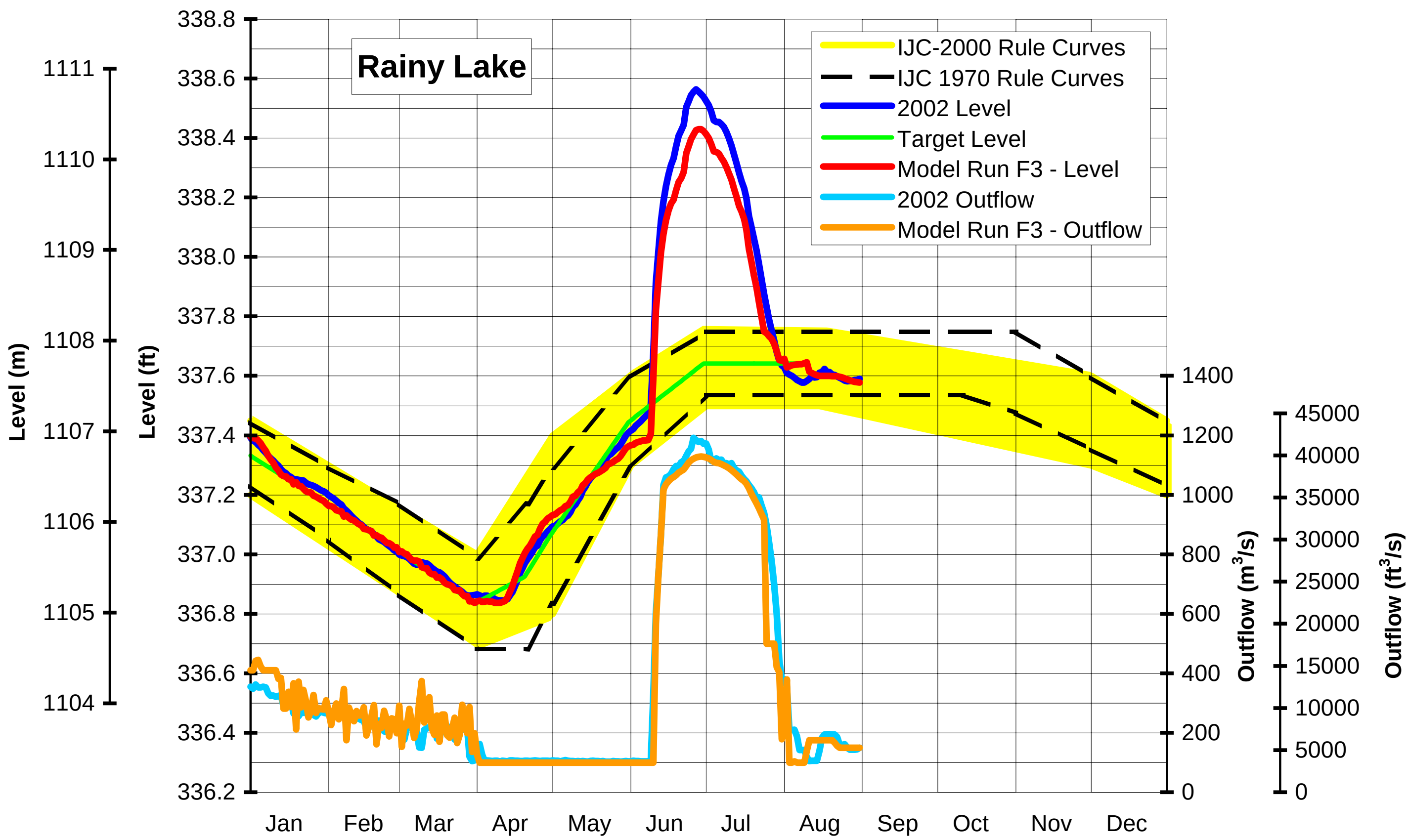


Peak Levels	2002 Level		Model Level		Difference	
	(m)	(ft)	(m)	(ft)	(cm)	(in)
	338.564	1110.8	338.367	1110.1	-19.7	-7.8

Figure 18

Model Results - Effect of Rule Curves
Spring Rainy Outflows at Minimum





Peak Levels	2002 Level		Model Level		Difference	
	(m)	(ft)	(m)	(ft)	(cm)	(in)
	338.564	1110.8	338.430	1110.3	-13.4	-5.3

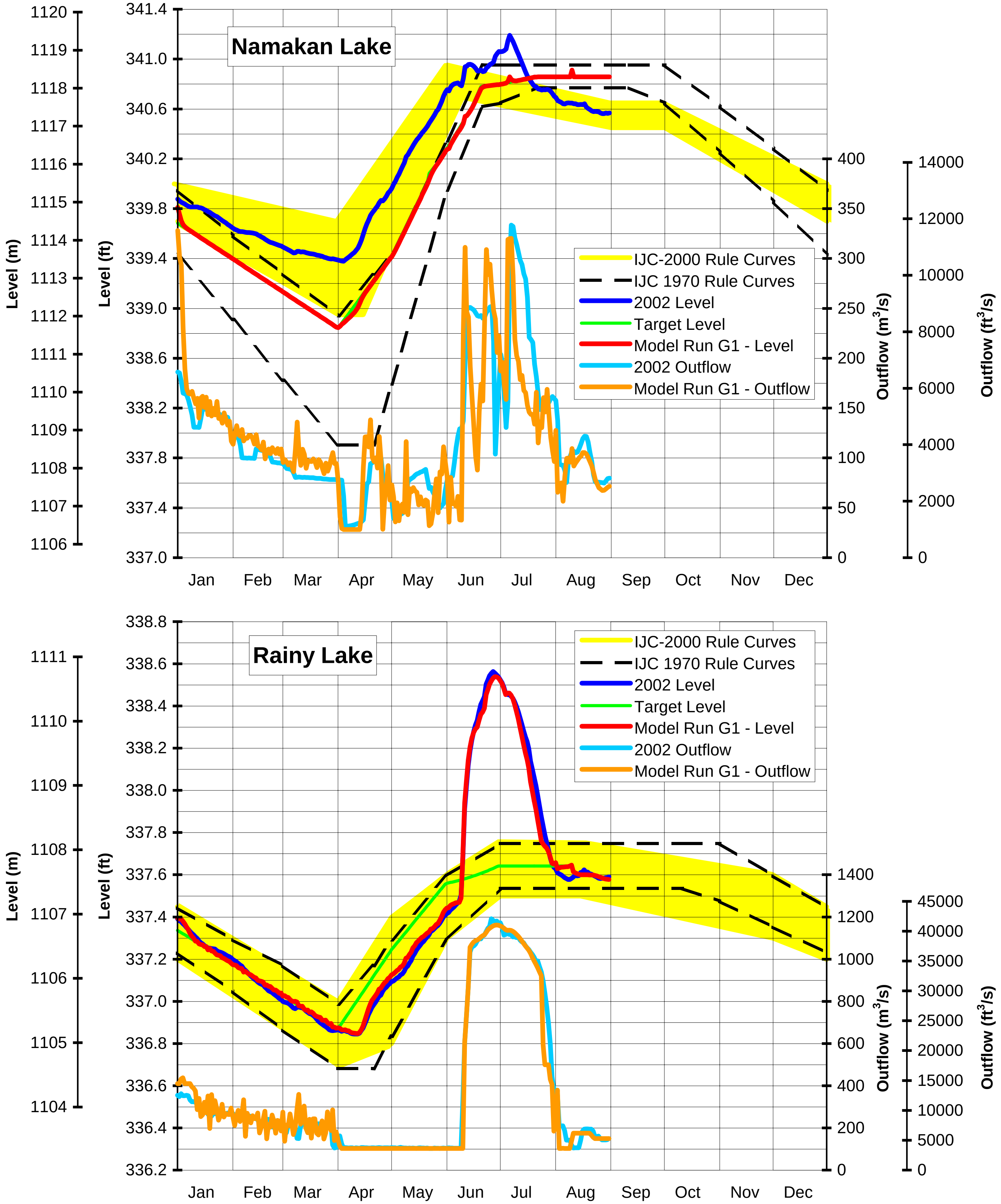
Comparison of Spring Lake Levels and Flows in 1970-1999

	Namakan Lake Median Spring Levels								
	1970-79			*1980-89*			*1990-99*		
	50 %ile		*% of 1970*	*50 %ile*		*% of 1970*	*50 %ile*		*% of 1970*
Date	*(m)*	*(ft)*	*IJC Band*	*(m)*	*(ft)*	*IJC Band*	*(m)*	*(ft)*	*IJC Band*
Mar 31	338.40	1110.2	46%	338.55	1110.7	61%	338.89	1111.8	94%
Apr 8	338.29	1109.9	34%	338.58	1110.8	59%	338.93	1112.0	89%
Apr 15	338.37	1110.1	37%	338.69	1111.2	62%	338.98	1112.1	85%
Apr 22	338.58	1110.8	47%	338.89	1111.8	70%	339.12	1112.6	88%
Apr 30	339.21	1112.9	81%	339.26	1113.1	86%	339.41	1113.5	100%
May 8	339.67	1114.4	105%	339.59	1114.1	95%	339.66	1114.4	103%
May 15	339.98	1115.4	119%	339.93	1115.3	112%	339.86	1115.0	102%
May 22	340.13	1115.9	115%	340.16	1116.0	120%	340.04	1115.6	99%
May 22	340.42	1116.9	127%	340.27	1116.4	90%	340.25	1116.3	86%
Jun 8	340.50	1117.1	85%	340.41	1116.8	61%	340.42	1116.9	66%

	Rainy Lake Median Spring Levels								
	1970-79			*1980-89*			*1990-99*		
	50 %ile		*% of 1970*	*50 %ile*		*% of 1970*	*50 %ile*		*% of 1970*
Date	*(m)*	*(ft)*	*IJC Band*	*(m)*	*(ft)*	*IJC Band*	*(m)*	*(ft)*	*IJC Band*
Mar 31	336.76	1104.9	24%	336.80	1105.0	36%	336.87	1105.2	61%
Apr 8	336.71	1104.7	8%	336.79	1105.0	30%	336.92	1105.4	64%
Apr 15	336.71	1104.7	6%	336.83	1105.1	35%	336.99	1105.6	70%
Apr 22	336.88	1105.2	37%	336.87	1105.2	35%	337.08	1105.9	78%
Apr 30	337.11	1106.0	64%	337.03	1105.7	45%	337.23	1106.4	90%
May 8	337.22	1106.4	67%	337.10	1106.0	39%	337.32	1106.7	91%
May 15	337.34	1106.8	78%	337.23	1106.4	50%	337.38	1106.9	88%
May 22	337.41	1107.0	76%	337.41	1107.0	75%	337.43	1107.1	80%
May 22	337.57	1107.5	96%	337.50	1107.3	71%	337.55	1107.4	88%
Jun 8	337.58	1107.5	81%	337.57	1107.5	76%	337.59	1107.6	84%

	Median Average Inflow March 31 - June 8				Median Average Outflow March 31 - June 8			
	Namakan		*Rainy*		*Namakan*		*Rainy*	
	(m^3/s)	*(ft^3/s)*	*(m^3/s)*	*(ft^3/s)*	*(m^3/s)*	*(ft^3/s)*	*(m^3/s)*	*(ft^3/s)*
1970-99	290	10300	422	14900	214	7570	307	10840
1970-79	334	11800	472	16700	250	8840	362	12800
1980-89	282	9950	368	13000	206	7280	253	8940
1990-99	254	8980	389	13700	193	6810	295	10400
2002	126	4450	193	6820	69	2440	107	3780

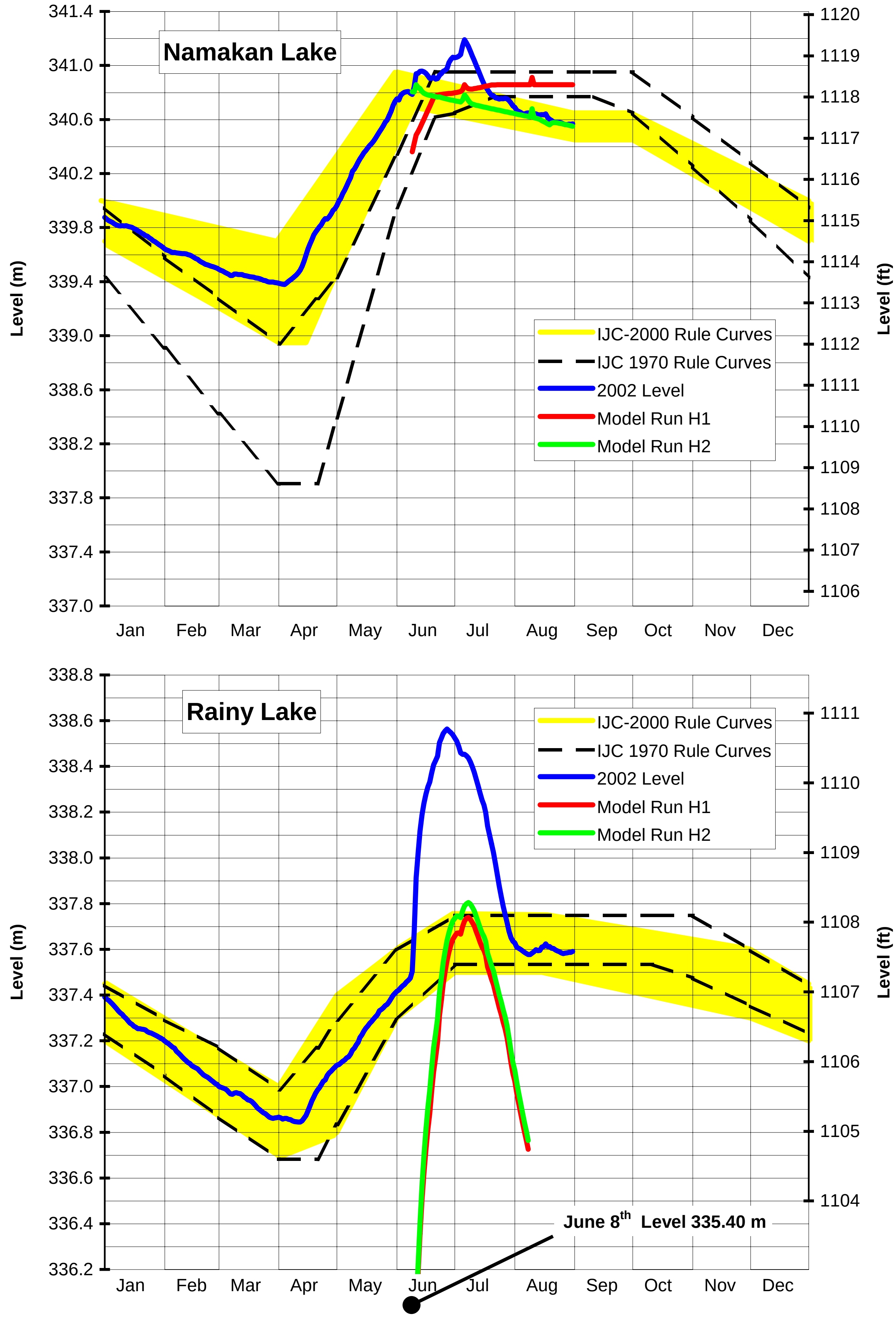
Model Results - Effect of Rule Curves
Operations Typical of 1990-1999



Peak Levels	2002 Level		Model Level		Difference	
	(m)	(ft)	(m)	(ft)	(cm)	(in)
	338.564	1110.8	338.539	1110.7	-2.5	-1.0

Figure 21

Model Results - Effect of Rule Curves
Drawdown Needed to Avoid High Levels



LWCB
Lake of the Woods
Control Board

LEGEND - LAKE AND RIVER GRAPHS

PRECIPITATION

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

Average - over the years 1970-1999

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

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

50 — Maximum level recorded and its year of occurrence

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

77 — Minimum level recorded and its year of occurrence

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.

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

APPENDIX C

PHOTOGRAPHS

Near Atikokan, Ontario
Photo Courtesy of Ontario Ministry of Natural Resources

Bridge on Turtle River in Ontario
Photo Courtesy of Ontario Ministry of Natural Resources

Railway Washout East of Fort Frances, Ontario
Photo Courtesy of Canadian National Railway Company

Road Washout East of Fort Frances, Ontario
Photo Courtesy of Ontario Ministry of Natural Resources

Rainy Lake Residence Near Ranier, Minnesota
Photo Courtesy of United States Army Corps of Engineers

Rainy Lake Residence Near Ranier, Minnesota
Photo Courtesy of United States Army Corps of Engineers

Rainy Lake Resort Near Ranier, Minnesota
Photo Courtesy of United States Army Corps of Engineers

Canal at Fort Frances, Ontario
Photo Courtesy of United States Army Corps of Engineers

Rainy Lake Dam from Downstream, International Falls, Minnesota
Photo Courtesy of United States Army Corps of Engineers

Road Washout West of Fort Frances, Ontario
Photo Courtesy of Fort Frances Times

Home West of Fort Frances, Ontario
Photo Courtesy of Fort Frances Times

Farm Near Stratton, Ontario
Photo Courtesy of Ontario Ministry of Natural Resources