Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board

2022 Post Flood Report

A Report on High Water Levels in the Rainy River Basin

Submission to the International Joint Commission
September, 2023

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List of Acronyms

CA- Canada

CoCoRaHS- Community Collaborative Rain, Hail & Snow Network

CN Rail- Canadian National Railway

ENSO- El Niño- Southern Oscillation

FEMA- Federal Emergency Management Agency

FFCS- Flow Forecasting and Communications Subcommittee

IJC- International Joint Commission

HFRRC- High Flood Risk Rule Curve

ILWCB- International Lake of the Woods Control Board

IRLWWB- International Rainy-Lake of the Woods Watershed Board

LWCB- Lake of the Woods Control Board

MNDNR- Minnesota Department of Natural Resources

NCRFC- North Central River Forecast Center

NOAA- U.S. National Oceanic and Atmospheric Administration

NWS- National Weather Service

ON- Ontario

OPG- Ontario Power Generation

PCA- Packaging Corps of America

SWE- Snow water equivalent

U.S.- United States

USACE- U.S. Army Corps of Engineers

USGS- U.S. Geological Survey

WLC- Water Levels Committee

Executive Summary

In the spring and summer of 2022, the Namakan Chain of Lakes[1] and Rainy Lake reached the highest water levels on record. The flood was a natural disaster that lasted for many weeks. Rainy Lake reached record-breaking water levels, and Namakan Lake ranked as the third highest on record. Since 1949, the International Joint Commission (IJC) has employed rule curves to regulate water levels on Rainy and Namakan Chain of Lakes. The Water Levels Committee (WLC) of the International Rainy-Lake of the Woods Watershed Board (IRLWWB), monitors hydrologic conditions throughout the year and provides dam operators, which are currently H2O Power in Canada and Boise Paper owned by Packaging Corps of America (PCA) in the United States, with directions for the operation of their discharge facilities to ensure the rule curves are followed.

This report provides a review of the conditions which led to the high-water event in 2022, a summary of WLC actions, and answers questions raised by the public. Additionally, the report includes an analysis of what would have happened if the High Flood Risk Rule Curve (HFRRC) had been employed starting March 10, 2022.

The following points highlight the most significant details in this report:

- On March 10, 2022 the WLC determined that the standard rule curve would be used in spring 2022. As discussed during the 2022 Pre-Spring Engagement, current and forecasted conditions did not support the use of the high flood risk rule curve (HFRRC) at the time. By March 31, the WLC provided a target range for Namakan Lake water levels to be between 339.65 m (1,114.3 ft) and 339.8 m (1,114.8 ft) on March 31. The Rainy Lake target range was for water levels to be between 336.90 (1,105.3 ft) and 337.0 m (1,105.6 ft) on March 31; a level within the upper range of the HFRRC.

- The 2022 high water event was caused by continuous above normal precipitation events through April and May, which filled all available storage space across the region. From April 1 to the end of May, the Rainy River basin, on average, received a total of 257 mm (10.1 in) of rainfall, more than twice the average for April and May.

- In response to the rising water levels following the April 22-23 precipitation event, dam operators pulled all logs from the sluices at the two dams at the outlet of Namakan Lake on April 26. As the lake levels rose, the gates at the International Falls/Fort Frances Dam were continually opened to maximize outflow. All gates were open at the International Falls/Fort Frances dam on May 5.
- Inflows for April through July were second highest only to the year 1950. As a result, the level of Namakan Lake rose to a maximum level of 342.18 m (1,122.69 ft), the third highest on record and only 7 cm (2.8 in) lower than the record level set in 1916. The level of Rainy Lake rose to 339.31 m (1,113.28 ft), setting a new record 8 cm (3.1 in) higher than the previous level record set in 1950.

[1] Namakan Chain of Lakes comprises of Namakan, Kabetogama, Sand Point, Little Vermillion, and Crane Lakes.

- After the flood event, computer simulation modeling was completed to investigate the effect of what operating under the HFRRC would have had. The results were compared with the 2018 standard rule curve that was employed in 2022, as well as the effect of operating at the bottom 25 percent of the Namakan 2018 rule curve would have made. It was further compared to the spring operations as they were directed in 2022. The simulation found that the difference in peak level on Namakan Lake would have been one cm less than what was experienced, and the level would have returned below the All-Gates Open level one day sooner. As for Rainy Lake, the reduction in peak level would have been four cm and the level would have returned below the All-Gates Open level two days sooner.
- In response to the 2022 flood event and observations during various public outreach activities, the WLC took several actions to improve communications and forecasting abilities in the basin.
    - First, WLC sent a letter to the North Central River Forecasting Center (NCRFC) on October 31, 2022 requesting additional forecasting support for the full Rainy River basin and building modeling capacity and support for snow water equivalent measurements to accurately quantify snow observations within the basin. Since the request, NCRFC has been actively working on additional river forecast modeling points within the basin, as well as adding Rainy-Lake of the Woods watershed flight paths for aerial snow surveys.
    - Second, the WLC requested an amendment to the 2018 Supplementary Order to eliminate the distinction between the regular and high flood risk rule curves for Rainy Lake, creating just one rule curve through the spring period (including removal of all references to a high flood risk rule curve from the Order). The WLC also requested the IJC repurpose the March 10th decision, regarding the rule curve decision, to a date by which the WLC establishes a "Spring Regulation Plan". The IJC issued a temporary supplementary order in March 2023 to implement these changes and would be considering a permanent change after the 2023 freshet. The WLC also included a second virtual public engagement opportunity in April 2023 to their established public engagement, which includes the Pre-Spring Engagement in late February/early March of each year.

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1 Introduction

The 2022 flooding in the Rainy River basin was a disaster of historic proportions. Rainy Lake reached record- breaking water levels, and Namakan Lake ranked as the third highest levels on record. Losses from the flood were widespread and included severe damages to homes, docks, boathouses, shoreline erosion, tree loss, infrastructure, and roads. Thousands of hours were spent on flood protection and mitigation such as sandbagging, berming, and water pumping, as well as recovery and remediation efforts as water levels lowered to normal ranges. Many recreational tourism operators across the region lost business and or had to close due to flooding. In all the economic, financial, and emotional toll on the entire community was significant. The Water Levels Committee (WLC) of the International Rainy-Lake of the Woods Watershed Board (IRLWWB) is responsible for monitoring basin conditions and ensuring the rule curves are followed under the International Joint Commission (IJC) Order for regulating water levels of Rainy and Namakan Lakes.

This report addresses the following questions and topics:

- The roles and responsibilities shared by the IJC, IRLWWB, and WLC within the whole Rainy-Lake of the Woods watershed;
- Hydrologic conditions that led to the extreme flooding in the Rainy River basin;
- Activities and decisions of the WLC in 2022;
- The role of rule curves during flood events and what would have happened if the HFRRC on Rainy Lake was implemented in 2022; and
- A summary of public engagement and what the WLC heard throughout the flood event and August 2022 Public Listening Sessions in Fort Frances, Ontario and International Falls, Minnesota.

2 IJC, IRLWWB, and WLC: Authorities, Roles, and Responsibilities

The dams at International Falls/ Fort Frances and Kettle Falls have been in the basin for over 100 years. The day-to-day operations of the dams are determined by the owners, which are currently H2O Power in Canada and Boise Paper owned by PCA in the United States (U.S.). Dam operators seek to maintain water levels in Rainy and Namakan Lakes within specific ranges, as defined by the International Joint Commission Orders.

The IJC is an independent, objective, and binational body established by Canada and the U.S. to prevent and/or resolve disputes under the 1909 Boundary Waters Treaty. The 1938 Rainy Lake Convention gave the IJC responsibilities to control water levels under emergency conditions. To do this, the IJC has employed rule curves, beginning in 1949 and update them to reflect current science and stakeholder benefits. The rule curves were last updated in 2018, following the release of the Rainy and Namakan Lakes Rule Curve Study report of 2017. The current IJC Order consists of a rule curve band for Rainy Lake and Namakan Lake. The rule curve band provides an upper and lower limit for the water elevation in the reservoir on any day of the year (lower in the winter, higher in the summer). The rule curves also establish minimum releases during low inflows and All-Gates Open levels during high inflows.

In 2013, the IJC established the International Rainy Lake of the Woods Watershed Board (IRLWWB) to assist with binational coordination of watershed management. The IRLWWB's mandate is to ensure compliance with the IJC's Order pursuant to the 1938 Rainy Lake Convention, to monitor and report on the ecological health of the Lake of the Woods and Rainy Lake boundary waters aquatic ecosystem, including water quality, and to assist the IJC in preventing and resolving disputes regarding the level of Rainy Lake and other boundary waters of the Rainy Lake watershed. The IRLWWB is comprised of federal, provincial, state, municipal and Indigenous representatives. Its activities are supported by an Industry Advisory Group, a Community Advisory Group, and four committees. The IRLWWB delegates its authority to ensure compliance with the IJC Order in emergency regulation of Rainy and Namakan Lake to the Water Levels Committee (WLC). The WLC monitors hydrologic conditions and may provide dam operators with directions for the operation of their discharge facilities to ensure that the rule curves of Rainy and Namakan Lakes are followed. The Adaptive Management Committee (AMC) was established in 2020 to monitor whether the latest rule curves perform as expected.

Lake of the Woods water levels are managed by the Canadian Lake of the Woods Control Board (LWCB) between lower and upper elevations set by the 1925 Lake of the Woods Convention and Protocol. The International Lake of the Woods Control Board (ILWCB), made up of co-chairs from the U.S. Army Corps of Engineers and Environment and Climate Change Canada, approve the actions of the LWCB whenever Lake of the Woods water levels rise above or fall below those set extreme elevations. The WLC does not have the authority to regulate levels of Lake of the Woods; therefore, the scope of this report focuses on the flooding of Rainy and Namakan Lakes. The LWCB's "2022 Flooding in the Winnipeg River Basin" report covers Lake of the Woods and is available on its website (https://www.lwcb.ca/permpdf/Reporton2022FloodinginWRBasin.pdf).

3 Hydrology Review: Winter-Summer 2022

This section provides an overview of the hydrological and meteorological conditions which contributed to the high-water conditions in the Rainy River watershed in 2022. A glossary of technical terms is provided in Appendix C. During the 2022 flood, a Frequently Asked Questions (FAQ) was developed to provide answers to public questions regarding the causes of the flood and the actions taken by the Water Levels Committee (WLC). The FAQ is available in Appendix F of this report.

These conditions provide important context for the rule curve operations and activities undertaken by the WLC (see Section 4). All precipitation, water level, and flow data provided in this report were obtained from the Lake of the Woods Control Board Secretariat database. The database collects the information from various U.S. and Canadian government agencies for the full Winnipeg River watershed. At the time of preparation of this report, this data was provisional and subject to revision. Refer to Appendix A for a map of the Rainy River basin and Appendix D for graphs of the water levels and flows of the Namakan and Rainy Lakes, Rainy River, and all contributing tributaries of the basin. Appendix D also includes an annual summary of precipitation across the entire basin.

3.1 Review of Drought Conditions through 2020 and 2021

The Rainy River basin experienced severe drought conditions between the spring of 2020 and the fall of 2021 due to lack of precipitation (Table 1). Although conditions over the winter of 2020 were normal, with average snow accumulation, precipitation from April to June was at less than 5th percentile[2] and ranked the lowest in the last 30 years. Very little precipitation in the summer of 2020 exacerbated the dry conditions, and by the end of August 2020, many parts of the basin were classified as abnormally dry, or in a moderate drought, on the North American Drought Monitor (Figure 1).

Table 1. Seasonal Cumulative Precipitation Statistics for the Rainy-Namakan Basin from Spring 2020 to Fall 2021

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
Spring 2020 (Apr-Jun)	120.8	4.8	<5%	30
Summer 2020 (Jul-Sep)	214	8.4	19%	26
Fall 2020 (Oct-Dec)	138.7	5.5	47%	15
Winter 2021 (Jan-Mar)	56.4	2.2	8%	28
Spring 2021 (Apr-Jun)	173.8	6.8	16%	26
Summer 2021 (Jul-Sep)	205.6	8.1	14%	27
Fall 2021 (Oct-Dec)	166.3	6.5	60%	12

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

[2] In statistics, denotes the relative position of a value in a set of ranked values. In this report, percentiles for water levels and flows are relative to values for a specific time of year recorded in the 30-year period from 1981-2010. See Appendix C for more information.

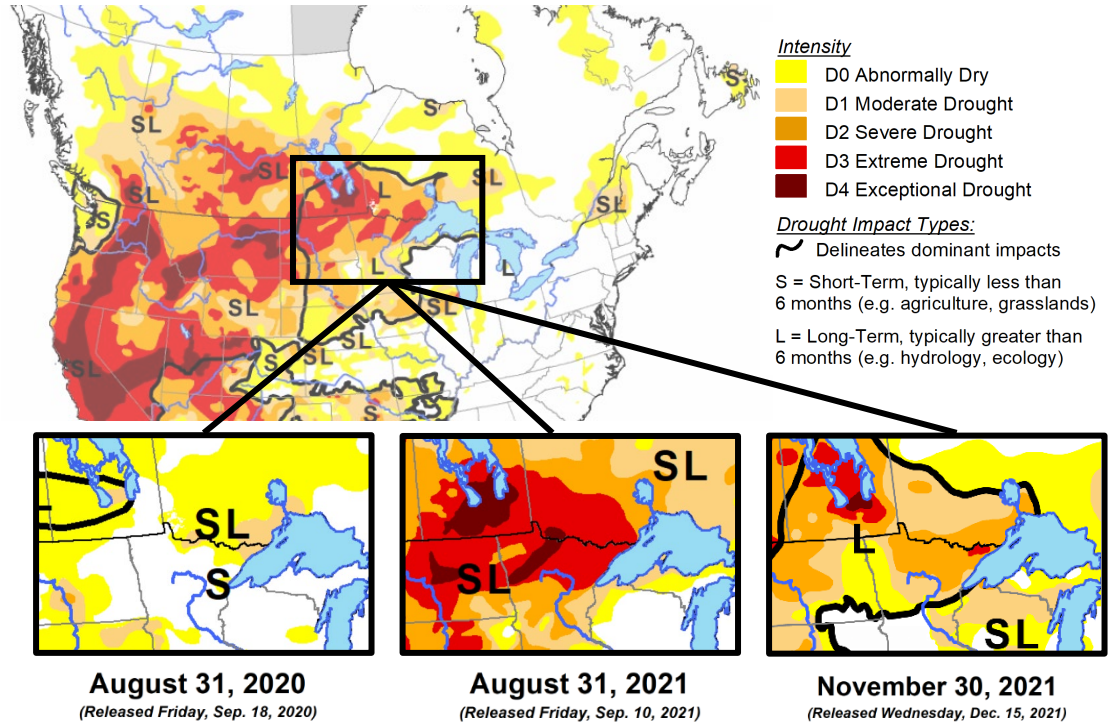


Figure 1. North American Drought Monitor Map of the Rainy River Basin (NCEI-NOAA)

Drought conditions improved slightly in the fall of 2020 when cumulative precipitation for the season ranked close to normal. However, drier conditions returned in the winter of 2021, with snow accumulation at less than 25th percentile. Another weak freshet occurred in the spring of 2021 with cumulative precipitation values dropping to below the 20th percentile. The dry conditions persisted into the summer months with declining cumulative precipitation, to the extent that the basin had been categorized as being in an extreme drought by the end of August (Figure 1). Precipitation maps (Figure 2 and Figure 3) for the period of January 1 to July 31, 2021, show the precipitation totals ranged from 200 to 350 mm (8 to 14 in). These ranges corresponded to precipitation deficit of 100 to 200 mm (4 to 8 in) in comparison to normal precipitation totals for this period.

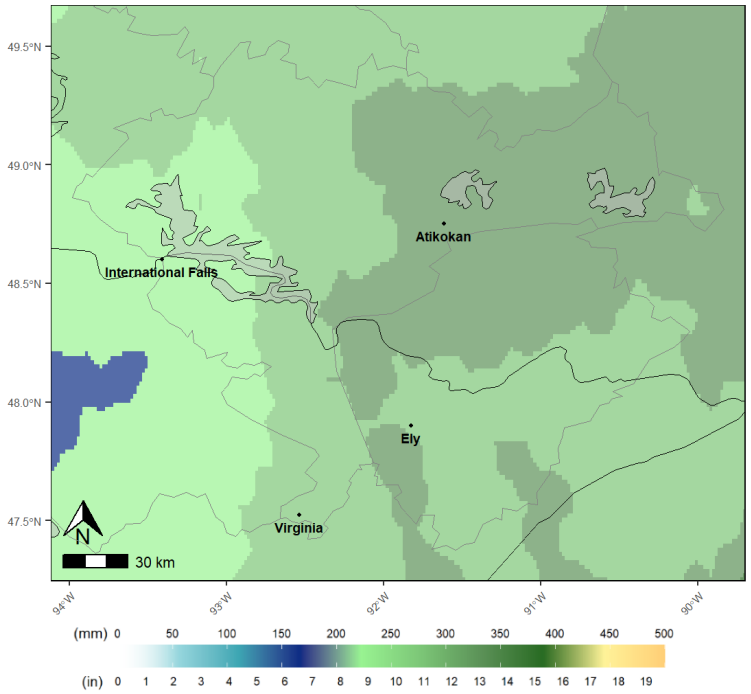


Figure 2. Total Precipitation for January 1 to July 31, 2021 (Canadian Precipitation Analysis)

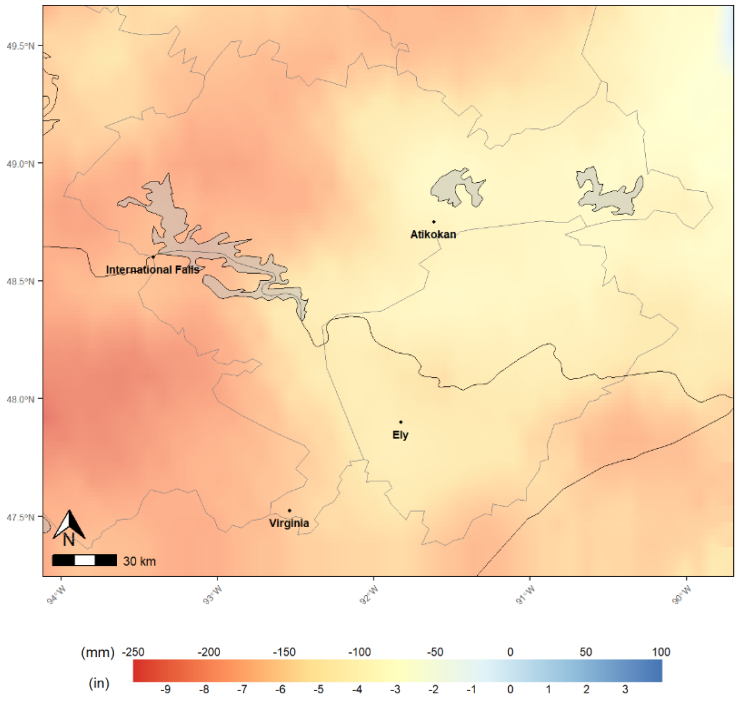


Figure 3. Difference from Normal Precipitation for January 1 to July 31, 2021 (Canadian Precipitation Analysis)

The tributaries throughout the Rainy River basin set low flow records due to the lack of precipitation in August 2021 (see Table 2). Most notable was the Atikokan River, which had the

5th lowest flow on record in October 2020 and recorded zero flows in August 2021. The latter record tied to the previous low flow record from August 1998.

Table 2. Daily Low Flow Records for Natural Tributaries in the Rainy River Basin

Rank	Atikokan River (since 1978)			Vermilion River (since 1979)		
	Date	Flow (m^3/s)	Flow (ft^3/s)	Date	Flow (m^3/s)	Flow (ft^3/s)
1	2021-08-26 & 1998-08-01	0	0	2021-08-26	0.19	6.8
2	2006-12-29	0.24	8.5	2006-10-09	0.31	10.8
3	2012-10-14	0.24	8.6	2012-01-22	0.44	15.7
4	2007-03-09	0.30	10.4	2007-02-16	0.53	18.6
5	2020-10-11	0.33	11.6	2011-10-07	0.56	19.9
Rank	**Turtle River (since 1914)**			**Little Fork River (since 1909)**		
	Date	Flow (m^3/s)	Flow (ft^3/s)	Date	Flow (m^3/s)	Flow (ft^3/s)
1	1918-03-17	1.42	50.2	1936-08-26	0.59	21.0
2	1998-09-18	1.88	66.4	1976-09-21	0.65	23.0
3	1940-10-25	4.28	151.2	2021-08-27	0.66	23.2
4	2021-08-25	4.50	158.9	2007-08-26	0.87	30.9
5	1937-02-18	4.84	170.9	2006-09-15	0.99	34.9

Source: Water Survey of Canada

Inflows to Rainy and Namakan Lakes were exceptionally low over the summer of 2020 and only got worse the following year. Inflow statistics in Table 3 show the severity and longevity of the drought experienced in 2020 and 2021. The very small freshet in the spring of 2020 resulted in average inflows to Rainy and Namakan Lakes ranking in the bottom third of spring inflows for the past 30 years. As the summer progressed, the lack of precipitation caused inflow to the lakes to drop considerably, with Namakan Lake inflows ranking the second lowest in the past 30 years and Rainy Lake inflows also ranking low, at 27thpercentile. The following seasons, namely the fall of 2020 and the winter and spring of 2021, only saw minor improvements, with inflows to both lakes remaining at or below the 25th percentile. Conditions worsened in the summer of 2021 again due to the lack of precipitation and Rainy and Namakan Lakes inflows fell to the 29th and 28th rank, respectively, for that season.

Table 3. Seasonal Average Inflow Statistics for Namakan and Rainy Lakes from Spring 2020 to Fall 2021

Period	Basin	Inflow (m^3/s)	Inflow (ft^3/s)	Percentile	30 Year Rank
Spring 2020 (Apr-Jun)	Namakan Lake	197.7	6,982	35%	21
	Rainy Lake	287.6	10,157	26%	24
Summer 2020 (Jul-Sep)	Namakan Lake	63.0	2,225	7%	29
	Rainy Lake	107.1	3,782	9%	27
Fall 2020 (Oct-Dec)	Namakan Lake	49.5	1,748	21%	26
	Rainy Lake	101.5	3,584	18%	25
Winter 2021 (Jan-Mar)	Namakan Lake	53.8	1,900	25%	25
	Rainy Lake	108.5	3,832	11%	28

Period	Basin	Inflow (m^3/s)	Inflow (ft^3/s)	Percentile	30 Year Rank
Spring 2021 (Apr-Jun)	Namakan Lake	175.7	6,205	32%	21
	Rainy Lake	264.3	9,334	25%	24
Summer 2021 (Jul-Sep)	Namakan Lake	33.7	1,190	<5%	29
	Rainy Lake	61.1	2,158	6%	28
Fall 2021 (Oct-Dec)	Namakan Lake	29.7	1,049	11%	27
	Rainy Lake	117.5	4,150	24%	24

Source: Lake of the Woods Secretariat

The Rainy and Namakan Lake levels were affected by prolonged drought conditions. The levels on both lakes remained within their respective rule curves throughout 2020. The level of Namakan Lake dropped slightly below the lower rule curve from August through October 2021. The lake levels recorded for this period were the lowest since the 2000 Rule Curves implementation for Namakan Lake. At Rainy Lake, the level dropped below the lower rule curve in July 2021, continued to decline to levels below the Drought Line by September 2021, and finally returned to the rule curve range in mid-October (Figure 4). The lake level in August was the second lowest since the implementation of the 2000 Rule Curves, the lowest being in 2003.

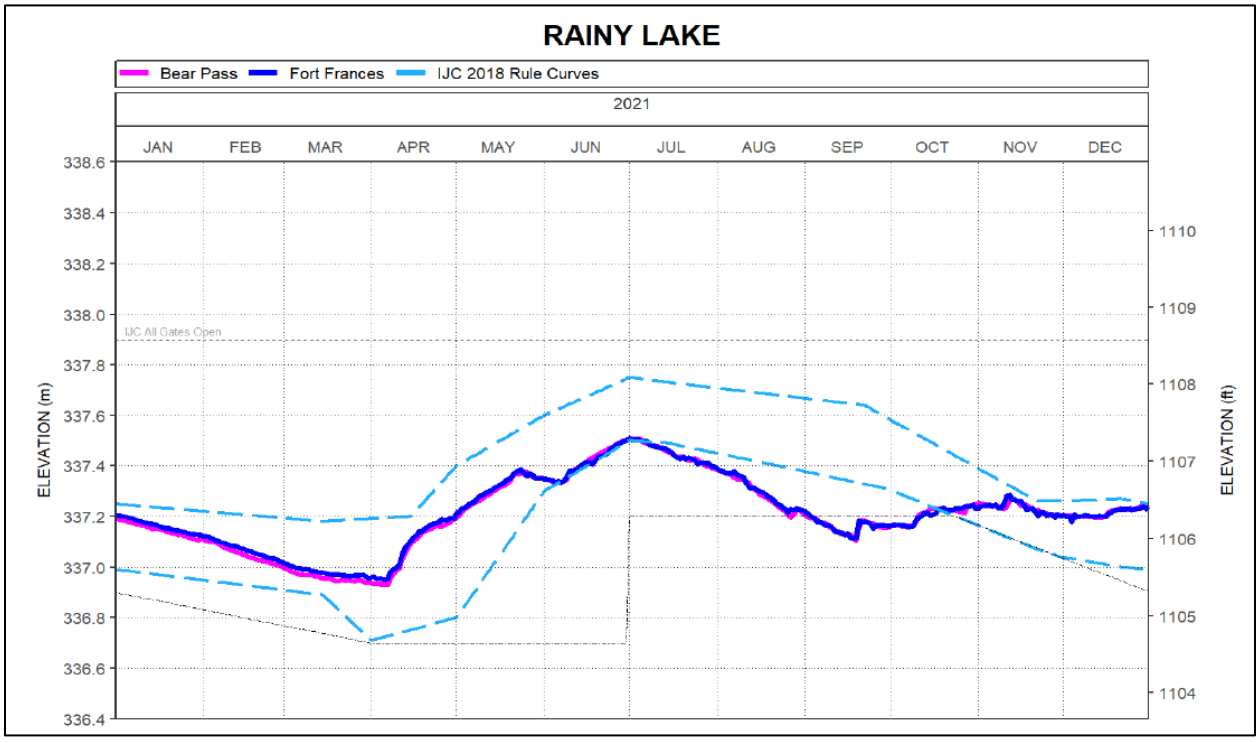


Figure 4. Rainy Lake Level from January 1 to December 31, 2021 (LWCB)

3.2 Watershed Conditions in Fall 2021 and Drought Improvement

In November, the Rainy River basin was still classified as being under a moderate to severe drought despite slight improvement in the fall of 2021 (Figure 1). Cumulative precipitation values (Table 4) indicated the precipitation was slightly above what is normally expected in

September. Despite this, the drought's intensity ranged from severe to extreme. The conditions improved in October, and by November most of the pockets of severe drought had disappeared. with precipitation just above normal at 53rd percentile. The precipitation deficit, which reached a peak at the end of the summer, had resolved by the end of the year, with minor exceedances of 50 millimeters above normal (2 in) in the Eastern portions of the Rainy River basin. Figure 5 shows precipitation totals were very close to normal for the remainder of the basin.

Table 4. Monthly Cumulative Precipitation Statistics for the Rainy-Namakan Basin for Fall 2021

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
September 2021	103.1	4.1	67%	13
October 2021	53.7	2.1	41%	21
November 2021	48.4	1.9	53%	13

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

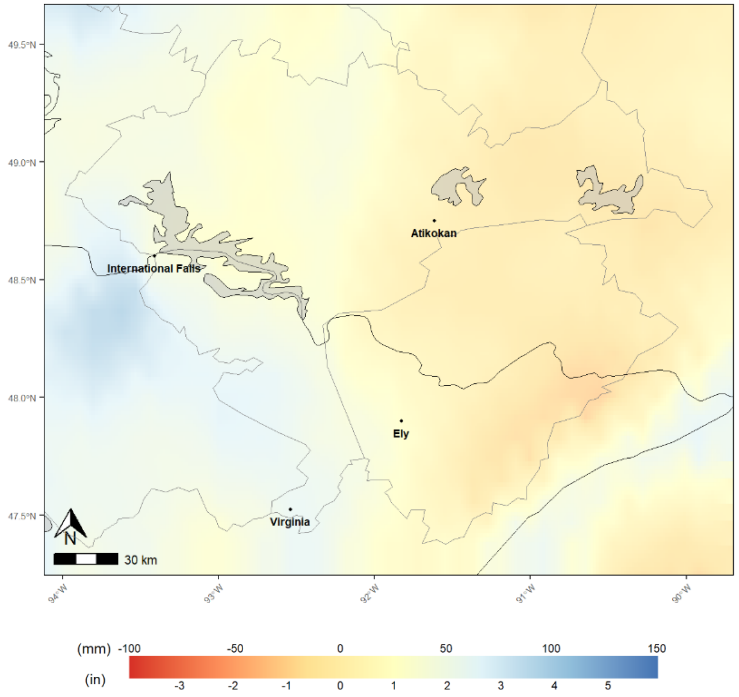


Figure 5. Difference from Normal Precipitation for October 1 to December 31, 2021 (Canadian Precipitation Analysis)

Although cumulative precipitation over the fall increased to normal, inflows to the lakes remained low. On the tail end of some of the lowest summer inflows in 30 years (see Table 3), the inflows from October to December 2021 only improved moderately. The average inflow to Namakan Lake over that period was at the 11th percentile and still ranked 27th of 30 years. Rainy Lake saw the most improvement, with inflow reaching the 24th percentile.

3.3 Snowpack Conditions in Winter 2022

From mid-February to the end of March 2022, there was above normal snow depth and snow water equivalent[3] (SWE) measured across the Rainy River basin. On February 22, the U.S. Army Corps of Engineers (USACE) in St. Paul, Minnesota completed the annual snow survey, results shown in Figure 6. On March 1, an additional measurement was conducted at Atikokan by Ontario Power Generation (OPG). The measurements are listed in Figure 5. The actual measured values of SWE ranged from 100 mm (4 in) at the Crane Lake measurement location, to as high as 147.5 mm (5.9 in) at the Ray location. Compared to the average SWE for this time of year, the measurements in 2022 ranged from 117 to 193 percent of normal. The Minnesota Department of Natural Resources (MNDNR) reported similar results in their snow depth maps of February 24 (Figure 7). The results showed the snow depth range of 24 to 30 inches (60 to 76 cm) for most of the Rainy River basin, translating to a snow depth ranking over the 80th percentile.

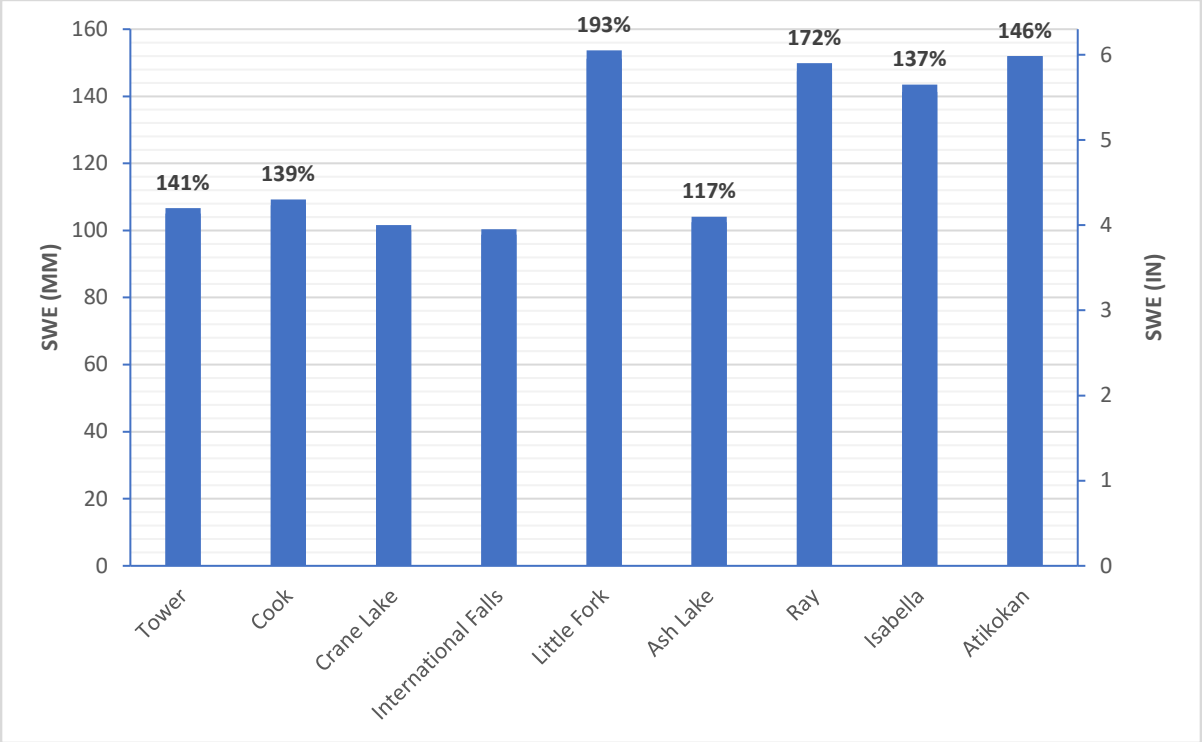


Figure 6. USACE and OPG Snow Water Equivalent Measurements in February 2022 and Percent of Normal for Locations Referenced in Figure 7 (USACE and OPG)

[3] Snow Water Equivalent (SWE) is the amount of liquid water stored in the snowpack. It is measured in millimeters or inches of water or melted snow.

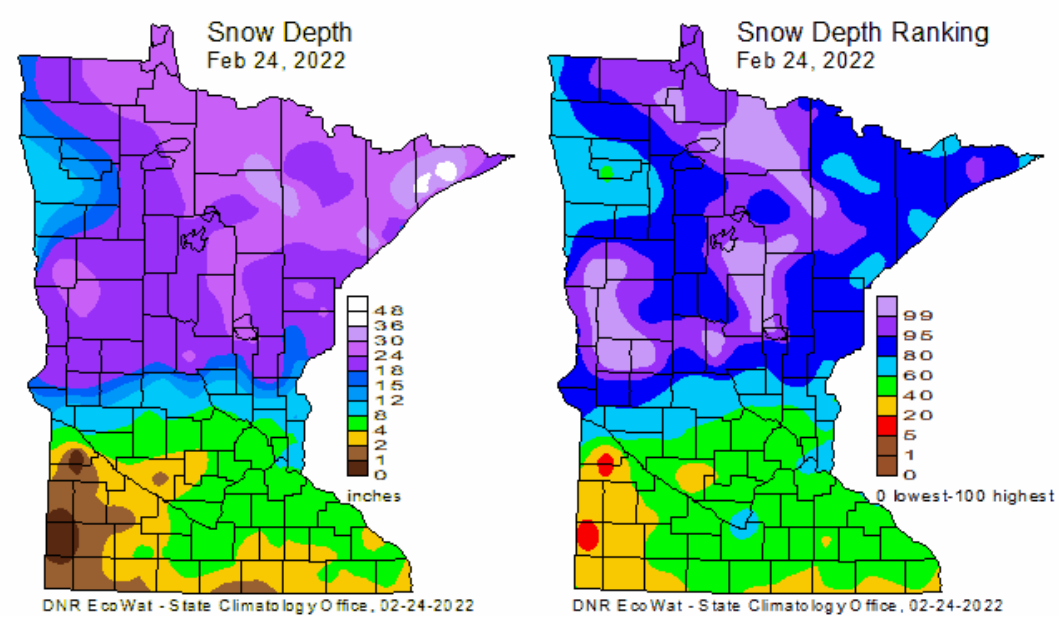


Figure 7. Minnesota Snow Depth and Rank Maps for the week of February 24, 2022 (Minnesota Department of Natural Resources)

Modeled SWE estimates completed in mid-February by the U.S. National Weather Service (NWS) were consistent with the USACE measurements in Minnesota, but under-estimated in comparison to measurements in Canada. These estimates are developed through a physically-based snow model which is calibrated using ground-based measurements, satellite snow observations, and, for the first time in this basin, airborne gamma surveys made in January 2022 [https://www.nohrsc.noaa.gov/snowsurvey/]. Figure 8 through Figure 10 show maps of the modeled SWE for February 22, March 15, and April 15. Furthermore, the maps show a ripening of the snowpack by mid-March, meaning the snowpack reaches a state where it can produce meltwater, with SWE appearing to reach its high for the season. In a typical year, once the snowpack has ripened and temperatures start to increase above the freezing mark, the snowpack melts relatively quickly. However, one month later, on April 15, the SWE estimates in the basin remained the same. This was caused by a shift in weather patterns that occurred mid-April when air temperatures fell below freezing, stalling the typical snowmelt pattern.

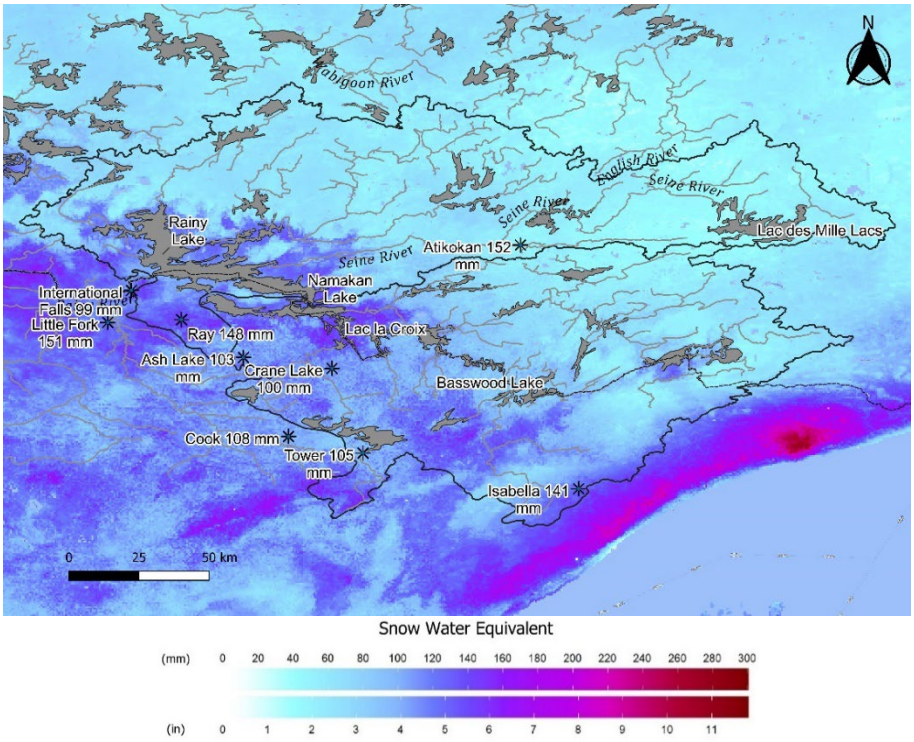


Figure 8. Estimated Distributed and Measured Point Snow Water Equivalent on February 22, 2022 (NOHRSC [NOAA])

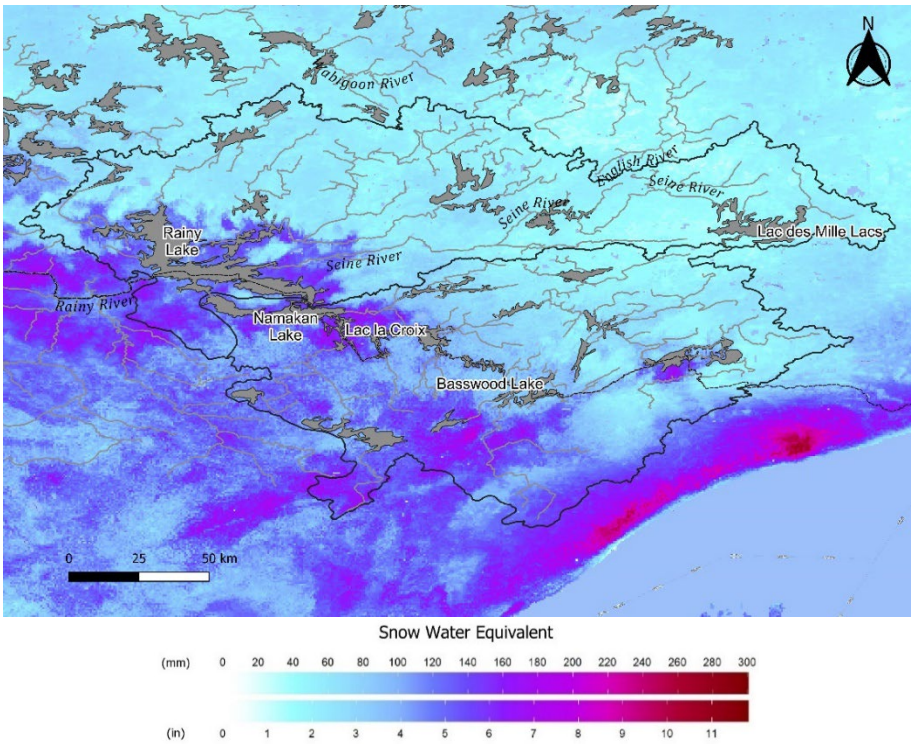


Figure 9. Estimated Distributed Snow Water Equivalent on March 15, 2022 (NOHRSC [NOAA])

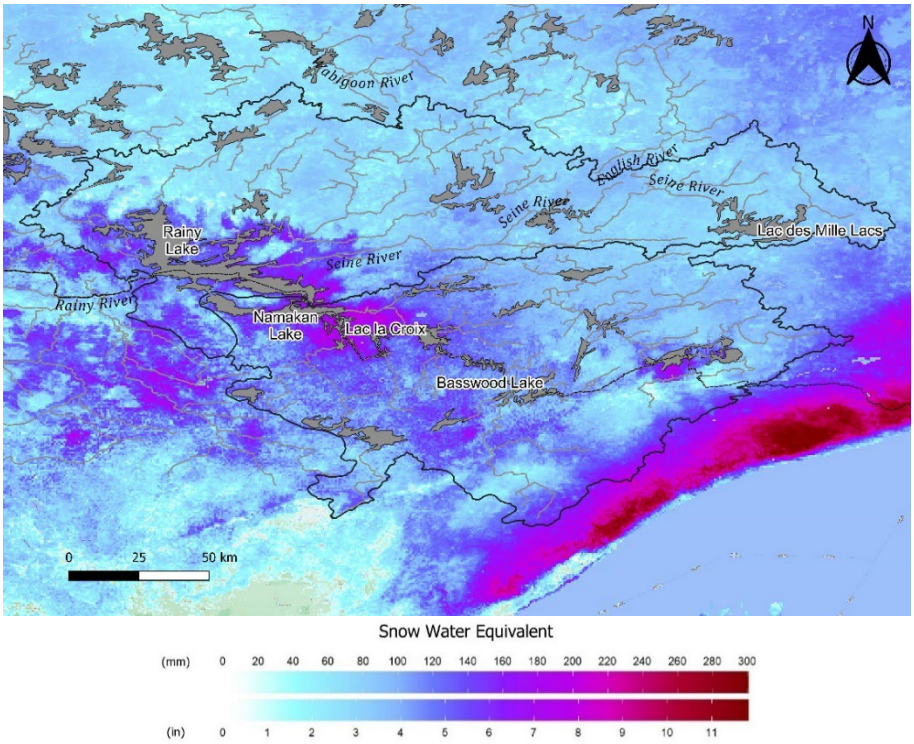


Figure 10. Estimated Distributed Snow Water Equivalent on April 15, 2022 (NOHRSC [NOAA])

The extension of the winter-like conditions and stalling of the melting snowpack is also evident in the plot of SWE over time at the Atikokan measurement location (see Figure 11). The blue bands reflect the percentiles of SWE from January through May, and the lightest blue section reflects the normal trend. In this case, the trend is for SWE to continue increasing until April, after which melt occurs, and drops off very quickly. The graph also indicates that, in extreme cases in dark blue, SWE can climb steadily over the winter and reach significant levels by April. The black line shows the evolution of SWE in 2022. From January to March, the line trended within the normal or high-normal range. In mid-March, with warmer temperatures, there was even a slight decline in SWE. But over the course of late March and early April, the SWE at Atikokan did not drop off as expected. Instead, it continued to climb and reached a high outside the range of measurement on April 15 before finally dropping off in the latter half of April.

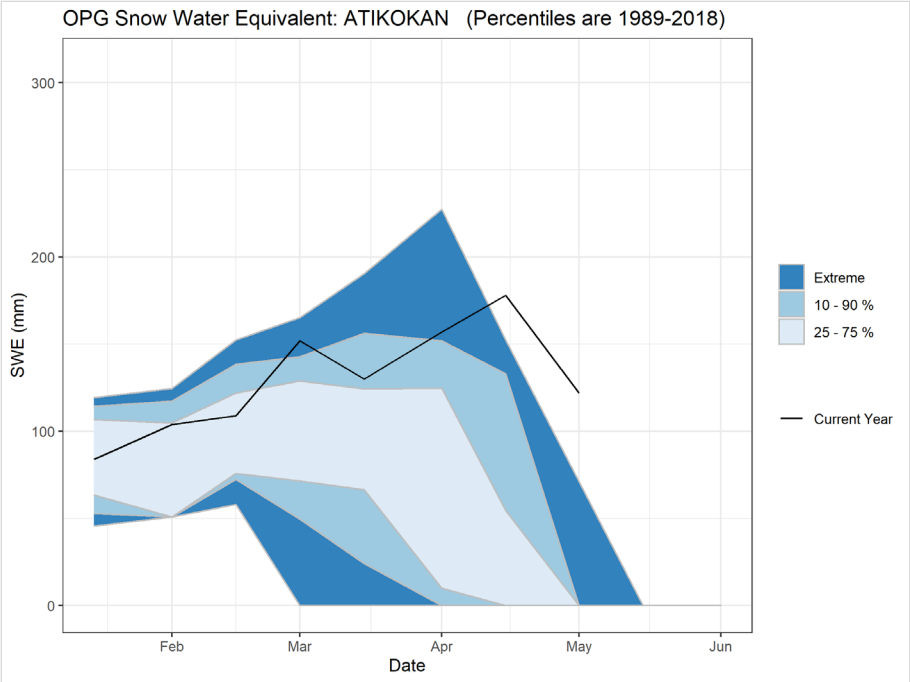


Figure 11. Measured (2022) and Historic Snow Water Equivalent at Atikokan, ON (OPG)

3.4 Summary of Precipitation for April to July 2022

Conditions changed dramatically in April and May 2022 and abruptly ended the two-year drought. Precipitation was abundant and regular through the spring. In April, a series of Colorado Low[4] systems crossed the basin. Although air temperatures in the first few days were above freezing, an additional 10 cm (4 in) of snow fell over the Rainy River watershed by the end of the first week of April. Conditions in the second week of April did not improve; air temperatures continued plummeting and the Colorado Low brought widespread, heavy snowfall to the basin. Snowfall totals ranged from 30 to 70 cm (12 to 28 in). The highest amounts of snow accumulated directly over the Namakan sub-basin. In the third week of April, the next Colorado Low struck, causing a rain-on-snow event that resulted in an almost instant depletion of the snowpack. Wet conditions continued into May, with precipitation in the form of rain. The largest single-day precipitation event so far that year occurred at the end of the month.

From April 1 to the end of May, the Rainy River basin had an average of 257 mm (10.1 in) of rainfall. This equated to more than twice the average for April and May (see Figure 13). Weekly precipitation totals consecutively outranked average precipitation (see Figure 14).

[4] A Colorado Low is a low pressure storm system that forms in winter in southeastern Colorado or northeastern New Mexico and tracks northeastward across the central plains of the U.S. over a period of several days, producing blizzards and hazardous winter weather (NOAA).

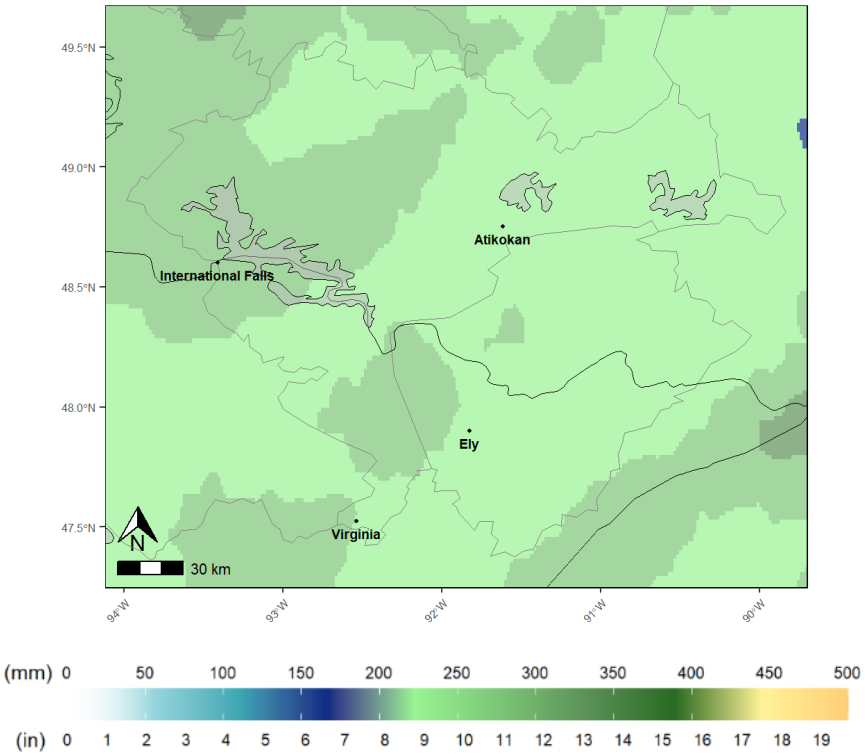


Figure 12. Total Precipitation for April 1 to May 31, 2022 (CaPA)

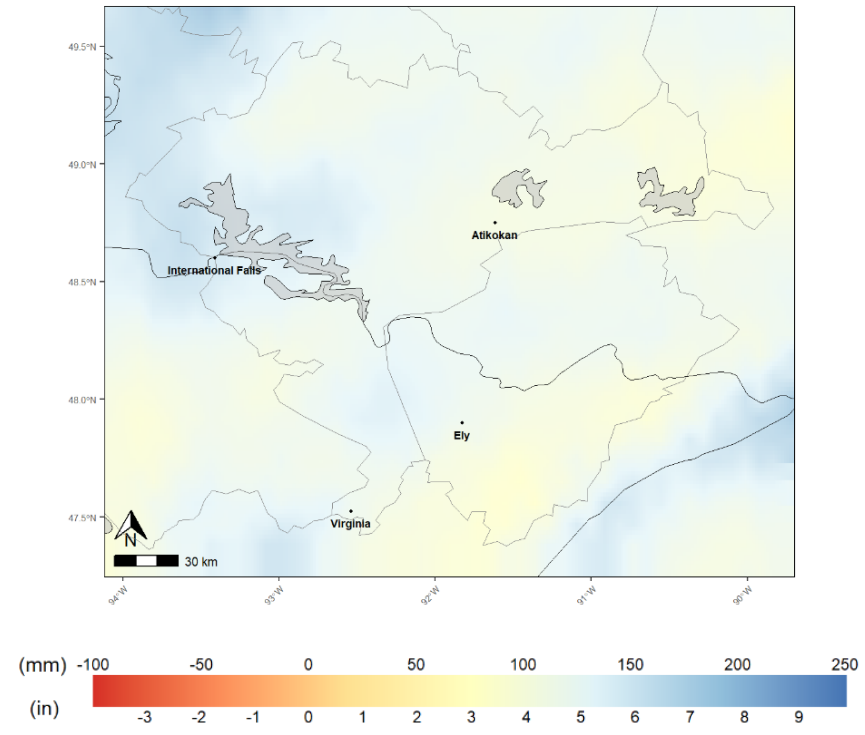


Figure 13. Difference from Normal Precipitation for April 1 to May 31, 2022 (CaPA)

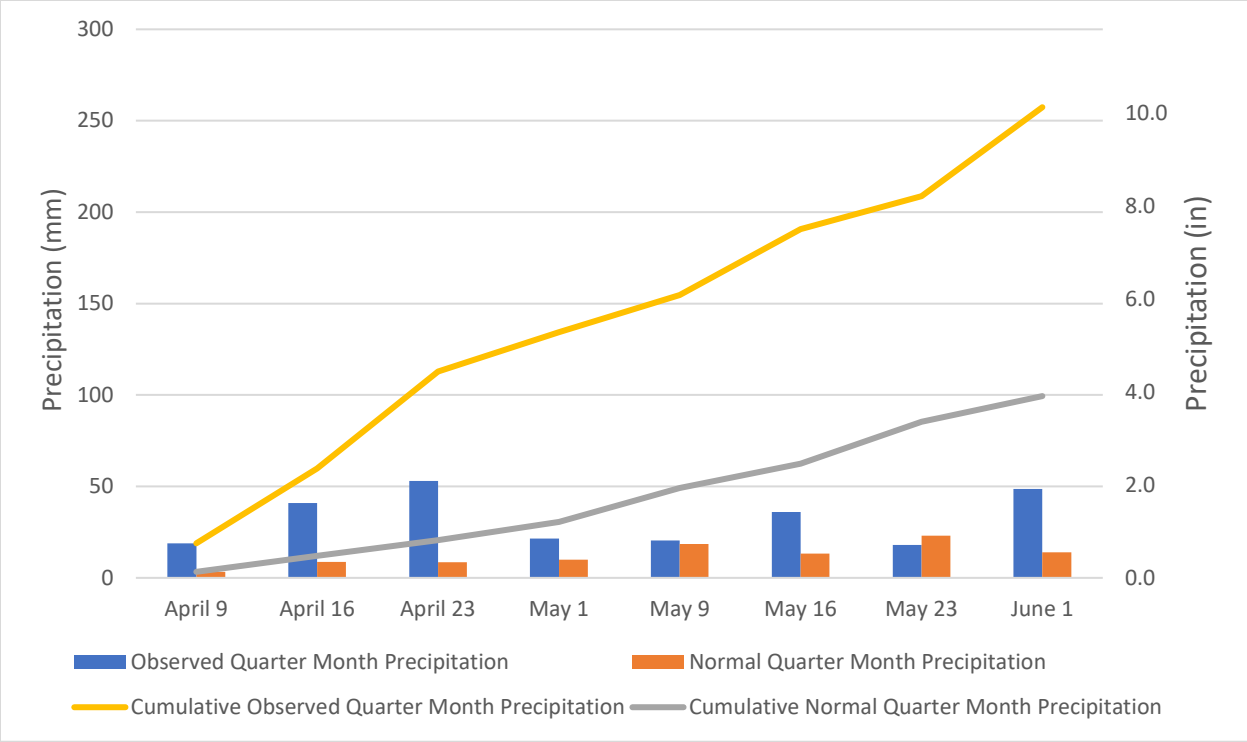


Figure 14. Rainy River Basin Mean Cumulative Precipitation for April 1 to May 31, 2022 from Environment Canada's Regional Deterministic Precipitation Analysis

Source: for data 1981 – 2022 Environment Canada's Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

The months of April and May ranking near the top of cumulative precipitation in the last 30 years (Table 5). In June, a reversal of conditions occurred. The Rainy River basin received half as much rainfall in June as it had the two previous months, and cumulative precipitation fell to the11th percentile of precipitation for the basin. Despite the much-needed relief from the wet conditions, the above-average precipitation returned to the basin in the last three weeks of July. The precipitation for July came in at the 86th percentile and ranked the fifth highest in the last 30 years.

Table 5. Monthly Cumulative Precipitation Statistics for the Rainy-Namakan Basin for April to July 2022

Period	Precipitation (mm)	Precipitation (in)	Percentile	30 Year Rank
April 2022	123.1	4.9	>95%	2
May 2022	134.3	5.3	89%	4
June 2022	68.8	2.7	11%	25
July 2022	157.4	6.2	86%	5

Source: for data 1981 – 2022 Environment Canada Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

3.5 Summary of Flows and Levels in Spring and Summer 2022

The intensity and longevity of the spring precipitation caused flows in the tributaries of the Rainy River watershed to remain at high or close to peak levels from late April to mid-June. The Vermilion River set a new peak flow record, and many other tributaries ranked second or third for all-time high flows. The long duration of these high flows fed the inflows to the lakes and ultimately became the driving force behind the flooding.

The average inflow to Namakan and Rainy Lakes was the highest on record for April and May combined (see Table 6). The inflows for April through July 2022 were second highest only to 1950. As a result, the water level of Namakan Lake rose to a maximum level of 342.18 meters (1,122.69 feet), the third highest on record, and only 7 centimeters (2.8 inches) lower than the record level set in 1916. The water level of Rainy Lake rose to 339.31 meters (1,113.28 feet) and set a new record 8 centimeters (3.1 inches) higher than the previous level record set in 1950.

The graphs of water levels and flows throughout the basin are included in Appendix D and illustrate the magnitude of the tributary flows and lake inflows. The graphs also provide previous level records shown in comparison to levels reached in 2022 on Namakan and Rainy Lakes.

Table 6. Namakan and Rainy Lake Record Inflows for Various Periods

	April 1 - May 31					
	Namakan Lake			Rainy Lake		
Rank	Year	Inflow (m^3/s)	Inflow (ft^3/s)	Year	Inflow (m^3/s)	Inflow (ft^3/s)
1	2022	542	19,141	2022	1098	38,776
2	1950	540	19,070	1950	877	30,971
3	1966	511	18,046	1966	865	30,547
4	2001	504	17,799	2001	864	30,512
5	1969	457	16,139	1927	860	30,371
	April 1 - July 31					
	Namakan Lake			Rainy Lake		
Rank	Year	Inflow (m^3/s)	Inflow (ft^3/s)	Year	Inflow (m^3/s)	Inflow (ft^3/s)
1	1950	583	20,589	1950	1,101	38,882
2	2022	499	17,622	2022	1,044	36,869
3	2014	462	16,316	1927	892	31,501
4	1968	444	15,680	2014	869	30,689
5	1966	441	15,574	2001	766	27,051

Source: LWCB

Table 7. Namakan and Rainy Lake All Time Record Levels

	Namakan Lake			Rainy Lake		
Rank	Date	Level (m)	Level (ft)	Date	Level (m)	Level (ft)
1	1916-05-23	342.25	1,122.92	2022-06-14	339.31	1,113.28
2	1950-06-07	342.2	1,122.76	1950-07-05	339.23	1,113.01
3	2022-05-31	342.18	1,122.69	1916-06-08	339.09	1,112.55

4	1927-05-19	341.97	1,122.00	2014-07-01	338.74	1,111.41
5	1938-05-22	341.84	1,121.58	1941-10-18	338.6	1,110.95

Source: LWCB

4 Rule Curve Operations and Water Levels Committee Activities Winter-Summer 2022

The following section provides a summary and timeline of the WLC activities and rule curve operations from February 2022 to when Rainy and Namakan lakes returned to their rule curves in August. Additionally, during the 2022 flood, a Frequently Asked Questions (FAQ) was developed to provide answers to public questions regarding the causes of the flood and the actions taken by the WLC. The FAQ is available in Appendix F of this report.

4.1 U.S. Agency Winter Planning Meeting and February Water Levels Committee Meeting with Flow Forecasting and Communications Subcommittee

The WLC and Flow Forecast and Communications Subcommittee[5] (FFCS) participated in an Annual Winter Planning Meeting on February 3, 2022, hosted by the USACE, St. Paul District. The NWS, U.S. Geological Survey (USGS), MNDNR, and other U.S. agencies also attended. Discussions circled around the current hydrologic and meteorologic conditions and available forecasts going into spring.

In late February, the WLC met with the FFCS to discuss current conditions and review the presentation for the Pre-Spring Engagement which would take place on March 3, 2022. The FFCS membership includes U.S. and Canadian WLC Engineering Advisors, Lake of the Woods Control Board Secretariat, U.S. National Weather Service – River Forecast Center, Boise Cascade, Packaging Corporation of America, H2O Power, and the Ontario Surface Water Monitoring Centre.

4.2 Pre-Spring Engagement

The WLC sent a calendar invitation via email to the distribution list of 87 representatives of basin interests 12 days in advance of the Pre-Spring Engagement Webinar on March 3, 2022. The WLC hosted the Webinar where the Engineering Advisors provided a summary of basin conditions and seasonal forecast information to approximately 37 participants. Participants included dam operators, IRLWWB members, U.S. and Canadian forecasting agencies, government staff at the municipal and county level, Indigenous communities and organizations, and property owner associations within the basin, to include resort and recreation organizations. Webinar participants were encouraged to provide their knowledge, subject-matter expertise, and share any concerns or additional information for consideration in advance of the freshet season.

During the Pre-Spring Engagement, the basin was in a drought condition. Base flows were in the low to normal range for that time of the year. The average winter temperatures were colder than in recent years, but warmer than during the previous high-water event in 2014. In the beginning

[5] The Flow Forecast and Communications Subcommittee is a subcommittee of the Water Levels Committee reestablished in 2021. The FFCS acts as an advisory role in flood forecasting and acting role in communication to the public.

of March, the accumulated snowpack was between 80th and 95th percentile range, based on historic records. The basin was in a La Niña condition, projected to continue through spring (March to May), and then a chance transition to El Niño- Southern Oscillation (ENSO) neutral. Data since 1970 show high water years occur most often when La Niña conditions are present also likely during neutral conditions. National Oceanic and Atmospheric Administration (NOAA) long-term forecasts of temperature indicated a 33 to 40 percent chance of above normal temperature for spring and equal chances of low, normal, or above normal precipitation.

Feedback from basin interests obtained at the Pre-Spring Engagement were consistent with the information provided by the WLC. Following the engagement, the Rainy Lake Property Owners Association wrote to the WLC, stating the WLC should operate on the side of caution based on the following points:

1. Temperatures are expected to remain well below freezing at night during the extended forecast. This may potentially push the ice-out date into mid-May, creating the potential for freshet and spring rains to enter the basin at the same time;
2. It is reported the lakes have as much as 32 in of ice at this time;
3. Area forestry experts have indicated higher than normal precipitation rates follow a drought year; and
4. Basin wide combination of rain and heavy wet snow (according to the National Weather Service, 6 in of water in early November were retained in the bush and will enter the watershed this spring.

4.3 Decision on Spring Target

When deciding on which Rainy Lake rule curve to follow, the Water Levels Committee must consider the risk of flooding as well as the risk of not refilling the lakes to their summer lake levels. When there is a high risk of spring flooding, the High Flood Risk Rule Curve shifts the refill of Rainy Lake to begin later in spring compared to the standard rule curve. Should the High Flood Risk Rule Curve (HFRRC) on Rainy Lake be implemented and forecasted flood conditions do not occur, there can be negative impacts on fish spawning, navigation, and aquatic vegetation diversity (if HFRRC is implemented every year).

On March 10, the WLC, in accordance with the IJC 2018 Supplementary Order, determined that the standard rule curve will be used in spring of 2022 to direct the operation of the International Falls/Fort Frances dam. A news release was issued to publicly announce the decision. The current and forecasted conditions, discussed during the Pre-Spring Engagement, did not support the use of the high flood risk rule curve at the time. In the recent years (discussed in Section 3.1), the water level conditions had been low. To balance the needs of the fisheries in the lakes, the lake levels were to be held in the middle range (25 to 75 percent) of the band. For the Namakan Lake, the March 31 target range was between 339.65 m (1,114.3 ft) and 339.8 m (1,114.8 ft). The Rainy Lake March 31 target range was 336.90 m (1,105.3 ft) and 337.0 m (1,105.6 ft), and within the upper range of the HFRRC (Figure 15). The red dashed lines are the upper and lower limits of the HFRRC, the black solid lines are the upper and lower limits of the standard rule curve, and the blue dotted lines are emergency water levels; the upper blue dotted line when all

gates at the dam are required to be opened and the lower blue dotted line at which point outflow from the dams is prescribed to a minimum allowable discharge.

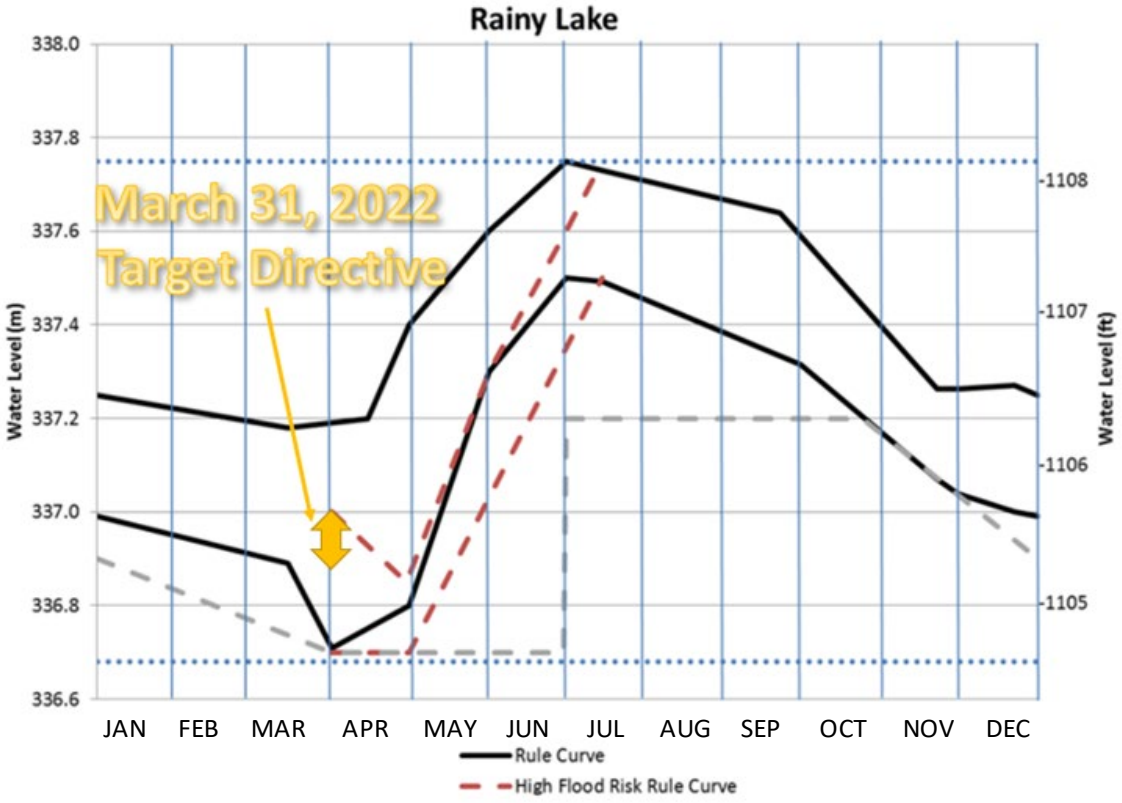


Figure 15. March 31, 2022, Rainy Lake Target Range under Standard Rule Curve

4.4 March 31: WLC Review of Conditions

On March 31, 2022, the WLC reconvened to review basin conditions. The drought condition improved to a moderate drought on the U.S. side of the basin, and the Canadian drought index indicated similar conditions. The base flows were still low to normal range, and snow depth in late March ranked within the 60 to 80 percentiles (less than 2014 and comparable to 2018). Some precipitation had occurred the week prior, but the tributary flows exhibited a minimal response to the precipitation. The Rainy Lake level was within the targeted middle of the standard rule curve and at the top of the High Flood Risk Rule Curve. The WLC decided to inform operators to continue targeting the middle of the band for both lakes.

4.5 April-May Operations

As mentioned in Section 3.4, conditions changed dramatically starting in April. The first and second in the series of Colorado Lows fell in the form a snow. Inflows into Namakan and Rainy Lakes remained within normal ranges during these snow events, and outflows from the dams were managed to remain within rule curves. However, the third in the series of Colorado Lows fell in the form of rain, driving a rain on snow event and significantly increasing inflows to both

lakes. In response to the extreme precipitation which occurred on April 22-23, the Namakan Lake outflow was increased to approximately 280 m^3/s (9,888 cfs), and the Rainy Lake outflow increased to approximately 740 m^3/s (26,133 cfs) on April 25. All logs were pulled from sluices at Namakan dams on April 26 and gates at the International Falls-Fort Frances Dam were opened to maximize outflow as lake levels rose, with all the gates open on May 5. The timeline of gate and log openings at both Rainy and Namakan Lakes is demonstrated in Figure 16 and Figure 17. For specific timeline of gate openings for Rainy Lake see Table 8. The graphs within the figures show the inflow (solid purple line), outflow (solid red line), and maximum theoretical outflow (dashed red line) for each lake April 1 through June 15, 2022. The graphs also contain numbered yellow bars showing the number of logs remaining in the sluices or the number of dam and canal gates open. The two dams at the outlet of Namakan Lake consist of five stop-log controlled sluices. Logs are stacked on top of each other in each sluice and water flows over the top of the stacked logs. The more logs are stacked, the less water passes through the outlet. There are 125 total logs between the two dams and Figure 16 provides the total number of logs in the dams at the correlating date. The dam between International Falls and Fort Frances has a total of 15 gate-controlled openings. Figure 17 shows how many of these gates are open.

Maximum theoretical outflow represents outflow if all gates were always open, or all logs were removed from the sluices, and lake elevations were high enough to be able to pass the maximum amount of flow possible out of the dams. Figure 16 shows that once all logs were removed from the dams at Namakan Lake, the outflow quickly matched the maximum outflow. Figure 17 shows that gates at the International Falls/Fort Frances dam were gradually opened and outflow from the lake rose to match the theoretical maximum outflow by mid-May. Theoretical maximum outflow was not achieved as quickly at the outlet of Rainy Lake because of limitations in the conveyance of the Rainy River upstream of the dam. For more information on the limitations of outflow from Rainy Lake, see a factsheet (included in Appendix G) and a series of three educational videos on the IRLWWB website. On Rainy Lake, only once the level has risen to the level greater than or equal to 337.7 m, or 1107.9 ft, is having all gates open necessary to efficiently pass the maximum flow out of Rainy Lake. Both figures show that even with all gates open, lake levels will continue to rise until the outflow from the lake matches the inflow to the lake, or when the purple line crosses the red line. At this point the lake level will be stable and the lake will only start declining once the inflows consistently remain below the maximum outflow.

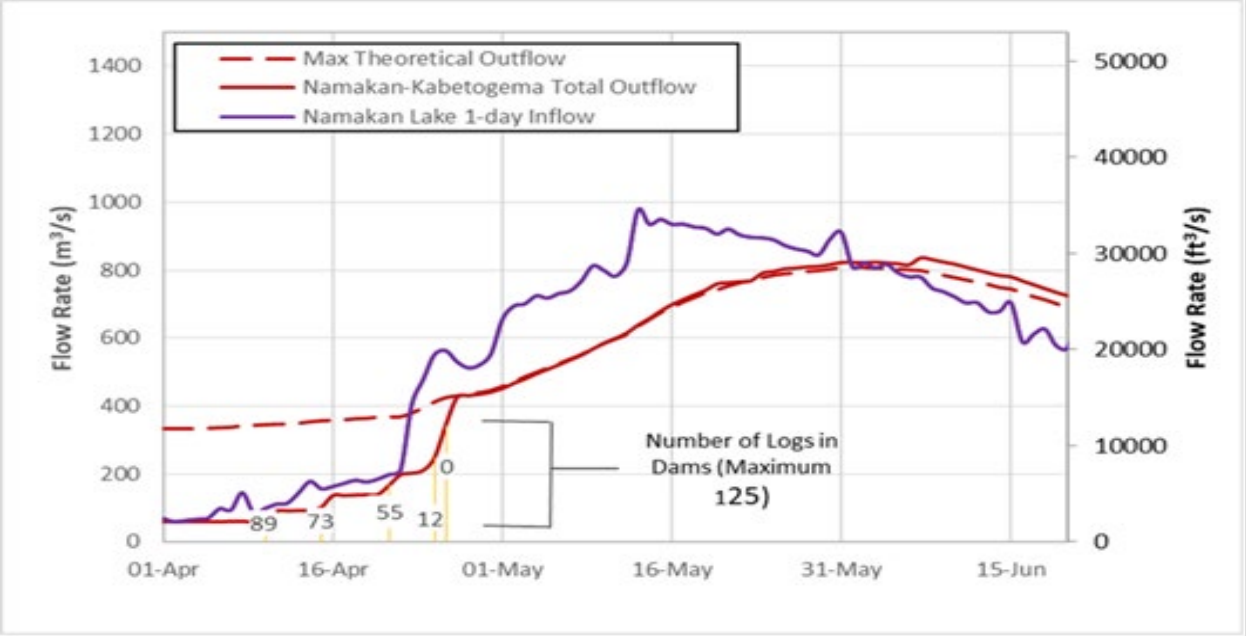


Figure 16. Timeline of Namakan Lake Gate Openings (LWCB)

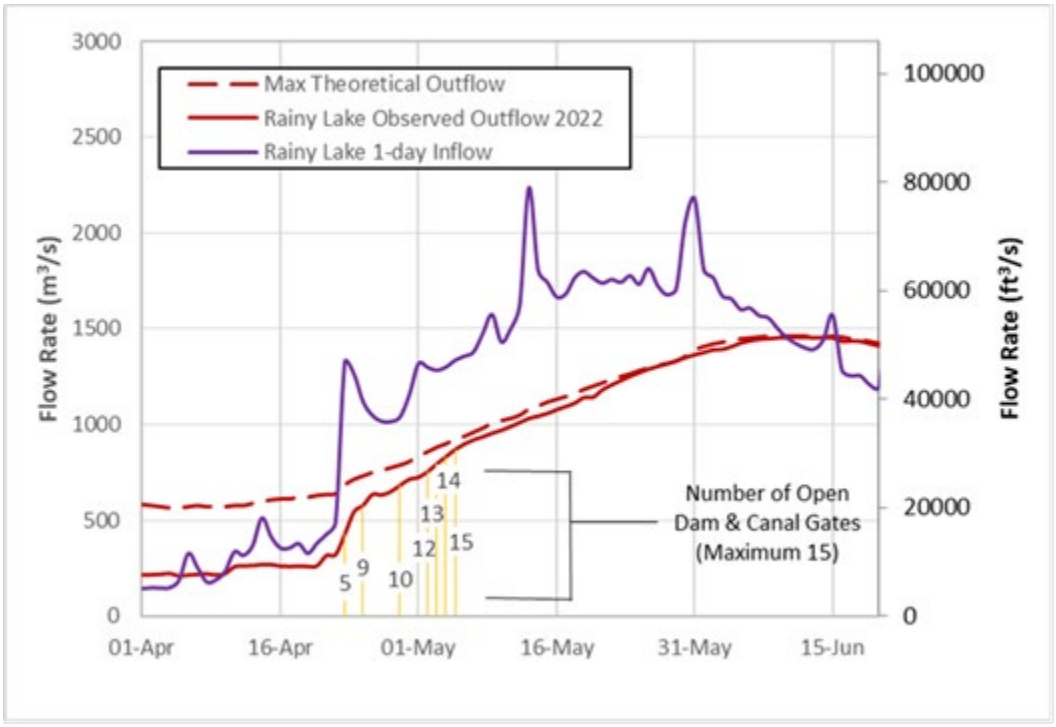


Figure 17. Timeline of Rainy Lake Inflows, Outflows, and International Falls/ Fort Frances Dam Gate Openings (LWCB)

Table 8. Timeline of gate openings for the dam at International Falls/ Fort Frances (15 total gates)

Date (2022)	Gates Open
April 27	9
May 2	12
May 4	14
May 5	All Gates Open

4.6 WLC Activities after All Gates Open

Once all sluices and gates were open at Namakan and Rainy Lake dams, there were no additional actions that the dam operators or the WLC could take to pass additional water. The rate of water released from both lakes steadily rose as the water levels of the lakes increased but outflow rates remained well below the inflow rates as week after week of above-average precipitation continued to fall. The WLC Engineering Advisors worked closely with Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (MNRF) and the U.S. National Weather Service (NWS) to provide guidance three days a week on forecasts for the levels of both lakes. The Lake of the Woods Control Board (LWCB) provided the level forecasts and communicated them through the NWS's Rainy River Basin webpage, which housed current water level and flow observations, precipitation, river level, and lake level forecasts. The NWS also conducted a weekly webinar for agencies and public members to attend. The forecast and basin conditions updates and weekly meetings continued until the end of the flood event.

At the end of May, the U.S. Co-Chair of the WLC and the public U.S. WLC member met with local officials and community members from around International Falls. During the week of June 6, 2022, the WLC and IJC representatives, including a U.S. Commissioner, traveled through the larger basin to meet with the affected residents and community officials. Local WLC members were consistently communicating with affected residents, providing information, and answering questions.

On June 14, water was discovered overflowing from Namakan Lake into Rainy Lake through an area north of the Kettle Falls hotel and Namakan dams. High water found an overflow channel from the bay just north of the Kettle Falls Hotel to the American Channel of Rainy Lake. Although some soil erosion occurred, and bedrock was visible, there was no concern of further erosion of the overflow channel. Both Kettle and Squirrel Falls dams were visually inspected and there was no concern with either dam structure. An area resident indicated that the overflow channel acted as a historic water passage for the Namakan Lake's summer levels in the 1970s. It is believed the water flow has ceased in the recent years because of beavers and fallen trees. To better under the total outflow into Rainy Lake, the USGS crew took flow measurements of the developed channel and upstream of the dams. The overflow channel did not impact normal operations at Namakan and Rainy Lakes since measured outflow was small compared to total inflow to the lake.

4.7 Return to Band

The Rainy Lake Property Owners Association sent a letter to WLC when the Namakan Lake water level fell below its prescribed All-Gates Open level on June 30. The letter requested that when Namakan Lake water level recedes to 1,118.8 feet (top of 1970 Rule Curve) operations on

the lake should follow the 1970 rule curve temporarily to speed up the decline of the Rainy Lake in the hope that residents have access to damages and start on restoration activities. The WLC had concerns over the risk of holding a steady Namakan Lake water level should an unforecasted precipitation event occur; however, no precipitation was forecasted for the period that Namakan Lake would be held at the 1970 Rule Curve. The WLC also wanted to ensure residents on Namakan Lake agreed with the recommendation to hold Namakan Lake water levels steady rather than continuing to keep the water level within the 2018 Rule Curve. Following a discussion amongst the WLC and Namakan Lake residents, the WLC requested a Temporary Order from the IJC to hold the lake at the upper limit of the 1970 Rule Curve.

On July 5, the WLC received the Temporary Order from the IJC. The dam operators were directed to make a minor adjustment from the standard Namakan Lake water level target to the temporary target range from 340.90 m to 341.0 m. The target was a 10 cm (4 in) range centered on the upper level of the 1970 Rule Curves, 340.95 m (1,118.6 ft). This level also follows the top of the 2018 Rule Curve in early June, but the 2018 Rule Curves drops gradually over the summer rather than holding flat per the 1970 Rule Curves (see Figure 18). The temporary target resulted in Namakan Lake being approximately 5-15 cm higher (2-6 in) than it would have been following the 2018 Upper Rule Curve.

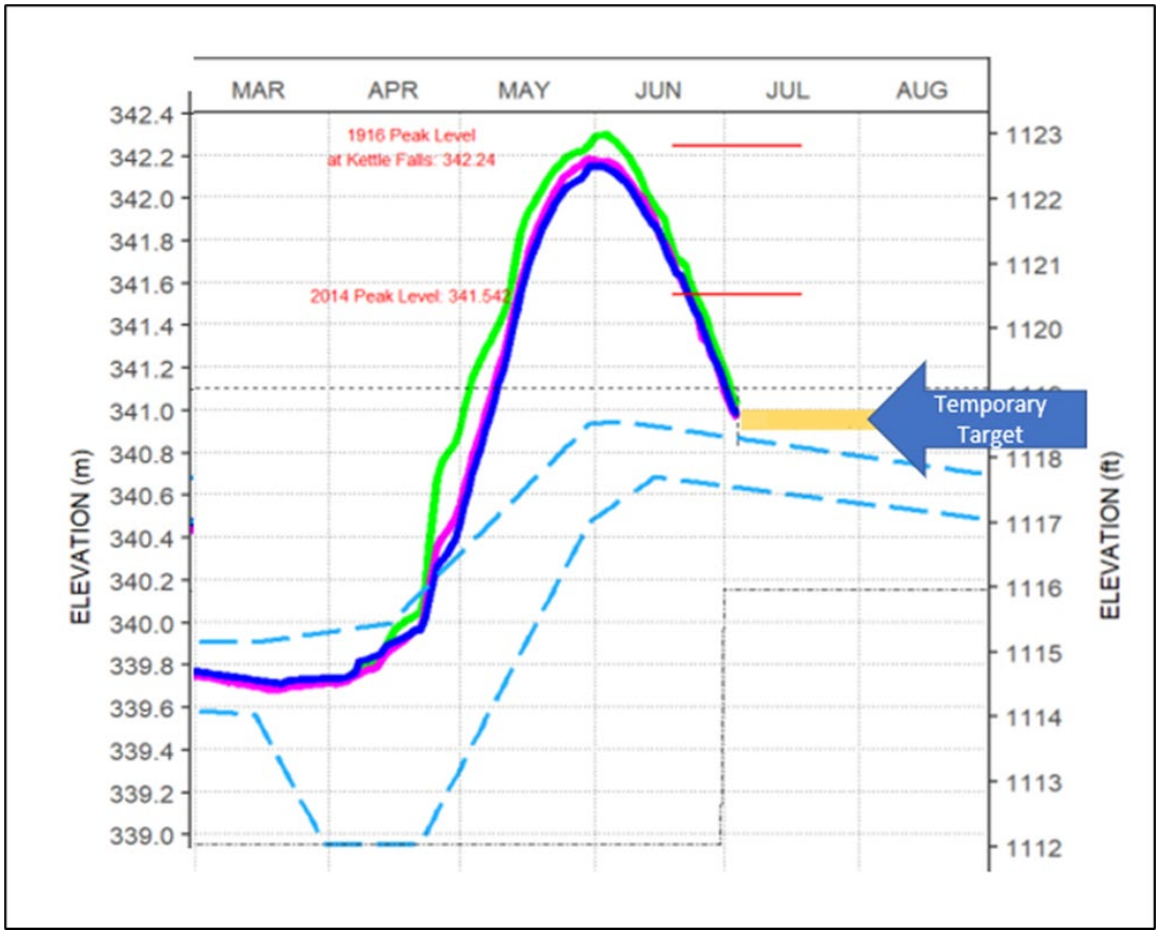


Figure 18. Temporary Target for Namakan Lake under the July 5 IJC Temporary Order, the blue dashed lines outline the 2018 rule curve, dark blue line indicates the Namakan Lake level at Kettle Falls, green lake indicates the Crane Lake level, and pink line indicates the Lake Kabetogama at Gold Portage.

On July 26, as Rainy Lake fell below the IJC All- Gates Open lake level, the WLC advised operators to set outflows from Namakan and Rainy lakes to target the middle 50 percent of their rule curve bands. The Namakan and Rainy Lakes returned to their standard rule curves on August 3, 2022.

5 Public Engagement

5.1 Basin Visits, Communications and Listening Sessions

In 2022, the WLC engagement with the public began with the Pre-Spring Engagement Webinar, hosted on March 3, 2022. Further information about the Pre-spring Engagement session is included in this report under section 4b. Following the webinar, the WLC received correspondence from and followed up on, input from the Rainy Lake Properties Association.

On March 9, 2022, the IRLWWB presented during the Annual Rainy-Lake of the Woods Watershed Forum on water level information including a 2021 Conditions Recap and a high-level overview of the 2022 conditions. The presentation highlighted that information on current water level and flow conditions in the basin can be found on the LWCB website, and that details of Water Levels Committee decisions regarding the implementation of rule curves on Rainy and Namakan Lakes are posted on the IJC website. The Annual Rainy-Lake of the Woods Watershed Forum was held virtually in 2022 due to public health concerns. There were over 144 people in attendance for the day-and-a-half event.

On March 10, the WLC posted a press release on the IRLWWB website. It was further distributed to the local media to inform the public about the decision to target the standard rule curve for spring 2021 to guide the International Falls/Fort Frances dam operation for Rainy Lake, as well as rule curve targets to guide operations at outlets of Namakan Lake. The WLC also informed stakeholders of the rule curve decision and targets through the WLC's email distribution list. Further information about the 2021 decision on the spring target can be found in this report under Section 4.3.

The sudden onset of the extreme precipitation occurred between April 22 and 23 rising water levels in Namakan Lake. On May 5th, a High Water and Flow Bulletin was posted to the IRLWWB website detailing the extreme conditions, with links to access updated flood risk information via the National Weather Service (NWS) and the Province of Ontario. The WLC collaborated with the NWS to share information with residents about the NWS webpage specific to Rainy River Basin conditions and their weekly webinar for agencies and public members.

The WLC visited the Rainy River basin twice during the 2022 flood event. On May 24 through 26, 2022, the U.S. WLC members toured the U.S. portion of the basin with Koochiching County Sheriff and Engineer to assess the effects of high-water conditions. The U.S. WLC team also visited resort owners on Rainy and Kabetogama Lakes to answer questions and hear their concerns as water levels were still rising.

June 7 though 11, WLC members from both sides of the border, an IJC Commissioner, and staff from the IJC toured the full Rainy-Lake of the Woods watershed. Given the extensive flooding throughout the region, the tour was coordinated with members of the LWCB and the International Lake of the Woods Control Board (ILWCB) and included visits to parts of the watershed outside the regulatory mandate of the WLC.

As part of the tour, the WLC met with Chiefs and members of Big Grassy on Lake of the Woods, Nigigoonsiminikaaning, and Couchiching First Nations. There was also engagement with town officials in Fort Frances and International Falls. The WLC observed flood damage, listened to the concerns and questions from the communities, and provided information about the flood, water regulation, and the role of the IJC.

In International Falls, the WLC met with Koochiching County Emergency Operations personnel and participated in the daily brief with the Minnesota Department of Homeland Security and Emergency Management. A media availability session was held in Ranier, Minnesota with local newspaper outlets from both sides of the border and member from the Border Lakes Association to answer questions regarding the flooding in the basin.

Throughout the summer, the WLC members and the IRLWWB responded to phone calls and emails with inquiries from residents about the flooding. The WLC continued participating in and sharing information about the National Weather Service's weekly webinars.

During the IRLWWB annual basin meeting the second week of August, the IRLWWB and WLC hosted two Public Listening Sessions: one in Fort Frances, Ontario, and the other in International Falls, Minnesota. A press release was posted on the IRLWWB webpage to inform the residents about the listening sessions. The goal for each session was to provide an opportunity for the community members to share their views and concerns with the Board and its Committees. Participants were asked to register in advance and submit questions. The WLC developed a video presentation about the 2022 flood. The video played at the beginning of each listening session, and is available on the IRLWWB website. The video followed a facilitated session for participants to ask questions and express concerns.

The IRLWWB also received a letter with recommendations from its Community Advisory Group (CAG) after the flood event, which is included in Appendix G. The letter noted improvements in emergency response compared to the 2014 flood event, but also noted challenges in communications during the 2022 flood event. The CAG's recommendations to the IRLWWB included:

1) an establishment of multi-agency information officer role and a potential development of an app that provides easy access to watershed-related information,
2) to investigate emergency water level regulations to allow balancing of Rainy Lake and Namakan Lake levels as flood levels drop',
3) investigation of a floodway on either side of the border, and
4) coordination with NWS on added capacity in basin forecasting of future flood events.

5) that the IRLWWB ask the IJC to urge governments to ensure that any plans to replace the Ranier rail bridge[6] are designed to minimize impacts on flows, and
6) for the WLC to consider reviewing rule curve decision process to allow for approval of a HFRRC later in spring or provide additional public updates as the spring freshet develops.

While establishing a multi-agency information officer (1) and developing an app is outside the scope of the WLC and the IRLWWB, the WLC is supporting multi-agency communication by providing links to water level data and emergency information on its website. Section 8 of this report provides summarizes websites and sources that provide information on basin conditions and water management in the basin, both in general as well as in times of flood.

Regarding coordination with the NWS (4), the WLC sent a letter to the North Central River Forecasting Center (NCRFC) on October 31, 2022 requesting additional forecasting support for the full Rainy River basin and building modeling capacity and support for snow water equivalent measurements to accurately quantify snow observations within the basin. Since the request, NCRFC has been actively working on additional river forecast modeling points within the basin, as well as adding Rainy-Lake of the Woods watershed flight paths for aerial snow surveys.

In response to the public concerns over the potential modification of the Canadian National (CN) Railway railroad bridge (5), the WLC brought the CN Rail bridge modification project to the attention of the IRLWWB and IJC. Section 5.2 also highlights the public concern for railroad bridge modifications and potential impacts to outflow from Rainy Lake.

Another WLC effort related to the recommendations was to address misunderstandings around the role the HFRRC plays in water level management (6). On January 3, 2023, the WLC sent a letter to IJC Secretariats requesting an amendment to the 2018 Supplementary Order eliminating the distinction between the regular and high flood risk rule curves for Rainy Lake, combining them into one rule curve through the spring period. In response to feedback that invoking the HFRRC in March was being misinterpreted by the public that the WLC was able to manage High Risk Floods with this curve to avoid damages, it was also recommended to remove all references to a high flood risk rule curve from the Order. The March 10th decision would then be the date by which the WLC establishes a 'Spring Regulation Plan'. In response to the request, on March 3, 2023, the IJC issued a Temporary Order to the 2018 Supplementary Order allowing for the temporary implementation of the recommendation. After the 2023 freshet, a permanent change would be considered with input from the public and a summary report from the WLC of its experience with the single rule curve.

The recommendation to investigate a balanced approach of emergency regulation for Rainy and Namakan Lakes stems from the July 2022 Temporary Order to hold Namakan Lake at the top of the 1970 Rule Curve to allow Rainy Lake to recede to its All-Gates Open level sooner (Section 4.7). To target outside the current rule curves, the WLC may request a Temporary Order from

[6] The CN Rail was proposing a partial replacement of the CN Railroad Bridge, Mile 85.0 over Rainy River at Fort Frances, Ontario, and Ranier, Minnesota. The bridge's movable span on the U.S. side was nearing its end of reliable service life, and CN Rail was proposing a replacement of the movable span.

the IJC in times it is advisable to do so. In the event that a Temporary Order can be implemented in an emergency situation, impacts and interests of both lakes are considered.

The recommendation to investigate a floodway within the basin (3) is outside the mandate of the IRLWWB and WLC. Any major structural solutions, like a floodway or a diversion, would have to consider downstream impacts. Solutions in one area of the basin may not be a solution for another area of the basin and may have impacts that exceed those of the pre-project conditions.

5.2 What We Observed and What We Heard

This section provides a summary of key observations, questions, and concerns, based on the opportunities to engage with the public through basin visits, correspondence, and the August Listening Sessions.

Damage to Properties, Infrastructure, and Economic Loss

The impacts on properties and infrastructure varied depending on the location within the Rainy River basin. Given the overwhelming amount of water that entered the basin quickly, the infrastructure was submerged in some areas and resulted in significant damage to the shoreline properties. There was extensive damage to homes and docks. In some places, the roads and harbors with berms were no longer visible. Resort owners and other small businesses suffered significant economic loss due to infrastructure damage. Some resorts had to shut down entirely due to their location on the lake, while others had to reduce summer reservation numbers. Tourism is a crucial economic driver for the region, and the financial hardship from the flooding occurred after two exceptionally lean tourism years due to the global pandemic.

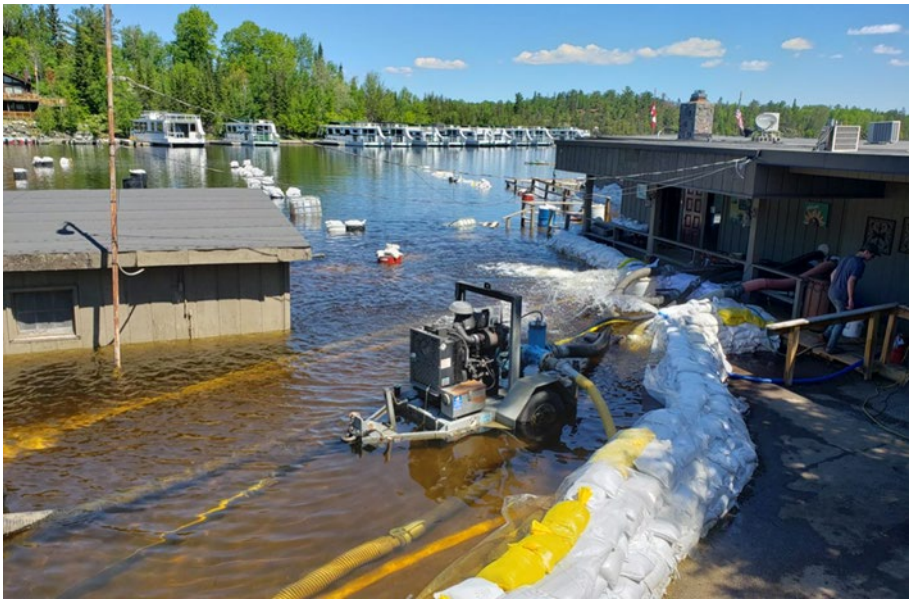


Figure 19. Flood mitigation efforts at Thunderbird Lodge in International Falls, MN (Photo Credit: Abigail Moore)

Sandbagging and Community Support

As water levels rose, states of emergency were declared at the state, provincial, and Federal levels. The State of Minnesota issued an Executive Order declaring a peacetime emergency on May 19 to provide on-site state assistance to the local governments. The U.S. Federal Emergency Management Agency declared a disaster in the basin on July 15 to provide Federal funding to the state, tribal, and local governments. Residents, with the help of various agencies, mounted a tremendous sandbagging effort to mitigate the impacts of the flood. The WLC and Board members observed and heard from the local community that the number of sandbags available improved compared to previous flood events. In addition to agency help, community members on both sides of the border made exceptional efforts to support each other, whether volunteering to fill sandbags or helping neighbors place sandbags around homes.

Figure 20. Koochiching County sandbagging station at International Falls, MN (Photo Credit: Rebecca Seal-Soileau)

Snow and Ice

The Board heard from multiple community members that there were concerns over the accuracy of snow data in the basin. There were questions about why the SWE data modeled and shown in the forecasting presentations did not reflect what individuals observed locally, especially in the more remote areas. There is an opportunity to build awareness about how a single observation of snow depth or ice thickness can vary from one location within the watershed and differ from broader averages for forecasting. The NWS identified that participation of citizens throughout the basin in their Community Collaborative Rain, Hail & Snow Network (CocoRaHS) would be of value to by providing additional data points to ground truth precipitation observations, which would support improved forecasts of lake and river levels. More information on CoCoRaHS is available at https://cocorahs.org/.

Water Level Committee Decisions

There were many questions about the significance of making a regulatory decision by March 10. Despite ongoing work by the WLC to monitor conditions in real-time during the spring, some public members held the misperception that the WLC was no longer engaged following the March 10th rule curve decision.

There were several comments related to concerns about the timing of gate openings at Rainy Lake as water levels rose and a general sentiment that the WLC could have done more to minimize the impacts of the flooding. A minority of people believed that the rule curves were designed to prevent floods or perceived it as an "emergency rule curve." It became evident that the term "High Flood Risk Rule Curve" is misleading as the high flood risk rule curve is only intended to provide modest mitigation under minor to moderate spring flood risk scenarios.

A key question that arose several times throughout the 2022 flood event and during the August Listening Sessions regarded the implementation of rule curves and what would have happened if the HFRRC had been used instead of the standard Rule Curve. Many of the community members felt that following the HFRRC could have 'taken the edge off' the impacts they were experiencing from the flood, while acknowledging the flooding could not have been prevented. Analysis of "what-if" scenarios regarding rule curves is covered in Section 6 of this report.

Outflow of Rainy Lake at the CN Railway Bridge Crossing

There is a restriction point that limits the outflow of water out of Rainy Lake into the Rainy River at the rail crossing between Fort Frances, Ontario, and Rainer, Minnesota, at the Southwest corner of Rainy Lake. Some community members understand that the dams need complete control of the outflow. There were several questions about whether changes could be made at this location to let more water out of Rainy Lake to reduce the effects of flooding. This line of inquiry, however, did not take into account the impacts this would have on downstream communities There were other questions about whether infrastructure changes, such as an emergency floodway to increase Rainy Lake outflows, would be a viable option to mitigate the severity of flooding. The Board was reminded that the restriction at this location is natural and existed before Koochiching Falls and Couchiching First Nation land was flooded with the building of the dams.

Community members also highlighted growing concern over the potential modification of the Canadian National (CN) Railway railroad bridge. Many asked how structural changes at the bridge crossings would impact water levels and flows, especially when the basin is experiencing a flood. The lack of information about the scope of the potential work was noted as a key concern. No official project information was available at the time of the August Listening Sessions; however, the WLC brought the CN Rail bridge modification project to the attention of the IRLWWB and IJC. Concerns for the project were then brought to the governments of Canada and the United States. They are responsible for assessing potential hydraulic impacts and how they may trigger the 1909 Boundary Waters Treaty and further involve the IJC.

Debris and Environmental Spill Concerns

There was a concern about hazards to boaters caused by the significant amount of large debris floating downstream. The hazard was in the form of trees, branches, docks, and other infrastructure detached from the shore. The potential for an environmental emergency from propane or other hazardous materials displaced due to the flood was also identified as a significant risk. The IRLWWB notified agencies on both sides of the border about these concerns.

Communications, Roles and Responsibilities

There were multiple reports that residents struggled to understand where to go for help and who was responsible for what during a flooding emergency. This included questions about where to find information on water levels and lake level forecasts. First Nation communities on Rainy Lake noted the lack of timely and local forecast information during the flooding. Among those who were aware of the NWS webpage and webinars, they were seen as effective and central hubs for information. Section 8 of this report provides additional detail, resources, and sources of information within the basin.

Many residents expected the IRLWWB and the WLC to be more active during the flooding. Although the WLC and IJC were actively working in the background during the flood event, the WLC's involvement was not made clear to the public. During the 2022 flood event, it was evident that the scope and limitations of the Board and Committee's mandate, compared to that of government agencies, were not well understood. Section 2 covers the roles and responsibilities of the IJC, IRLWWB, and WLC for Namakan and Rainy Lakes.

The Lake of the Woods community members asked who is responsible for water level decision-making in part of the basin. Many appeared surprised to learn that the mandate for the WLC of the IRLWWB is limited to Rainy and Namakan Lakes and that the separate Lake of the Woods Control Board (LWCB) is responsible for water level decisions on Lake of the Woods, as per the Canada-U.S. 1925 Lake of the Woods Convention and Protocol. Many were unaware that the aquatic ecosystem health mandate of the IRLWWB extends further to include Lake of the Woods and felt these governance arrangements needed to be clearer and were not developed with community interests as a priority.

There was an interest in understanding what kind of communication was taking place to coordinate between the various Boards and Committees and whether anyone was looking at water level issues throughout the system more holistically. The perceived disconnects between the upstream and downstream regulators exacerbated concerns that opportunities were missed to reduce or balance flood impacts.

The IJC has since developed an infographic, available on the IRLWWB website (https://www.ijc.org/en/rlwwb/key-roles-and-responsibilities-binational-management-water-levels-rainy-lake-woods-watershed) to better identify the key organizations involved in binational management of water levels in the Rainy-Lake of the Woods watershed and distinguish their roles and responsibilities.

Misinformation throughout and after the flooding, amplified by social media, worked against the IJC and the public interest. In general, community members and governments have appreciated IJC engagement since 2014; however, there was a desire for more information and inclusion. The community and local media also appreciated IJC basin visits and public information sessions.

Flood resilience and climate change adaptation

Other key topics identified in public feedback were plans for avoiding another catastrophic flood and climate change. Some raised concerns about the changing frequency of flood events and wanted to know what could be done if larger floods occurred more often. There were calls to help the community increase shoreline resiliency, and questions about if and how water regulation would change for future floods at the same or greater scale as the 2022 event.

Accounts from individuals and businesses that had invested in enhancing or moving infrastructure further away from high water marks, based on lessons learned from past flooding, were also shared; unfortunately, in some cases, the scale of flooding in 2022 was so significant that flood damages were experienced even with adaptation and resiliency attempts.

One way the IJC assesses the impacts of regulatory changes is through adaptive management. Adaptive management can ensure that improved future knowledge can be translated into informed lake-level and flow-release decisions. The Adaptive Management Committee (AMC) was established in June 2020 with an overall objective to monitor and understand how the 2018 Rule Curves affect water levels and flows of Namakan and Rainy Lakes, and Rainy River. Their work will support an objective review of the rule curves in the future.

Ecological impacts

High water levels can have positive and negative ecological impacts. The high-water levels in the spring and summer negatively impacted the wild rice harvest in 2022. Coochiching First Nation stated that the annual traditional wild rice roast was impacted by the poor harvest on Rainy and Namakan Lakes. A potential benefit is that invasive cattail species were choked out by the high-water levels, which may provide more habitat for other species, like wild rice, in the future. Some fish species benefited from the high-water levels, with an increase in spawning habitat. However nesting bird habitats were flooded by the high-water levels.

6 Role of the 2018 Rule Curves

6.1 Purpose of High Flood Risk Curve

After the 2018 Rule Curves for Rainy Lake were developed, an additional High Flood Risk Rule Curve (HFRRC) was created as a second option to the standard rule curve. This second curve, as outlined in the IJC 2018 Supplementary Order, is designed to be used in the event forecasts in early March predict that indicators of high inflows in the upcoming spring are prevalent. During the development of the HFRRC, model simulations indicated that peak levels for moderately large inflow events could be slightly reduced by providing additional drawdown capacity on Rainy Lake in April. For extreme inflow events, the High Flood Risk Rule Curve was shown not

to have the capacity to prevent extremely high levels on Rainy Lake and, therefore, cannot prevent flooding.

6.2 Rule Curve "What-If Modeling"

In the spring of 2022, the WLC directed the dam operators to target the middle of the standard rule curve for both Namakan and Rainy Lakes rather than targeting the HFRRC for Rainy Lake. As flood conditions developed and worsened in the following months, many were left wondering if the flooding may have been avoided had the HFRRC been targeted in the spring. To answer this question, the Shared Vision Model (SVM) of the 2000 Rule Curve Review was used to explore what-if scenarios on Namakan and Rainy Lakes.

Four scenarios were modeled to determine if different regulation strategies in the spring would have influenced the peak levels at Namakan Lake and Rainy Lake. The strategies considered were:

- Operating to the middle of the 1970 Rule Curves
- Operating to the bottom 25% of the 2000 Rule Curves
- Operating to the bottom 25% of the 2018 Rule Curves for Namakan Lake and using the High Flood Risk Rule Curve on Rainy Lake
- State of Nature (assumes dams limiting or regulating flow out Namakan and Rainy lakes do not exist)

These scenarios were modeled for the three largest flood events available in the datasets: 1950, 2014, and 2022. The resulting peak levels and the number of days the level remained above the All- Gates Open level for each lake are presented in Table 9. The results indicate that regardless of which Rule Curve was used, or if no dams existed at all, the level of each lake rises above the All- Gates Open level during these flood events. Furthermore, using one set of rule curves over another has very little influence on the peak level attained by each lake. For all of these extreme flood events, using the 2018 Rule Curves, including the HFRRC, over the 2000 Rule Curves might have resulted in peak levels approximately 1 cm lower on Namakan Lake and up to 3 cm lower on Rainy Lake in 2014. The number of days above All Gates Open also saw a reduction of 1 day at the most.

A similar difference in peak levels was achieved using the 1970 Rule Curves, where the difference in peak level compared to the implementation of the 2018 Rule Curves would have again been 1 to 3 cm on either lake. A somewhat larger difference in peak level compared to the 2018 Rule Curves are seen when simulating the State of Nature. In this case, levels on Namakan Lake may have been as much as 5 cm lower in 2022, and the level on Rainy Lake may have been up to 7 cm lower in 2022.

Table 9. Simulated Peak Levels on Namakan Lake and Rainy Lake in 1950, 2014 and 2022 under various Regulation Strategies

	Namakan Lake Peak Levels in meters (number of days above all gates open)		
Regulation Strategy	**1950**	**2014**	**2022**

1970 RC (middle)	342.19 (65)	341.51 (40)	342.07 (40)
2000 RC (bottom 25%)	342.23 (67)	341.52 (41)	342.11 (42)
2018 RC (bottom 25% Nam, high risk Rainy)	342.22 (66)	341.52 (40)	342.10 (41)
State of Nature	342.19	341.51	342.05
	Rainy Lake Peak Levels in meters (number of days above all gates open)		
Regulation Strategy	**1950 Peak Level (m)**	**2014 Peak Level (m)**	**2022 Peak Level (m)**
1970 RC (middle)	339.10 (103)	338.59 (53)	339.16 (64)
2000 RC (bottom 25%)	339.11 (101)	338.60 (51)	339.19 (65)
2018 RC (bottom 25% Nam, high risk Rainy)	339.10 (101)	338.57 (51)	339.17 (64)
State of Nature	339.09	338.62	339.10

In the spring of 2022, the WLC directed the dam operators to target within the 25 to 75 percent band of the 2018 Rule Curves on Rainy Lake. A simulation of this regulation strategy was completed, and these results can be compared to the other simulations using the 2018 Rule Curves, as shown in Table 10. The difference in peak level on Namakan Lake would have been only 1 cm, and the level would have returned below the All-Gates Open level one day sooner. As for Rainy Lake, the reduction in peak level would have been 4 cm and the level would have returned below the All-Gates Open level two days sooner.

Table 10. Simulated Peak Levels on Namakan Lake and Rainy Lake in 2022 under Regulation Strategies using the 2018 Rule Curves

	Namakan Lake Peak Levels in meters
Regulation Strategy	**2022 Peak Level (number of days above all gates open)**
2018 RC (between 25% and 75%) ***- used in 2022***	342.11 m (42)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	342.10 m (41)
	Rainy Lake Peak Levels in meters
Regulation Strategy	**2022 Peak Level (number of days above all gates open)**
2018 RC (between 25% and 75%) ***- used in 2022***	339.21 m (66)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	339.17 m (64)

For those impacted by flooding it is understandable that every centimeter of flood level and every day above the All-Gates Open level is meaningful, and therefore even these relatively small reductions in lake level and time are significant. However, it is key to recognize that implementing the High Flood Risk Rule Curve comes with significant risks. In the early spring the prospect of flooding is judged only based on indicators of potential, while the main driver of flooding, spring precipitation, cannot be forecasted out more than a few days. Drawing down the

lakes to the bottom of their rule curves based on the possibility of reducing a flood by centimeters and days in anything but the most exceptional case of potential risk is irresponsible, as the negative consequences of that action (i.e. when flood inflows do not develop) cannot be taken lightly.

7 Hazard Management and Flood Resiliency

2022 is the fourth year since 2000 where very high-water levels occurred, with the last high-water event in 2014. Rainy Lake hit record-setting water levels that were 8 cm (3.1 in) above the previous record set in 1950. Namakan Lake experienced the third highest water levels on record, just 7 cm (2.8 in) lower than the record level set in 1916. Flooding has always occurred in the Rainy River watershed and will continue to do so in the future. As discussed in Section 6, no rule curve changes will prevent high water levels in the face of extreme precipitation in the future.

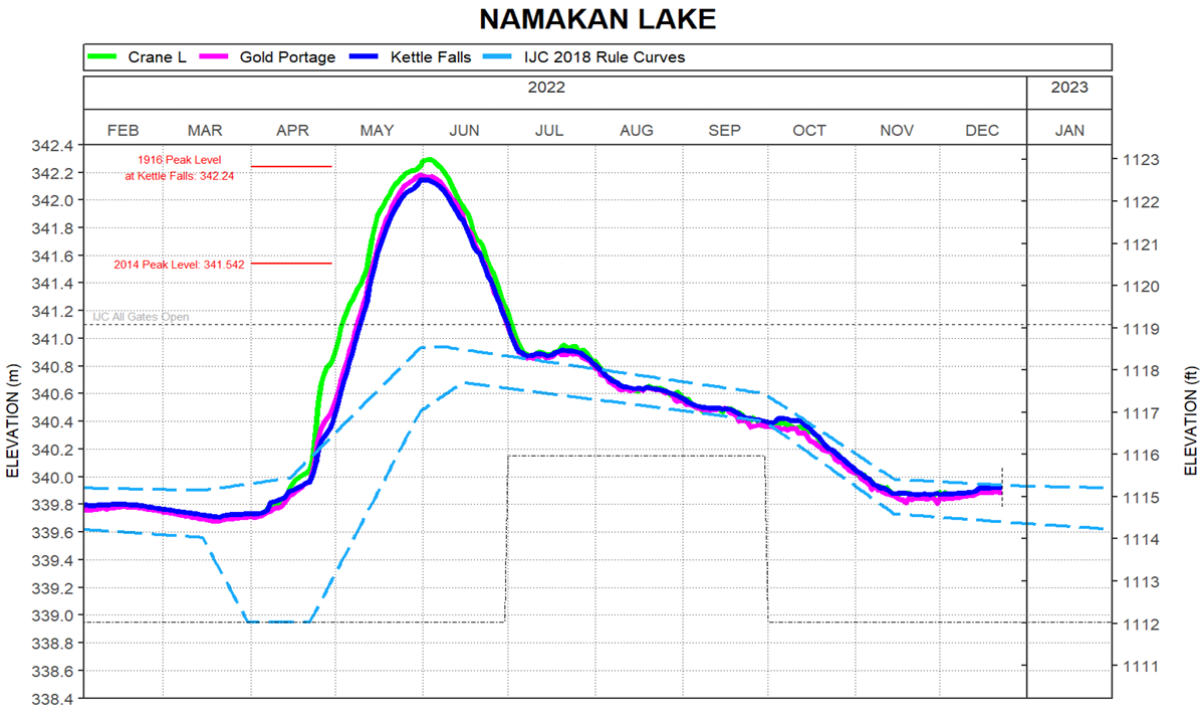


Figure 21. Namakan Lake levels in 2022 with 1916 and 2014 peak water levels marked for comparison (LWCB).

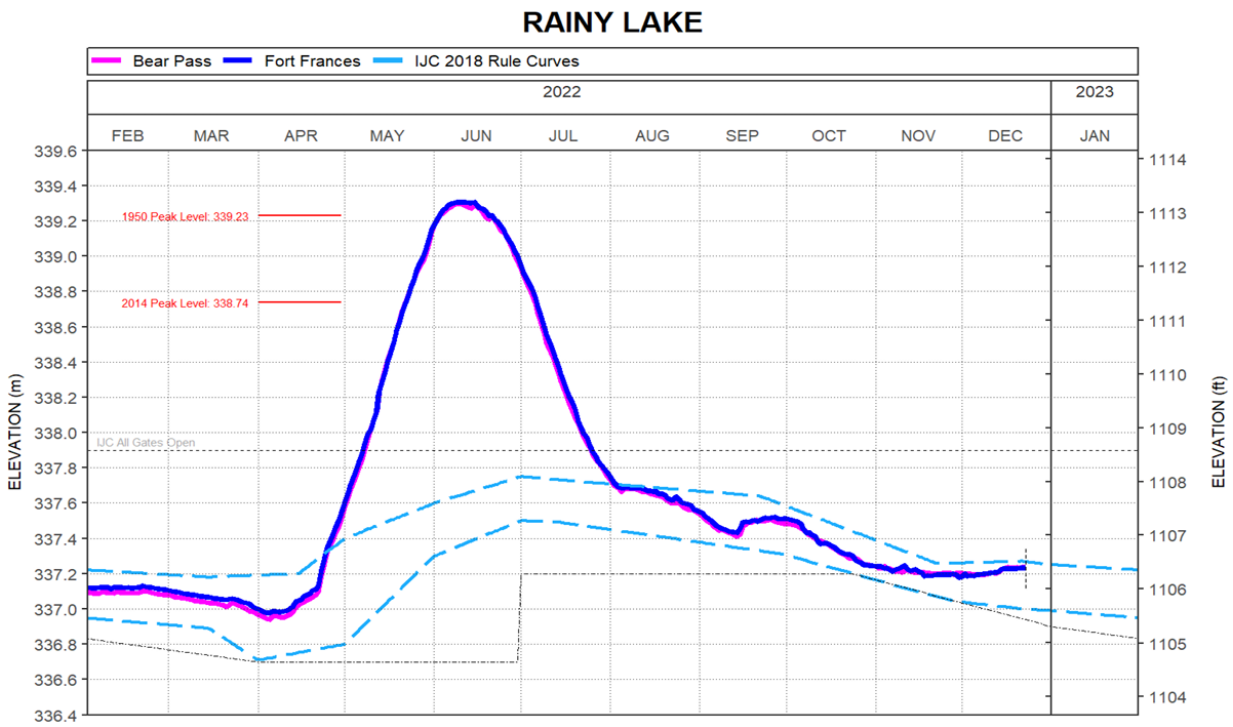


Figure 22. Rainy Lake levels in 2022 with 1950 and 2014 peak water levels marked for comparison (LWCB).

This strongly implies that the community focus on resiliency and develop capabilities to persist through the next flood (or drought). For shoreline structures such as docks and boathouses, there is an inherent compromise between building structures at a level that is suitable during normal water level years and also building them high enough to ensure minimal damage is sustained in times of moderately high-water levels. For example, the town of Rainy River, Ontario, rebuilt a road along Rainy River to the elevation of the sand berms used in 2014 flood fighting efforts. The mitigation minimized the flood damages in 2022 though there was still visible shoreline infrastructure damage. Unless such structures are built above the historic high-water levels, which would likely limit their usefulness in most years, they will inevitably be inundated and suffer some damage in years of extremely high inflow. When building or repairing structures that are not designed to withstand some degree of inundation, such as cabins or homes, local regulations that define hazard land elevations should be followed. The Federal Emergency Management Agency (FEMA)'s Flood Map Service Center (https://msc.fema.gov/portal/home) is the official public source for flood hazard information like maps and flood insurance studies. Effective November 17, 2022, the FEMA Flood Insurance Study for Koochiching County, MN and incorporated areas published peak discharge frequency (Table 11) and peak elevation frequency (Table 12) relationships for floods of selected recurrence intervals (10%, 2%, 1%, and 0.2% chance of exceedance) for the Rainy River at Fort Frances, Rainy Lake near Canadian National Railroad, and the entire Koochiching County shoreline of Lake Kabetogama.

Table 11. FEMA FIS Flow Frequency Analysis for Rainy River at Fort Frances Gaging Station

	Location	Peak Discharge

Flooding Source		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Rainy River	Rainy River at Fort Frances Gaging Station	36,500 cfs (1,034 cfs)	42,000 cfs (1,189 cms)	45,000 cfs (1,275 cms)	52,000 cfs (1,473 cms)

Source: FEMA FIS for Koochiching County (November 17, 2022)

Table 12. FEMA FIS Elevation Frequency Analysis for Rainy and Kabetogama Lakes

Flooding Source	Location	Elevations (datum NAVD88)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Rainy Lake	Rainy Lake near Canadian National Railroad	1110.0 ft (338.3 m)	1112.5 ft (339.1 m)	1113.5 ft (339.4 m)	1115.5 ft (340.0 m)
Lake Kabetogama	Entire shoreline in Koochiching County	-	-	1123.1 ft (342.3 m)	-

Source: FEMA FIS for Koochiching County (November 17, 2022)

8 Resources and Sources of Information

During many of the public meeting sessions held in response to the 2022 flooding, members of the public indicated a keen interest in obtaining more information on basin conditions and water management in the basin, both in general and in times of flood.

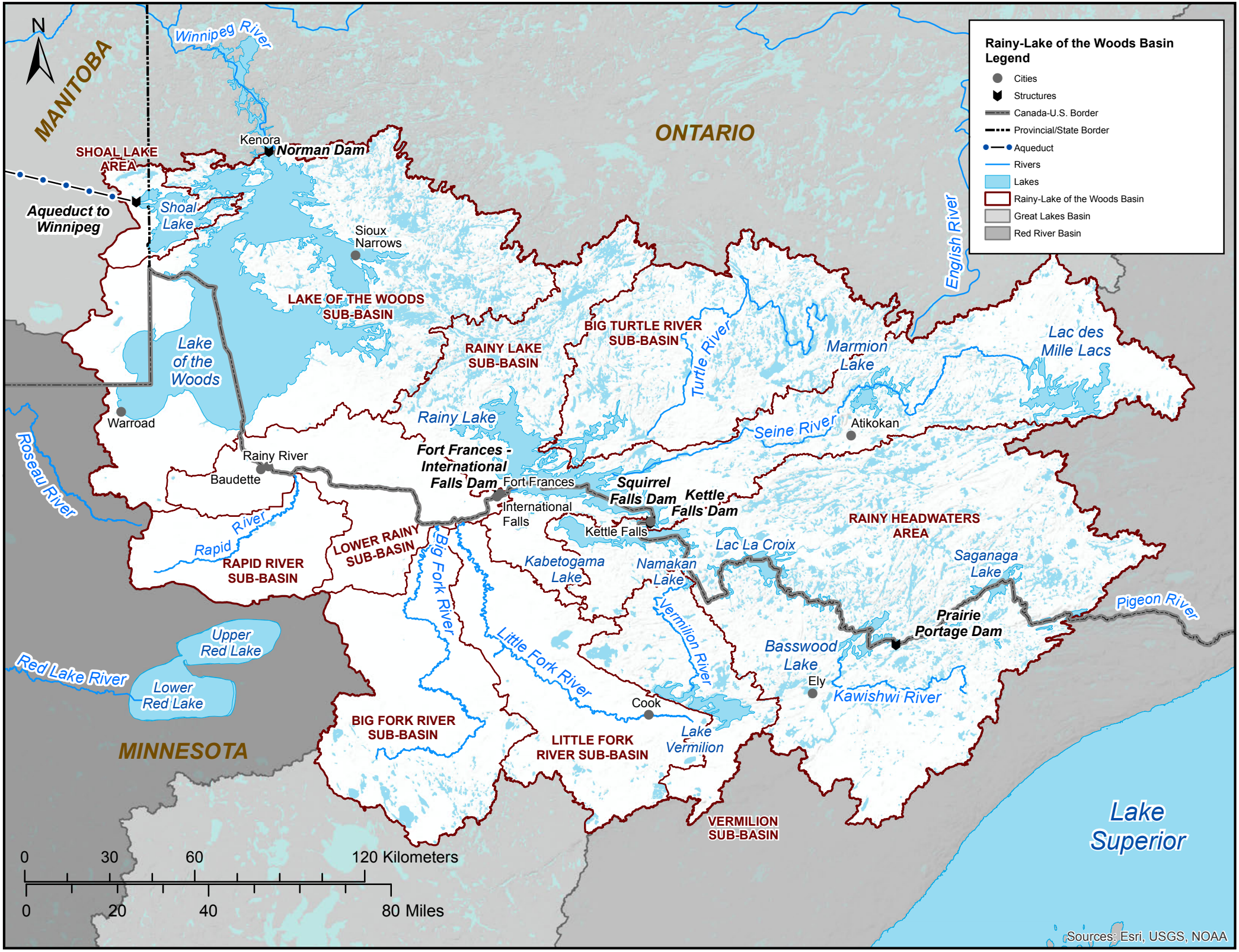
Information about the IJC and the IRLWWB, including the Water Levels Committee can be found on the IJC website https://www.ijc.org/en/rlwwb. Of special interest on the website are a series of three videos that explain the hydraulic limitations at the outlet of Rainy Lake that govern what water management is achievable during years such as 2022 (https://www.ijc.org/en/rlwwb/watershed/simulation). On the IRLWWB website, the public can also see notifications of public meetings and webinars, such as the Pre-Spring Engagement session hosted by the WLC each spring, as well as announcements of decisions and other activity by the Board and its committees. The website also has links to explore in detail the Orders provided to the IRLWWB and WLC by the IJC Commissioners, which include direction on the application of the rule curves for Rainy and Namakan Lakes.

For current and historical information on conditions in the basin, such as water levels in the lakes, outflow from the lakes, and flow at key points throughout the basin, the Lake of the Woods Control Board is one source (https://www.lwcb.ca/waterflowdata.html). Alternatively real time and historical water data can also be obtained from the Water Survey of Canada (https://wateroffice.ec.gc.ca/) and the United States Geological Survey (https://waterdata.usgs.gov/nwis).

As explained in this report, the IRLWWB and WLC only monitor for compliance with the IJC rule curves and issue instructions and targets to the operators of the dams at the outlets of Rainy and Namakan Lakes only under limited circumstances. Day to day operational decisions, including achieving specified targets and overall compliance with the rule curves, are made by the actual dam operators, H2O Power and PCA. The H2O Power website (https://www.h2opower.com/water-management/) provides a summary table of lake levels and scheduled gate and log operations, for those interested in having a more in depth understanding of actions that are occurring to regulate water in the basin.

Finally, the IRLWWB WLC, although responsible for overseeing regulation of this transboundary basin, is not a flow-forecasting agency. Rather, those responsibilities, along with associated public safety responsibilities, lie with governments on either side of the border. In Ontario, the Ministry of Natural Resources and Forestry, Surface Water Monitoring Centre, operates the provincial Flood Forecasting and Warning Program (https://www.lioapplications.lrc.gov.on.ca/webapps/swmc/flood-forecasting-and-warning-program/#ontarioFloodMap). Included in the information they provide are notices of flood watches and warnings and special watershed conditions statements, as well as local and provincial flood messages and information about states of emergency.

In response to the need to provide increased public information during the 2022 flood event, the United States National Weather Service created a new Rainy River Basin page on their website (https://www.weather.gov/dlh/RainyRiverBasin). The NWS basin page contains information on basin conditions and various information resources related to water level and flow conditions and water management throughout the basin, including flood briefings when flooding is forecasted.


N
MANITOBA
ONTARIO
MINNESOTA
Winnipeg River
Kenora
Norman Dam
SHOAL LAKE AREA
Aqueduct to Winnipeg
Shoal Lake
Sioux Narrows
LAKE OF THE WOODS SUB-BASIN
Lake of the Woods
Warroad
Rainy River
Baudette
Roseau River
RAINY LAKE SUB-BASIN
BIG TURTLE RIVER SUB-BASIN
Turtle River
Marmion Lake
Lac des Mille Lacs
English River
Rainy Lake
Fort Frances - International Falls Dam
Fort Frances
International Falls
Seine River
Atikokan
Squirrel Falls Dam
Kettle Falls Dam
Kettle Falls
RAINY HEADWATERS AREA
Lac La Croix
Saganaga Lake
Pigeon River
Prairie Portage Dam
Namakan Lake
Kabetogama Lake
LOWER RAINY SUB-BASIN
RAPID RIVER SUB-BASIN
Rapid River
Big Fork River
Little Fork River
Vermilion River
Basswood Lake
Ely
Kawishwi River
Upper Red Lake
Lower Red Lake
Red Lake River
BIG FORK RIVER SUB-BASIN
LITTLE FORK RIVER SUB-BASIN
Cook
Lake Vermilion
VERMILION SUB-BASIN
Lake Superior
Rainy-Lake of the Woods Basin Legend
Cities
Structures
Canada-U.S. Border
Provincial/State Border
Aqueduct
Rivers
Lakes
Rainy-Lake of the Woods Basin
Great Lakes Basin
Red River Basin
0 30 60 120 Kilometers
0 20 40 80 Miles
Sources: Esri, USGS, NOAA

Appendix B- References

Environment Canada. *Regional Deterministic Precipitation Analysis (RDPA-CaPA).* https://weather.gc.ca/grib/grib2_RDPA_ps10km_e.html

Federal Emergency Management Agency. November 17, 2022. *Flood Insurance Study Koochiching County, Minnesota and Incorporate Areas.* https://msc.fema.gov/portal/downloadProduct?productTypeID=FINAL_PRODUCT&productSubTypeID=FIS_REPORT&productID=27071CV000A

_IRLWWB WLC. April 2015. *Report on High Water Levels in the Rainy River Watershed In 2014.* https://www.ijc.org/en/rlwwb/report-high-water-levels-rainy-river-watershed-2014

International Rainy and Namakan Lakes Rule Curves Study Board. June 2017. *Managing Water Levels and Flows in the Rainy River Basin.* https://www.ijc.org/sites/default/files/IRNLRCSB_Final_Report_2017l.pdf

IJC. March 2018. *Official Compilation of the Order Prescribing Method of Regulating the Levels of Boundary Waters.* https://www.ijc.org/sites/default/files/2018-11/Docket%2050%20Official%20Compilation%20Rainy-Namakan%20Rule%20Curves%202018%2009%2013.pdf

Lake of the Woods Control Board. *Basin Data*. https://www.lwcb.ca/waterflowdata.html

MN DNR. *Weekly Snow Depth and Rank Maps.* https://www.dnr.state.mn.us/climate/snowmap/index.html

NOAA. *Interactive Snow Information*. National Operational Hydrologic Remote Sensing Center. https://www.nohrsc.noaa.gov/interactive/html/map.html

NOAA. *North American Drought Monitor (NADM).* National Centers for Environmental Information. https://www.ncei.noaa.gov/access/monitoring/nadm/maps

Appendix C – Glossary of Technical Terms

Antecedent Moisture Conditions— in hydrology, the degree of moisture in the soils of a watershed ahead of a precipitation event. The antecedent moisture conditions can significantly affect the flows that develop in a watershed in response to a rain event.

CaPA - The Canadian Precipitation Analysis, an Environment Canada product, is the data source for all precip-itation maps used in this report. CaPA combines different sources of information on precipitation into a sin-gle, near real-time analysis. Sources of information include surface monitoring stations, satellite and radar data, and atmospheric models. CaPA records for the Rainy River basin data back to 2003.

Colorado Low- A low pressure storm system that forms in winter in southeastern Colorado or northeastern New Mexico and tracks northeastward across the central plains of the U.S. over a period of several days, producing blizzards and hazardous winter weather.

Drainage Basin (Basin)– See Watershed.

Freshet—The period in spring when snowmelt contributes to rising flows in a watershed.

Headpond— The area of water directly upstream of a dam where water may be stored.

Hydraulic Head (Head)— In open channel hydraulics, a measure of the energy of water, given as the height of water above a certain elevation. In this report, the head at the outlets of Namakan Lake and Rainy Lake is directly related to the maximum outflow rate that can be achieved, the higher the lake level (head), the high-er the outflow capacity.

Inflow— In this report, inflow refers to the rate of water flowing into a lake. Inflows in the watershed are computed through a simple water balance equation, where known quantities are the change in volume of a lake over a specified time period and the outflow from the lake over the same period.

Median—In statistics, the middle value in a ranked group of values, the 50th percentile. May be different from the average, or mean, of the same group of values.

Normal— In this report, the normal range for a historical data set is considered to be data falling between the 25th and 75th percentile, representing the middle 50 % of historic data.

Outflow— In this report, outflow refers to the rate that water is released from a lake through a dam. Outflow is computed based on the hydraulic characteristics of the control structure and the elevation of the lake sur-face (head).

Percentile— In statistics, denotes the relative position of a value in a set of ranked values. A 75th percentile lake level or river flow is greater than 75 % of all other values recorded at the same time of year but is less than the remaining 25 %. A 25th percentile lake level or river flow is greater than 25% percent of all other values recorded at the same time of year, but less than the

remaining 75%. In this report, percentiles for water levels and flows are relative to values for a specific time of year recorded in the 30-year period from 1981-2010.
Percentiles indicate how often a particular lake level or flow has occurred historically. A 50th percentile value, known as median, indicates that values have been higher than this value 50 % of the time, and lower than this value 50 % of the time. In other words, values have historically been at or above the 50th percentile one year in every two, and lower than this value one year in every two. Similarly, for a 75th percentile lake level value, 75% of the time the values have been lower, and 25% of the time values have been higher. The 75th percentile was reached or exceeded one year in four, on average. A 90th percentile lake level has been reached or exceeded, on average, once every ten years, and a 95th percentile once every twenty years.
A 25th percentile value has been reached or exceeded 75% of the time. In other words, values at or *lower* than the 25th percentile have occurred, on average, once every four years while a 10th percentile or lower has been reached once every ten years.

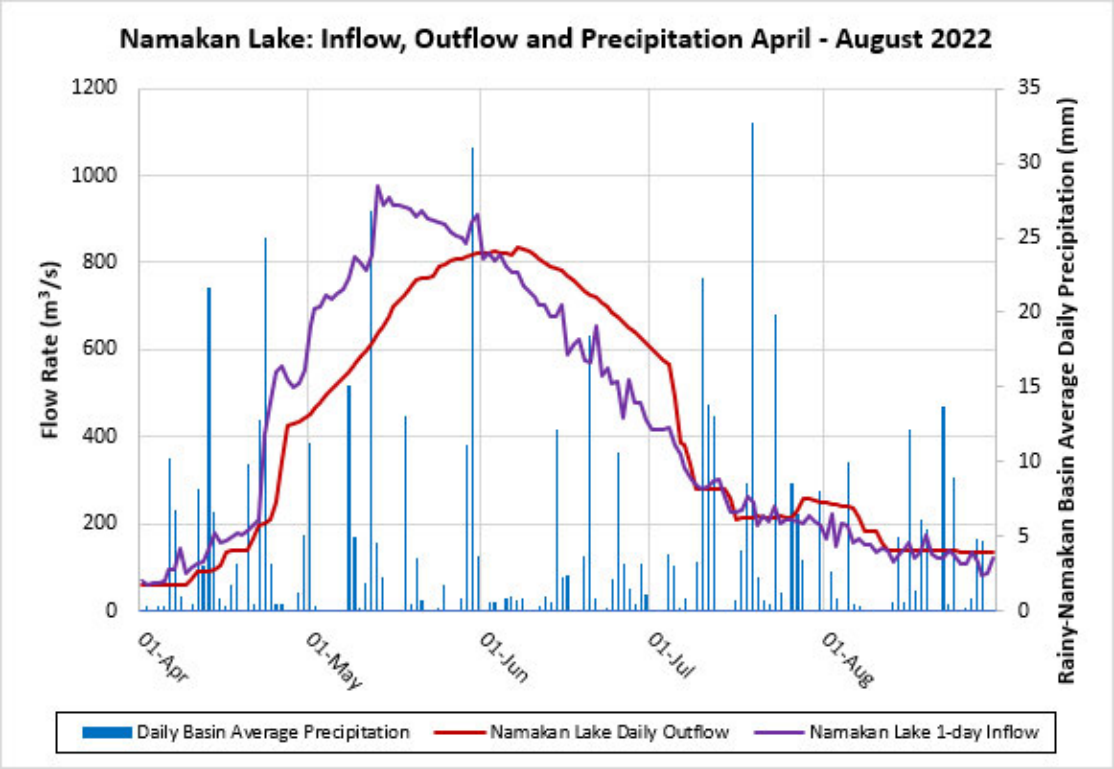
Snow Water Equivalent— The quantity of water contained in the snowpack. It can be thought of as the depth of water that would theoretically result if the snowpack were melted.

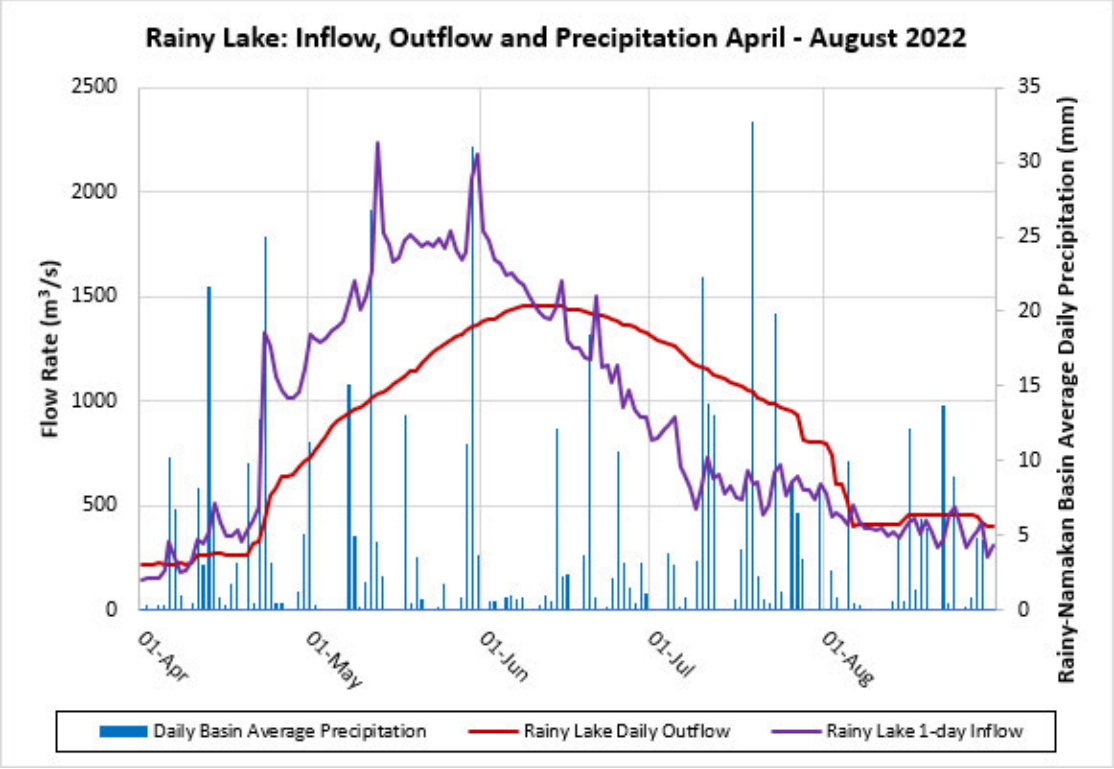
Tailwater– The waters immediately downstream from a dam.

Watershed - In hydrology, the extent of land from which water drains to a given location such as a lake or river.

Appendix D- 2022 Water Level and Flow Graphs

This appendix provides graphs of precipitation, water levels, and flows of key lakes and rivers in the Rainy River basin.





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LEGEND - CURRENT DATA GRAPHS

PRECIPITATION


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


Average - over the years 1986-2015

WATER LEVELS & FLOWS

Actual Data


Actual data for the dates shown
- levels are 1-day means plotted daily
- inflows are 7-day means plotted daily
- outflows are daily values

The most recent data is missing if the actual data line does not extend to this vertical line (on 12-month plots only)

Rule Curves (Namakan & Rainy Lakes)


IJC Upper & Lower Rule Curves


IJC Drought Line

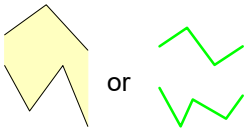
IJC Upper Emergency Level

IJC "All Gates Open" Level

Statistical Data

50 Maximum level/flow 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/flow 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.

In general, percent data is based on the period 1986-2015, while maximums and minimums are based on each site's period of record up to 2015. For further information on specific periods used for individual sites, please see the following page.

Datums for water levels are:
- Lake St Joseph - GSC (1923 preliminary) datum
- Lac Seul - GSC (1923 preliminary) datum
- Lac La Croix - USC&GS (1912) datum
- Namakan Lake - USC&GS (1912) datum
- Rainy Lake - USC&GS (1912) datum
- Lake of the Woods - Lake of the Woods datum
- Winnipeg River in Ontario - GSC (1923 Bulletin) datum
- Winnipeg River in Manitoba - GSC datum

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LEGEND - CURRENT DATA GRAPHS

WATER LEVELS & FLOWS

Statistical Data

Percent data is based on the period 1986-2015, except for the following:
- Raft Lake Level 1984-2015
- Raft Lake Outflow 1984-2015
- Rainy River Level Below Fort Frances 1988-2015

All maximum/minimum level and flow statistics end in 2015. Start dates for individual sites are provided in the following table.

Site	Minimum	Maximum
Lake St Joseph Level	1958	1958
Lac Seul Level	1935	1935
Ear Falls Tailwater Level	1958	1958
Manitou Falls Forebay Level	1958	1958
Lac La Croix Level	1921	1921
Namakan Lake Level	1949	1912
Rainy Lake Level	1949	1911
Rainy River Fort Frances Tailwater Level	1988	1988
Rainy River Manitou Rapids Level	1928	1928
Lake of the Woods Level	1927	1927
Winnipeg River Level Below Norman Dam	1958	1950
Winnipeg River Level at Minaki Winnipeg	1958	1950
River Outflow at Slave Falls Winnipeg	1927	1927
River Level at Nutimik Lake Winnipeg	1958	1958
River Outflow at Seven Sisters	1958	1958

PRECIPITATION

Data Sources

Precipitation data is from the Regional CaPA (Canadian Precipitation Analysis) Analysis of Environment and Climate Change Canada.

Precipitation averages are computed using station data from various sources as reported in the Database Report.

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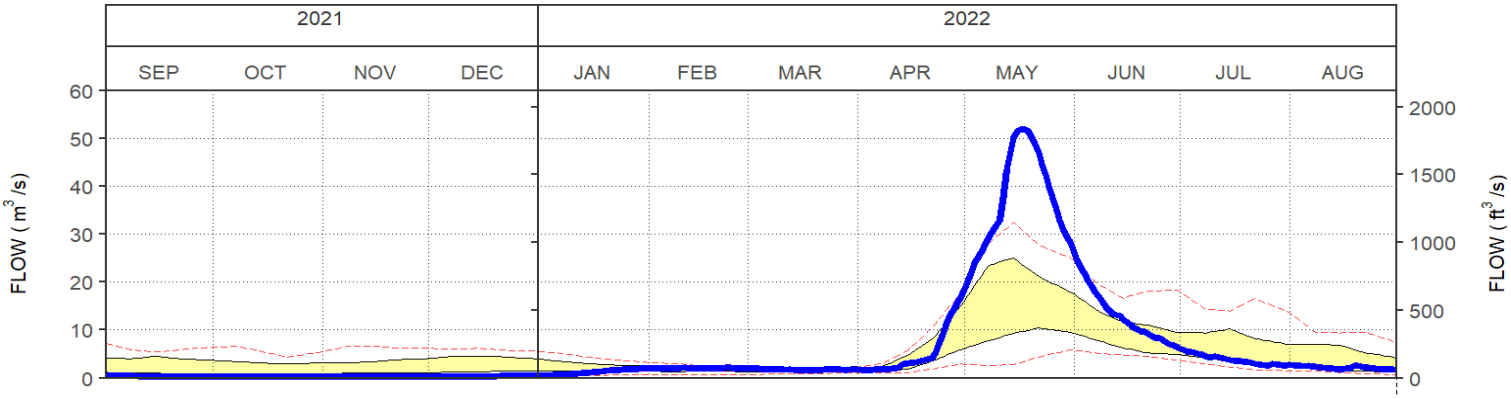
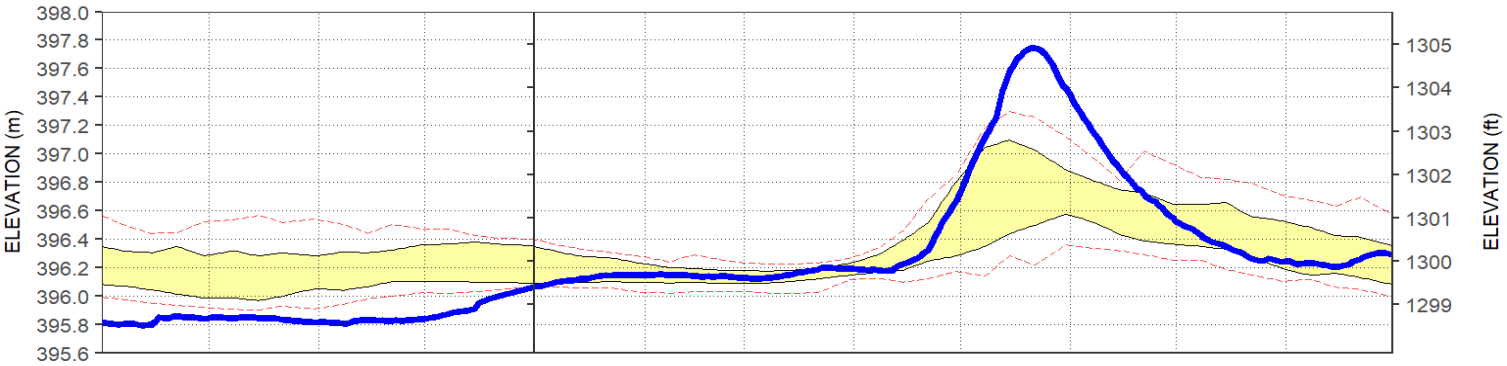
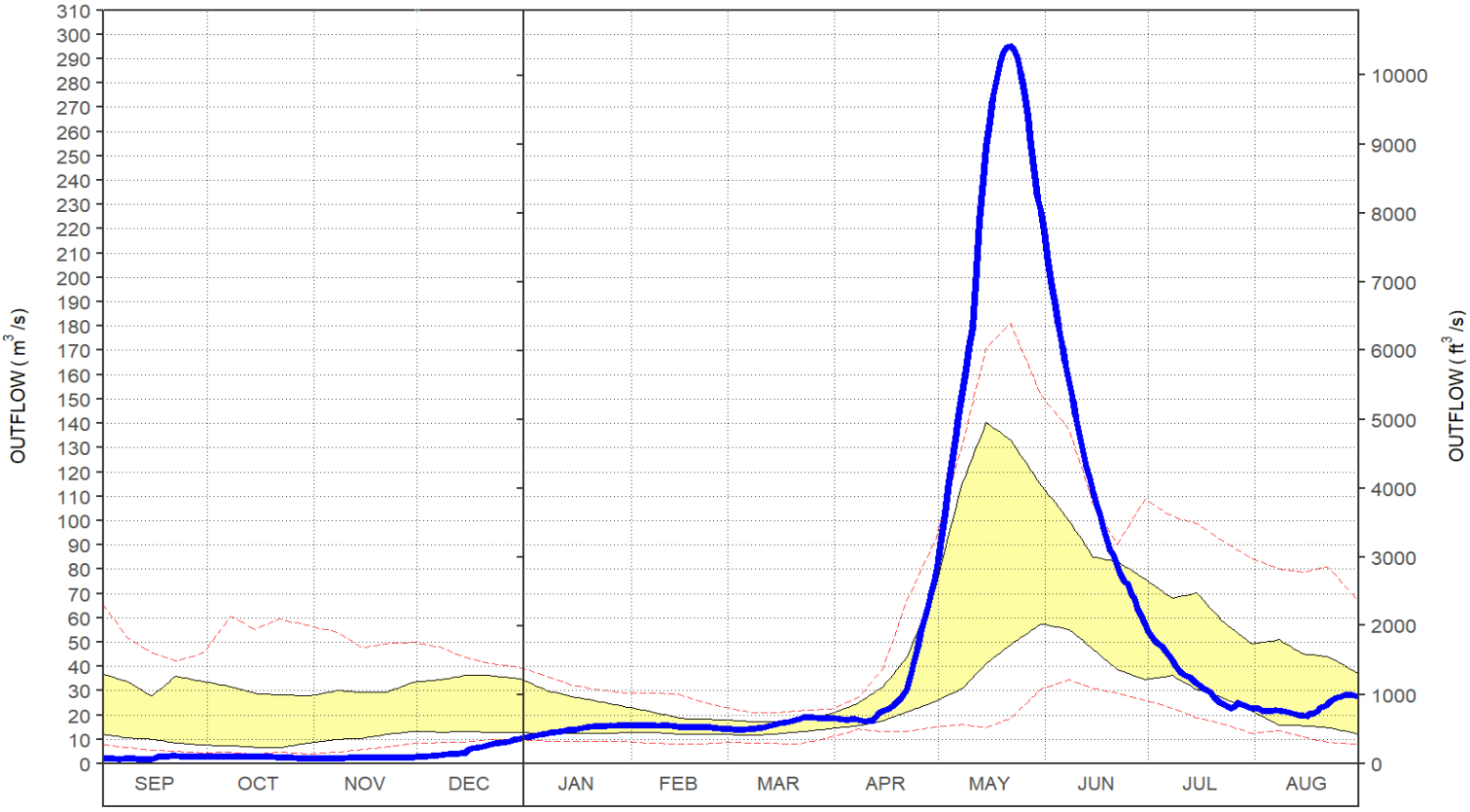
KAWISHIWI RIVER FLOW



BASSWOOD LAKE LEVEL



BASSWOOD LAKE OUTFLOW



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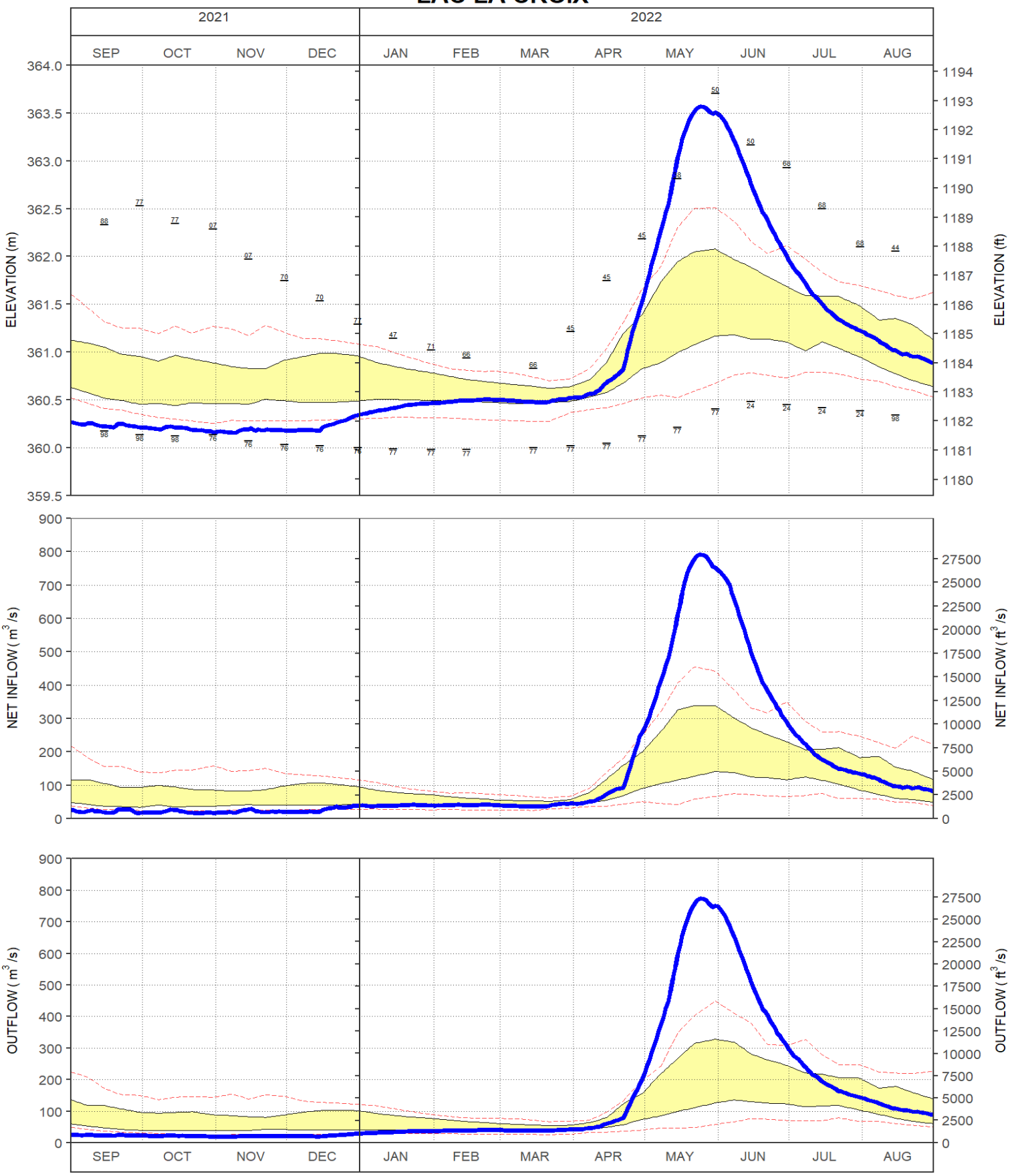
LAC LA CROIX



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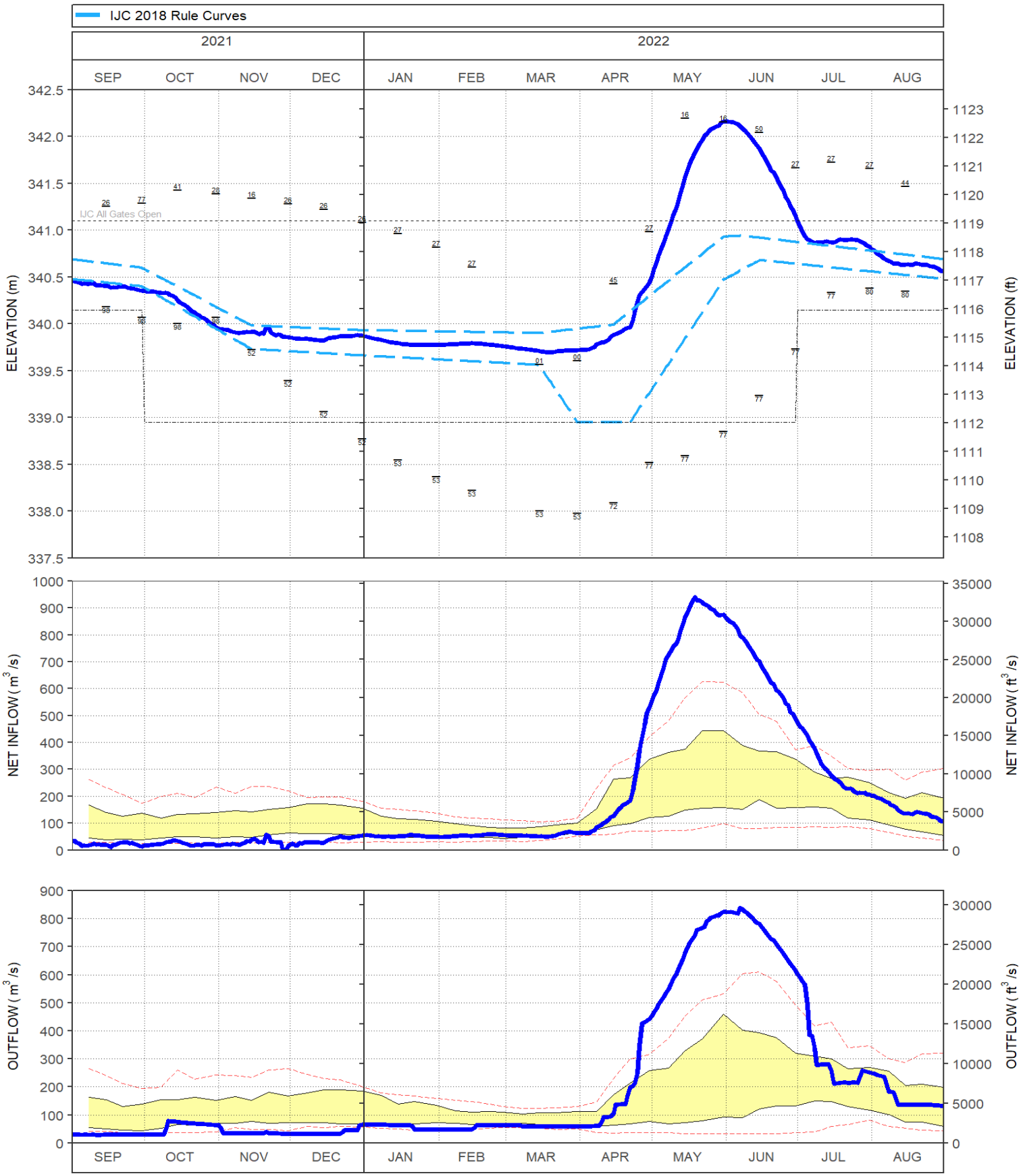
NAMAKAN LAKE



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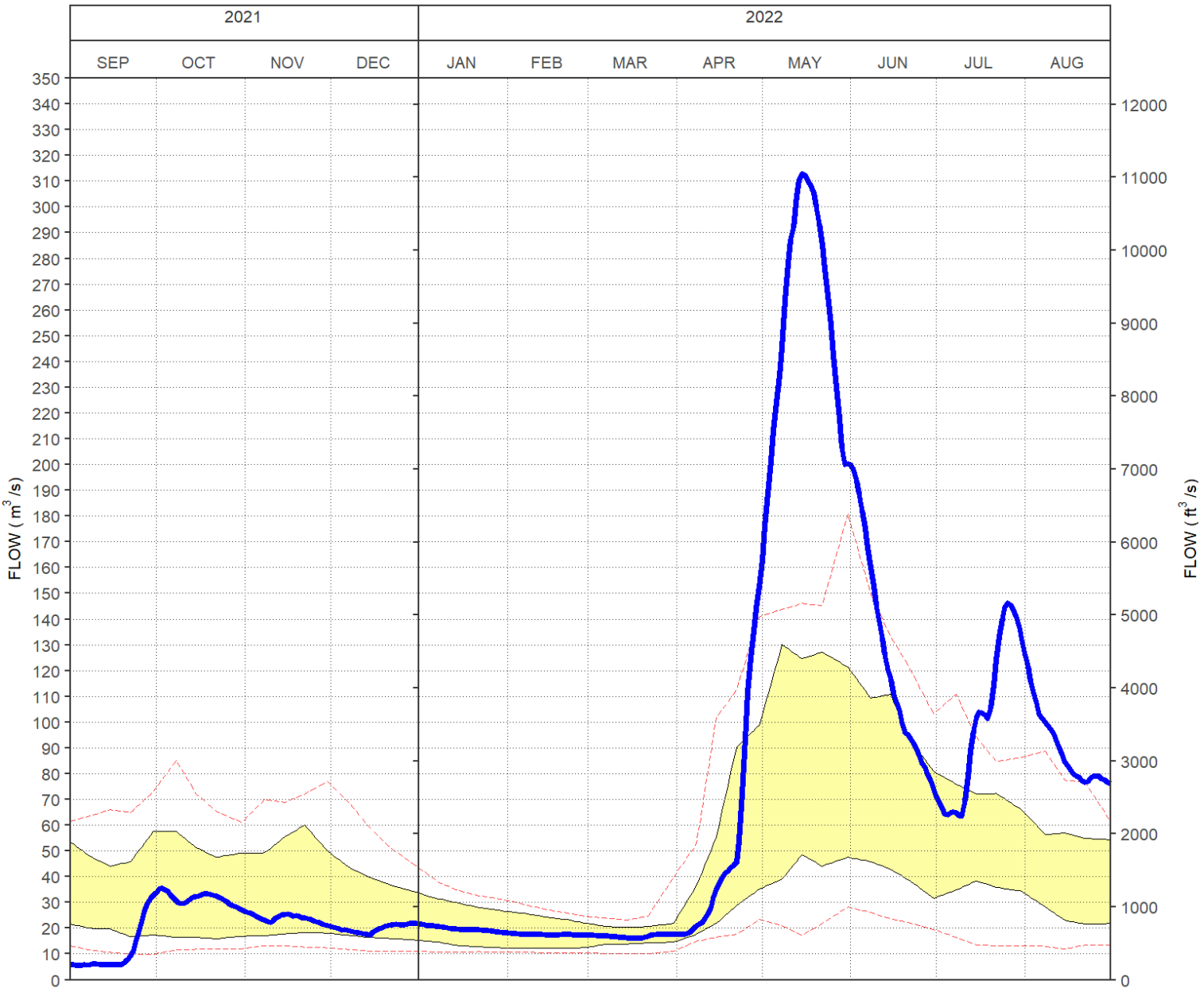
TURTLE RIVER FLOW



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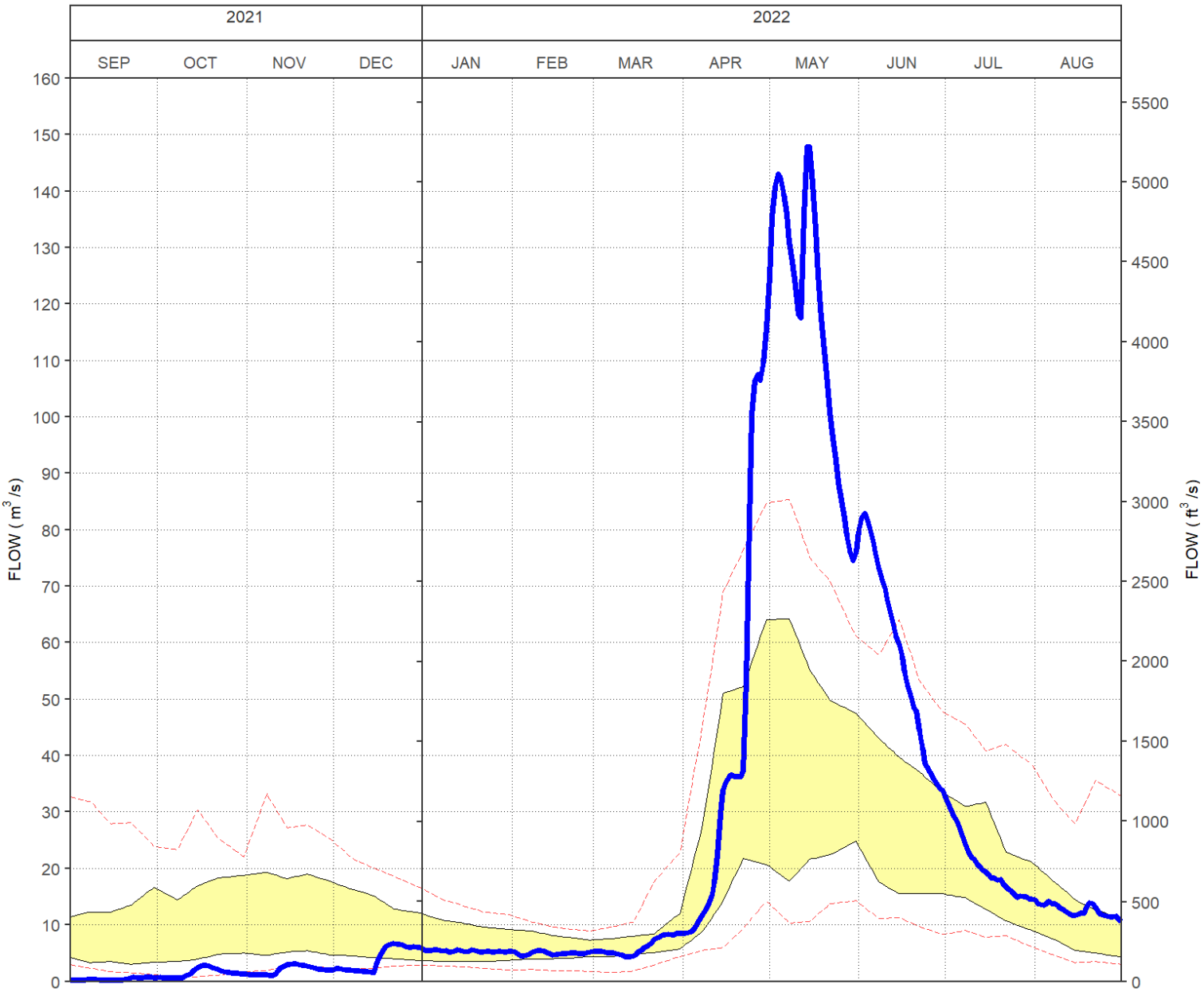
VERMILION RIVER FLOW



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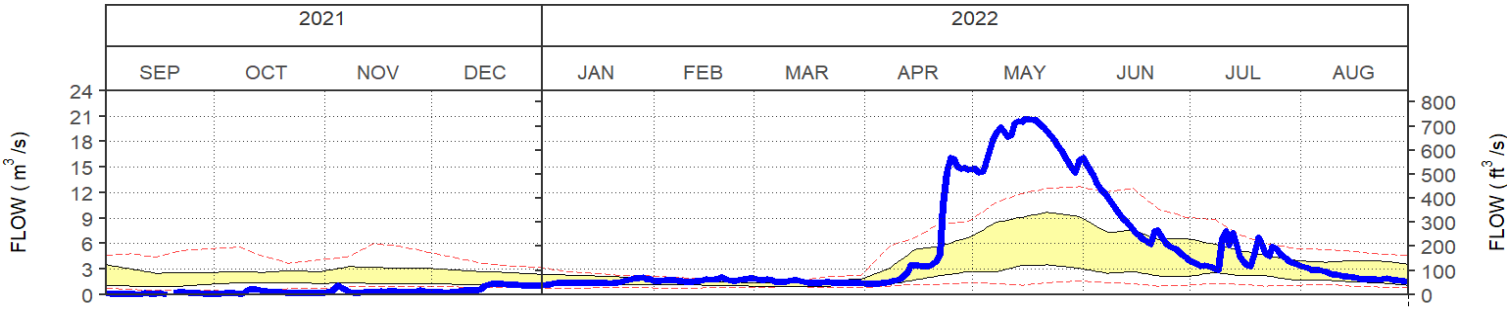
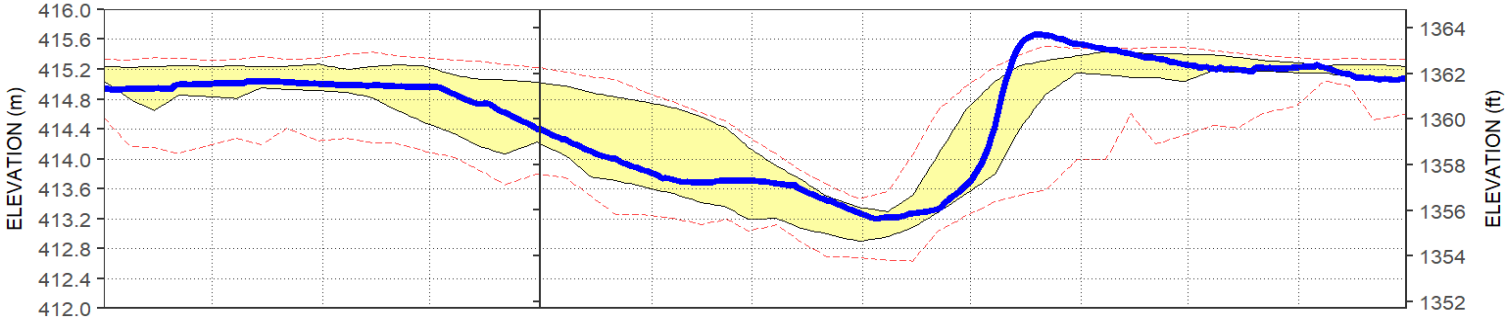
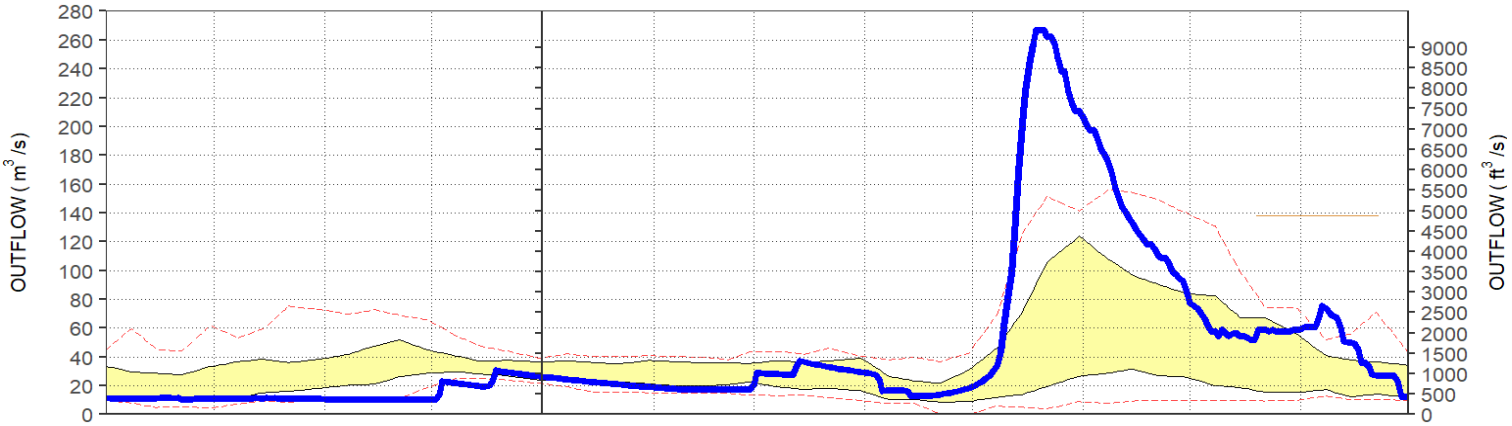
ATIKOKAN RIVER FLOW



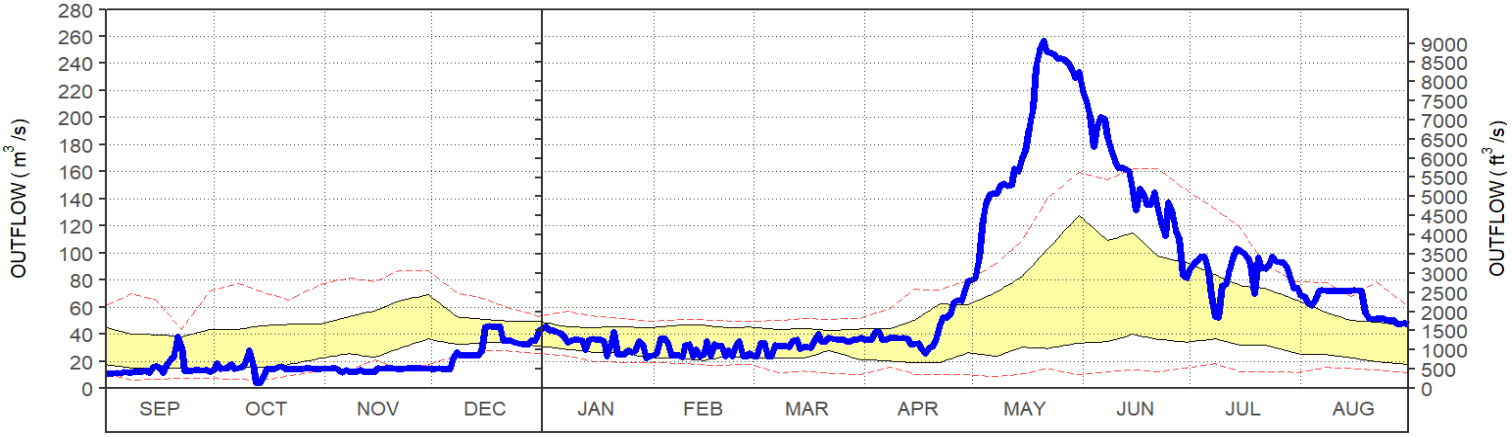
RAFT LAKE LEVEL



RAFT LAKE OUTFLOW



SEINE RIVER OUTFLOW AT STURGEON FALLS



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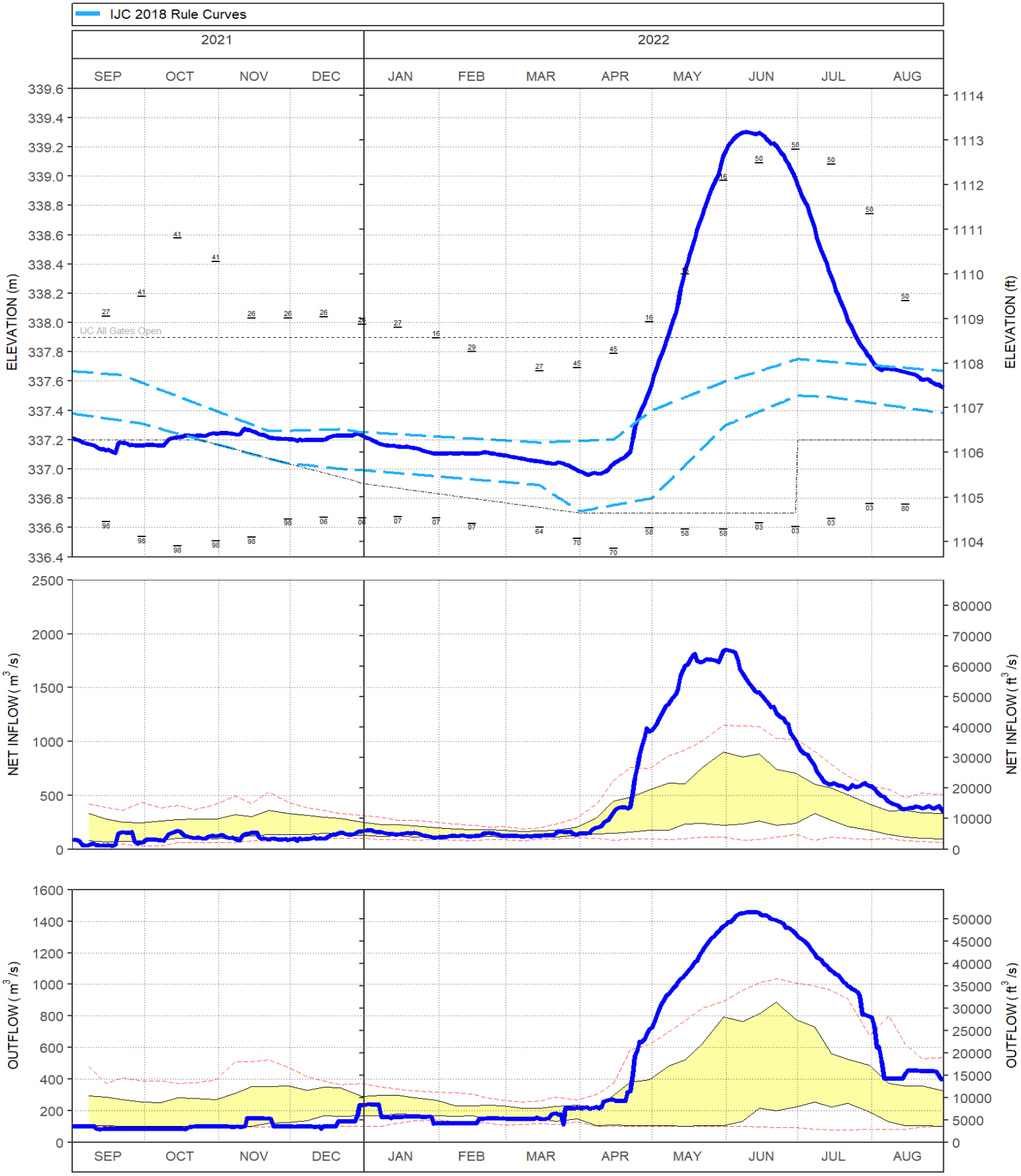
RAINY LAKE



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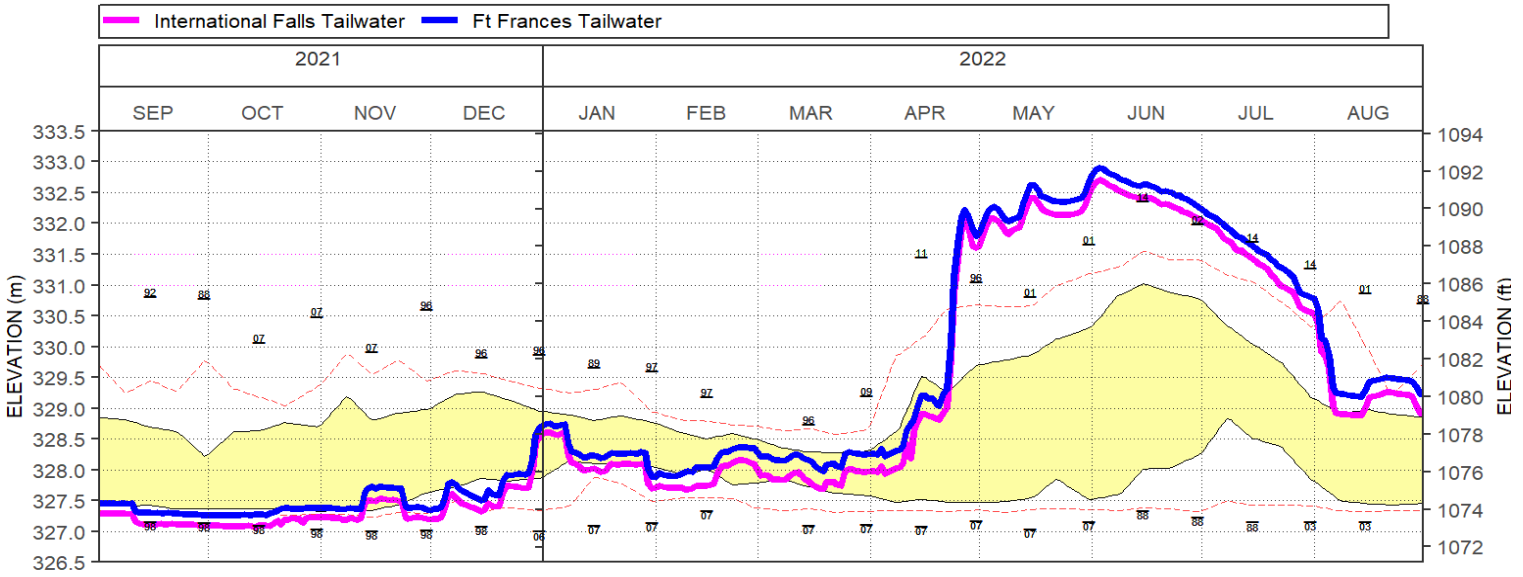
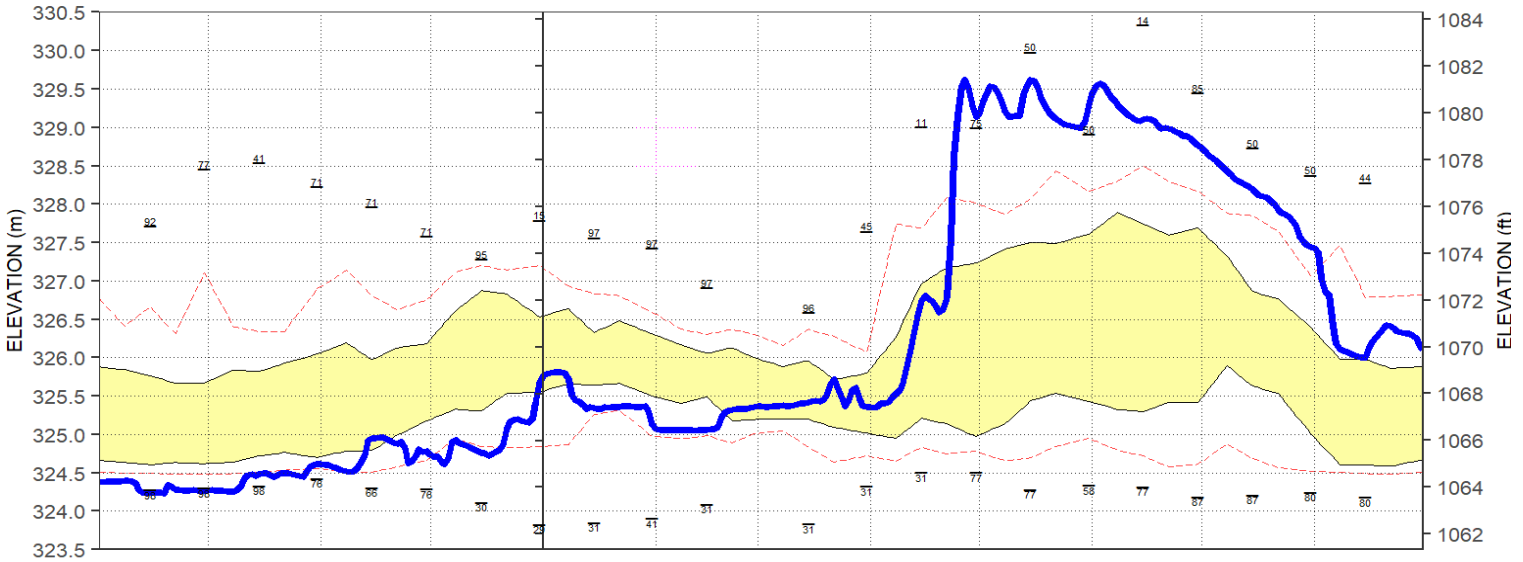
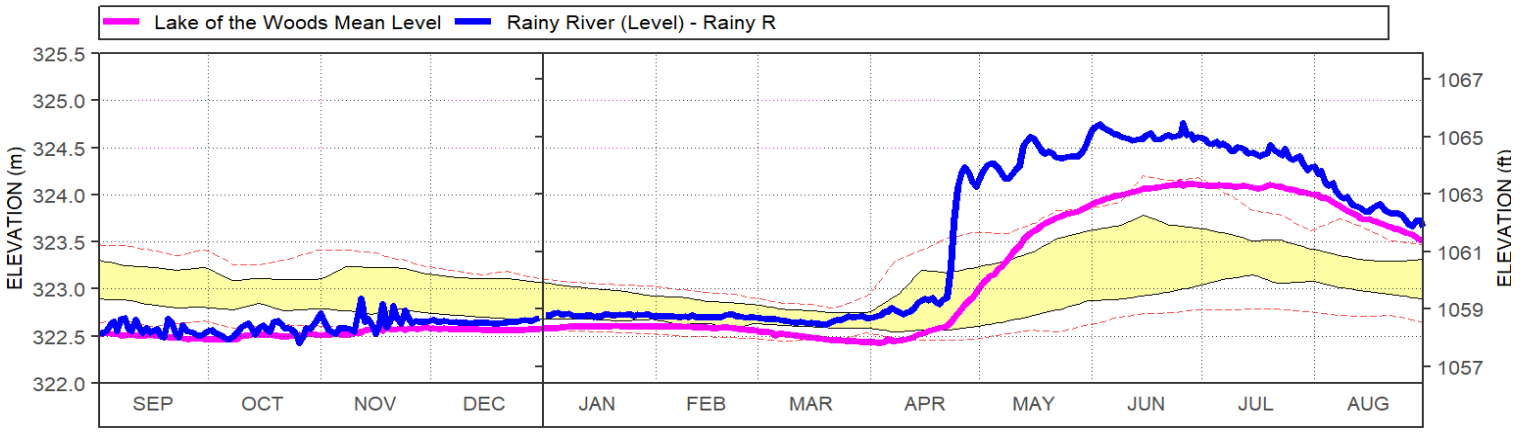
RAINY RIVER BELOW RAINY LAKE DAMS



RAINY RIVER LEVEL AT MANITOU RAPIDS



RAINY RIVER LEVEL AT TOWN OF RAINY RIVER



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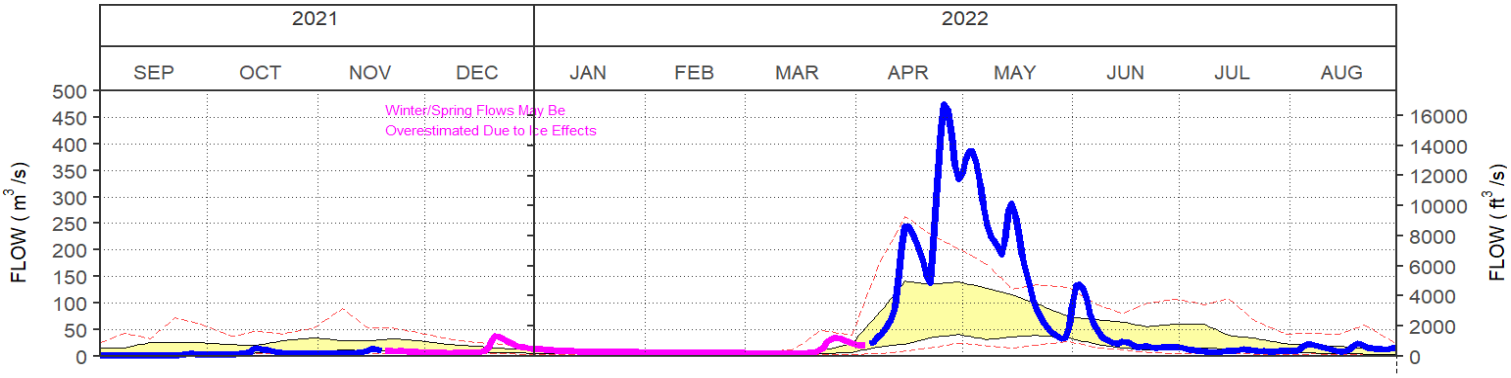
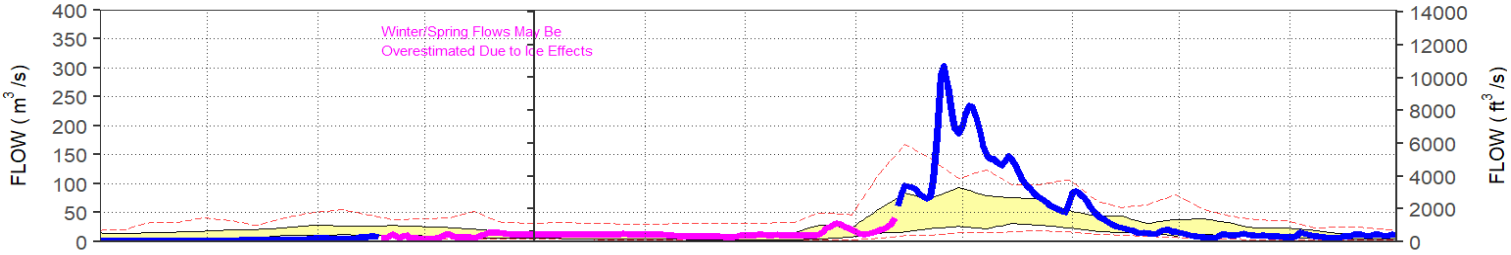
Provisional Data

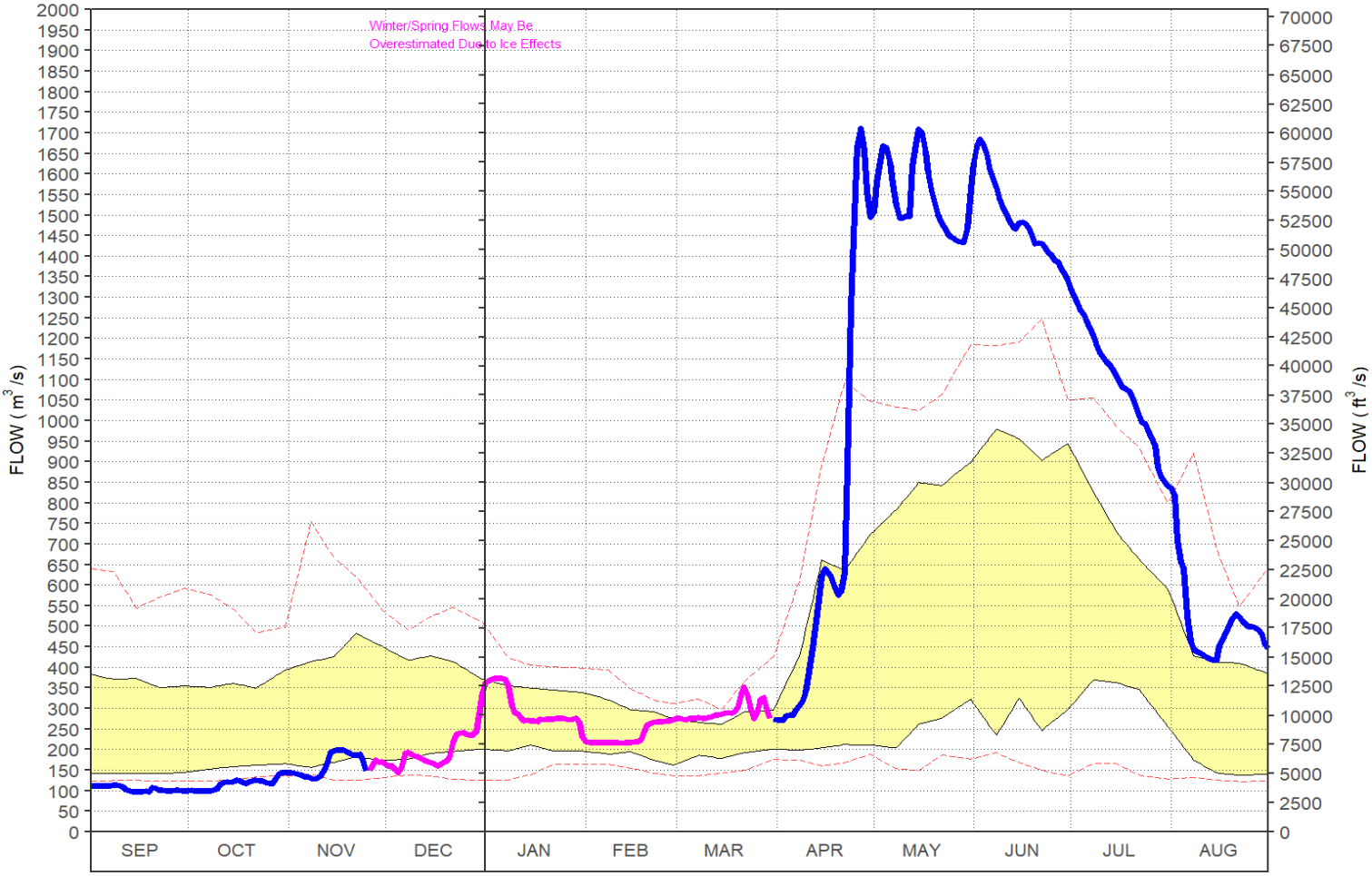
LITTLE FORK RIVER FLOW



BIG FORK RIVER FLOW



RAINY RIVER FLOW AT MANITOU RAPIDS



Appendix F- 2022 Rainy-Lake of the Woods Flooding Frequently Asked Questions

Q: Why did the flooding occur in the spring and summer of 2022 and how severe is it?

A: The Rainy River basin is one area of a much larger region that has seen record or near-record flooding this spring. This area extends to the north (English River basin and beyond) and west (Red River and other regions of Manitoba). The high-water conditions have followed well above-normal precipitation across the region nearly every week from the last two weeks of March through the end of May.

Total April 1-May 31 Precipitation by Sub-Watershed Region

Rank	Lac Seul		English River		Rainy-Namakan		Lake of the Woods		Winnipeg River, Ontario	
	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)	Year	Precip (mm)
1	2022	248	2022	274	2001	261	2022	272	2022	282
2	2001	222	1985	195	2022	257	2001	233	2001	192
3	1985	206	1974	184	1985	204	1985	213	2010	181
4	2012	191	2005	182	1974	200	1999	211	1998	179
5	2004	191	2014	181	1938	197	1937	198	1999	172
MEDIAN	142 mm		128 mm		127 mm		122 mm		121 mm	
Years of Record	109		120		117		120		119	

This precipitation fell largely as snow until late April, adding to the winter's accumulated snowpack. A series of Colorado Lows brought widespread, heavy rainfall, causing a rain-on-snow melt period over frozen ground from late April through much of May. The rapid runoff of the rain and snowmelt led to record flows in many tributary rivers including all major tributaries to Rainy Lake and Namakan Chain of Lakes. The total inflow to the Namakan Chain of Lakes and Rainy Lake set records for the April-May period, far exceeding the outflow capacity of the dams at either lake outlet. This also occurred at natural (undammed) lakes in the watershed, such as Lac La Croix.

These record flows resulted in an extended period of uncontrolled lake level rise for both the Namakan Chain of Lakes and Rainy Lake despite the dams being fully opened by the dam operators well before the lakes rose above the IJC's "All

Gates Open" level. For Namakan Lake, the level has risen to the highest point since 1916, just shy of the record set in that year. For Rainy Lake, a new record was set, 7 cm (2 ¾ in) higher than the previous 1950 record.

The resulting flooding has caused widespread damage to communities, homes, businesses, and natural shorelines. First Nations, municipalities, and counties around Rainy Lake and the Namakan Chain of Lakes declared states of emergency. States of emergency have also been declared for other communities in the Rainy River watershed that border other water bodies due to the flooding (e.g. Seine River, Lac La Croix, Rainy River). Beyond the Rainy River, states of emergency were declared in locations as widespread as Sioux Lookout and in the Whiteshell region of Manitoba. Evacuations took place in the Whiteshell and at Grassy Narrows First Nation on the English River. This event was a wide-ranging natural disaster. Unlike other natural disasters such as earthquakes and tornadoes, this one is caused by multiple weather events, as week after week of above normal precipitation fell through April and May, filling all available storage space and flooding water bodies across the region.

Flood mitigation efforts such as sandbagging have been extensive across the Winnipeg River basin in an effort to protect critical infrastructure, homes and businesses with thousands of hours of volunteer effort.

The Canadian Lake of the Woods Control Board produced a webinar on May 10 that describes in greater detail how basin conditions led to spring flooding across the larger Winnipeg River basin this spring.

Q: Why did the Water Levels Committee decide in March to follow the standard rule curve and not use the High Flood Risk Curve?

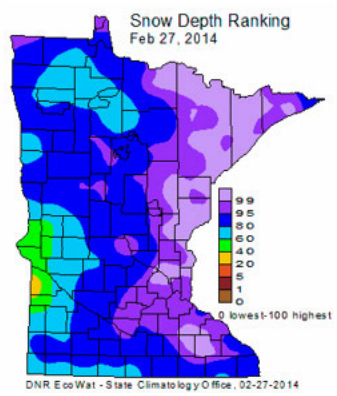
A: Based on the data available at the time, the Water Levels Committee concluded that there was not a *high risk* for flooding in the spring. In making the decision, the Water Levels Committee considered the following information:

Current Conditions at the time of the decision:

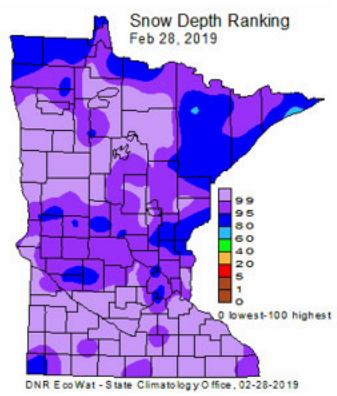
1. The current drought status for the basin ranged from abnormally dry in portions of Canada to moderate to severe drought in the U.S. Drought conditions indicate capacity in the basin to absorb precipitation and reduce runoff.
2. Base flow conditions were in the low to normal range for this time of year, consistent with the drought status. The tributary flows are the best indicator of the basin hydrology and capacity to absorb spring runoff. They did not indicate a lack of capacity in the watershed and therefore did not indicate a high risk for flooding heading into the spring.
3. Overall average winter temperatures were colder than recent years, but warmer than 2014 when spring flooding last occurred in the basin. Colder temperatures accumulated over the winter indicate a delay in ground thawing is possible and therefore an increased risk of rain-on-snow runoff.
4. The accumulated snowpack *depth* at the time of the decision was higher than normal, falling in the 80 to 95 percentile range based on historic records. Snowpack was much less than in 2014 and comparable to 2019 when normal spring flows developed. However, according to the National Weather Service, the water contained in the snowpack, the Snow Water Equivalent, was moderate, generally between 3-5 inches of water. This was less than in 2019 and much less than in 2011, 2013, or 2014 (there was no high water in 2011, or 2019, while in 2013 Rainy Lake rose slightly above the All Gates Open level and 2014 was the highest level since 1950).

Winter To Date

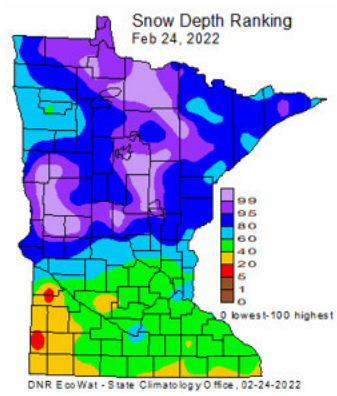
Snowpack Depth Ranking in Minnesota



2014

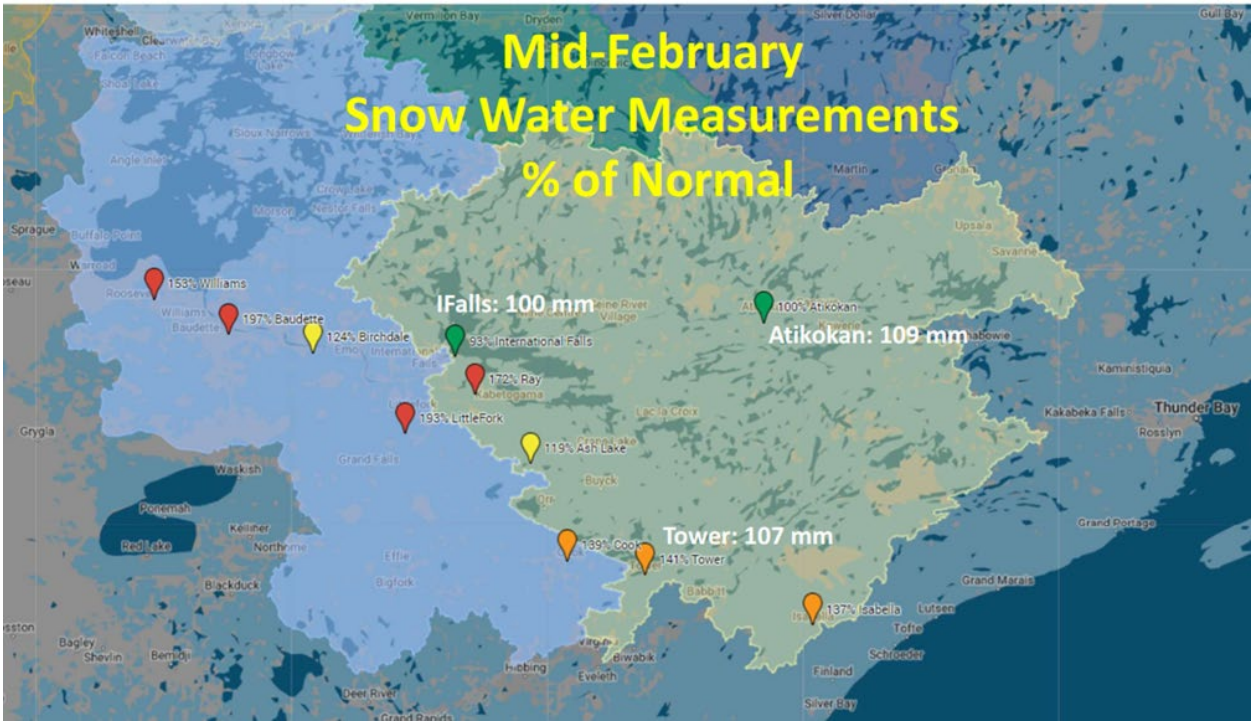


2019



2022

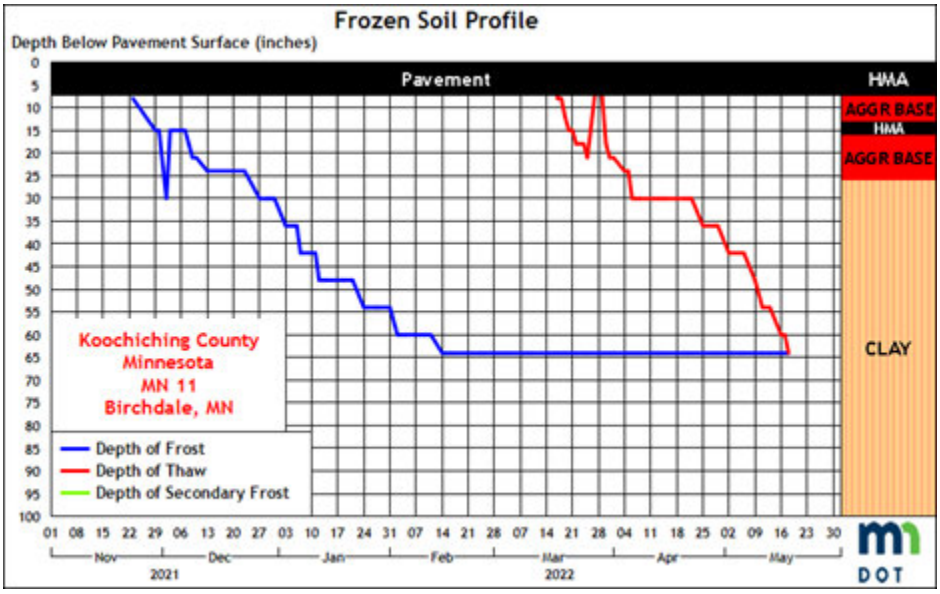
- *On-the-ground measurements of the snowpack water content were conducted at locations across the Rainy River watershed in late February by the US Army Corps. Of Engineers. Measurements indicated higher than normal snow water equivalent in general, with the highest amounts to the west of Rainy Lake in the local Rainy River watershed. The measurement at International Falls was slightly below the median while slightly above at Ash Lake. Compared to the measurements taken in 2014, values were generally less in 2022 (65% of the 2014 value at Tower, 78% at Cook, 72% at Ash Lake and 69% at Birchdale). The measurement at Ray, MN indicated higher snow water content in 2022 compared to 2014.*

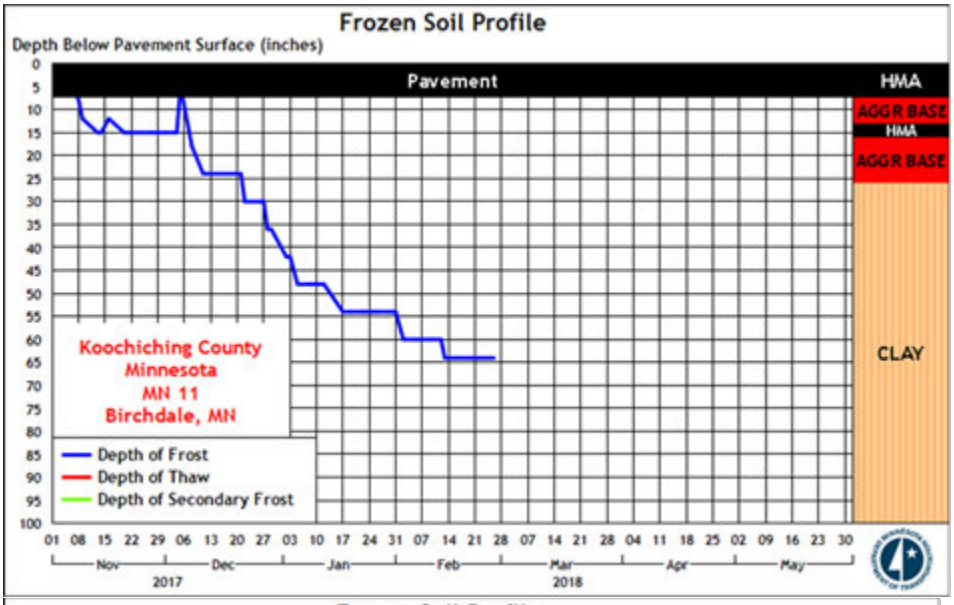


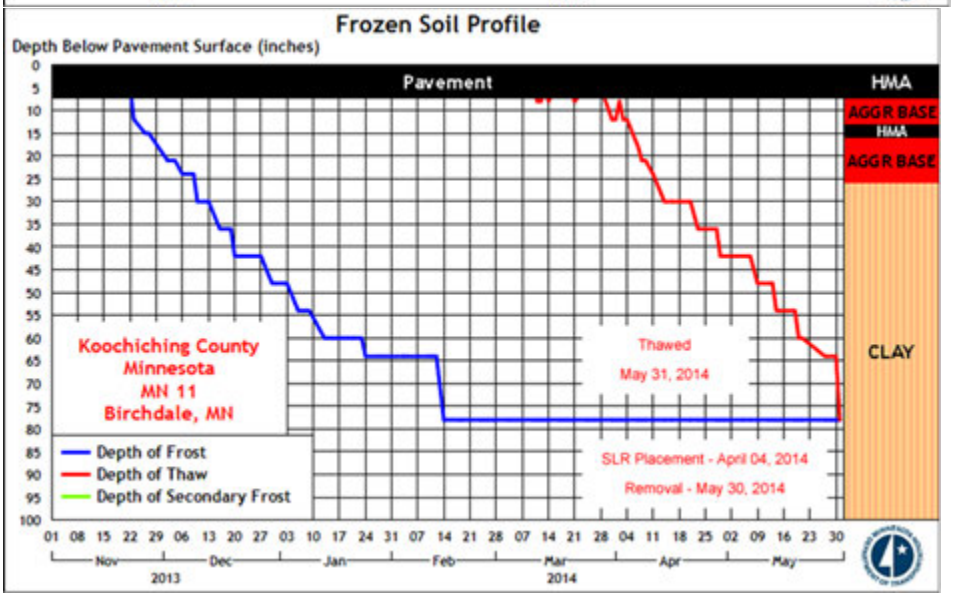
- *A SWE measurement by Ontario Power Generation at Atikokan on February 15 was 100% of normal, while on March 1 it was 146% of normal (falling to 131% by March 15).*

- According to the Accumulated Winter Severity Index provided by the Midwestern Regional Climate Center, the winter began as average then progressed to the severe range by the middle of February when measured by the accumulated snow and severity of cold weather. The severity of the winter was much less than in 2014, and was comparable to recent years that had no high water issues in spring.
- The degree of cold of the winter was evaluated by looking at the accumulated Heating Degree Days for International Falls. This measurement provides an all-season estimate of the temperature as an indicator of likely ground frost penetration. In general, the colder the winter, the greater the frost depth, although early snowpack accumulation can provide some insulating effect. The accumulated Heating Degree Days to the end of February indicated that this winter was colder than normal, but much warmer than in 2014.

Frost depth measured at Birchdale was 64 inches, the same as in 2018 and much less than the 78 inches in 2014.







Q: What forecast information was available at the time:

- A: There was a La Niña pattern in place in the fall and winter. Recent projections of the El Niño–Southern Oscillation (ENSO) in the Pacific Ocean by NOAA showed a 77% chance to continue as La Niña in the Northern Hemisphere this spring (March-May 2022) and then a 56% chance of a transition to ENSO-neutral by May-July 2022.
- Historic data since 1970 show that high water years occur most often when La Niña conditions are present and are less likely during neutral conditions.

- The NOAA long-term forecasts of temperature showed a 33-40% chance of above normal temperatures through March, April, and May.
- The NOAA long-term forecast of precipitation showed equal probabilities of low, normal, or above normal precipitation through March, April, and May.
- Temperatures were expected to fall well below freezing at night during the extended forecast.

Q: What was the feedback from basin interests:

A: Feedback from basin interests is consistent with the information provided by the Water Levels Committee at the pre-spring engagement.

- Ice thickness on the lakes this winter was in the normal range. Early snowpack insulated ice from the colder than normal temperature.
- The snowpack was greater than 2021, but significantly less than in 2014 (extreme event).
- Water level conditions have been low in recent years and refilling the lake (i.e. not holding the lake 20 cm lower) would be beneficial from a fisheries perspective.

Following the pre-spring engagement, the Rainy Lake Property Owners Association wrote to the WLC with the following points:

1. Temperatures are expected to remain well below freezing at night during the extended forecast. This may potentially push the ice-out date into mid-May creating the potential for freshet and spring rains to enter the basin at the same time.

2. It is reported the lakes have as much as 32 inches of ice at this time.

3. Area forestry experts have indicated that higher than normal precipitation rates follow a drought year.

4. Basin wide combination of rain and heavy wet snow (according to the national weather service 6 in of water) in early November has been held up in the bush and will enter the water shed this spring.

The WLC reviewed the feedback provided by RLPOA with the following assessments:

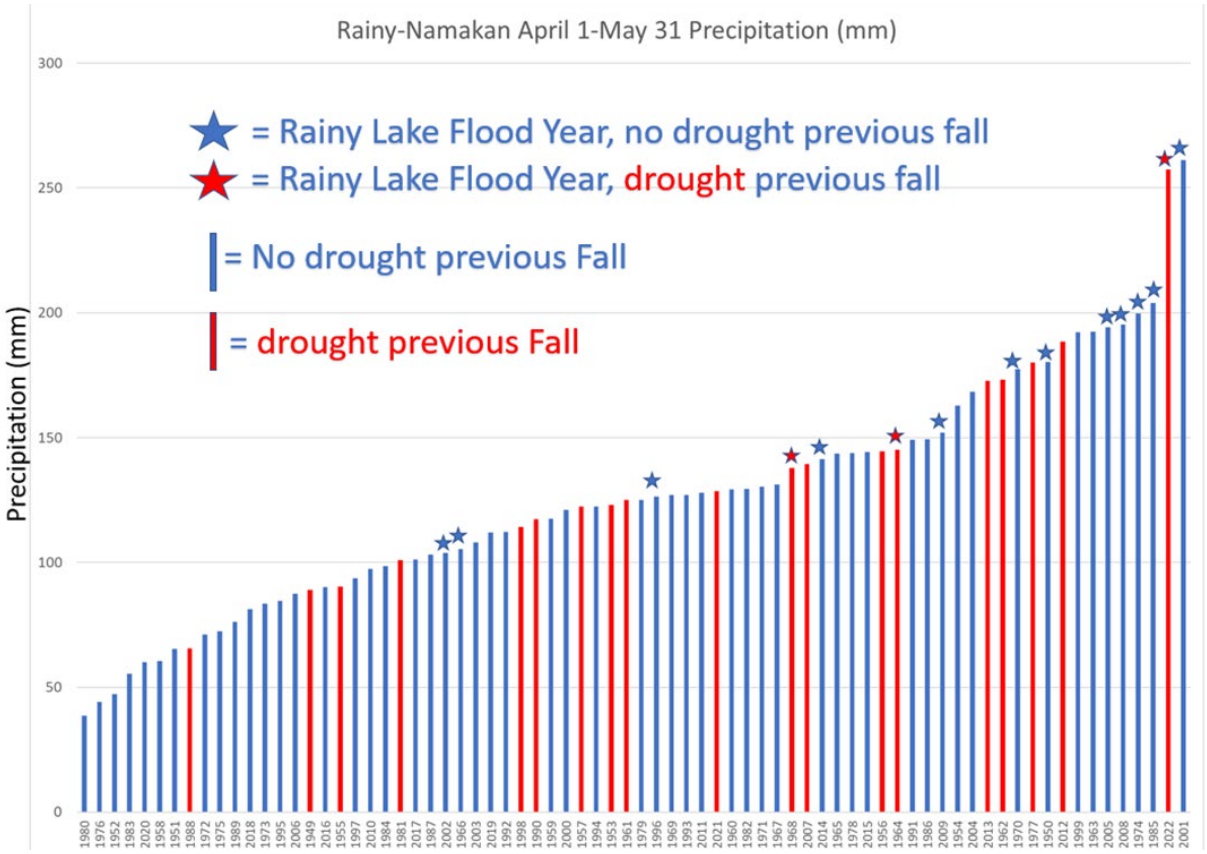
1. The ice out date is not hydrologically relevant to the freshet response. The ice and the snow on top of the lake are already indicated in the lake level measurements. The frost depth, however, is relevant in the event of a rain

on snow condition and late ice-out is an indirect indicator of basin temperature and ground conditions. The long-term forecast from NOAA indicated a slightly higher chance of warmer spring temperatures. While not known at the time of the decision on the High Flood Risk Rule Curve, the average March temperature for the Rainy Lake area in 2022 was 21.1 F, slightly warmer than the median of 20.8 F for 128 years of record, and much warmer than the 13.5 F recorded in 2014. April, however, was much colder than normal, the 13th coldest on record for the area, with an average temperature of 33 F. Data source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/

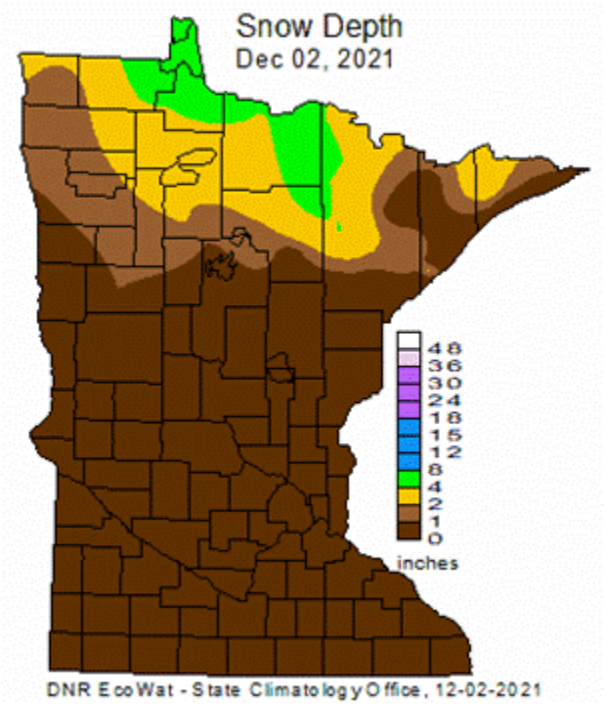
2. Ice thickness is also not hydrologically relevant to freshet response other than as an indirect indicator of basin temperature and frost depth. Accumulated temperature data are more useful for this purpose. The WLC understood that the winter was colder than normal, but not nearly as severe as 2014.

3. The WLC reviewed historical precipitation data following drought years to evaluate whether a trend exists. It confirmed there is a slight skew towards wetter springs following a drought the previous fall (see graph below). However, of the fourteen flood years for Rainy Lake since regulation began in 1949, only two followed droughts the previous fall, whereas seven followed wet conditions the previous fall. This makes sense hydrologically as there is more room in the watershed to absorb runoff after the ground thaws if the underlying watershed is dry, and less if wet.

4. Area-weighted average precipitation across the Rainy-Namakan local watershed in November 2021 was 47 mm (1.9 in) based on the Canadian Precipitation Analysis (CaPA) data. The total for the US-portion of the Rainy Lake watershed was 52.8 mm (2.08 in) according to the National Weather Service (link: https://arcgis.dnr.state.mn.us/ewr/climatetrends/). Total precipitation measured at International Falls airport in November was 45.7 mm (1.8 in).



There was approximately 6 inches of snowpack accumulation by the end of November in the area around Rainy Lake, which is not equivalent to 6 inches of water.



Hydrologically, water is always moving through the system and does not get "held up" in the bush to be released later unless it is accumulated as snowpack. Most of the month's precipitation occurred on November 11 and 12 when temperatures were near the freezing mark. According to the National Weather Service data, between a trace and an inch of accumulated snow water equivalent followed this precipitation, much of it entered the system as runoff. The response to this can be seen in the hydrographs of the area tributaries. This precipitation did not significantly alter the flows in the basin, but it did result in some drought category improvement.

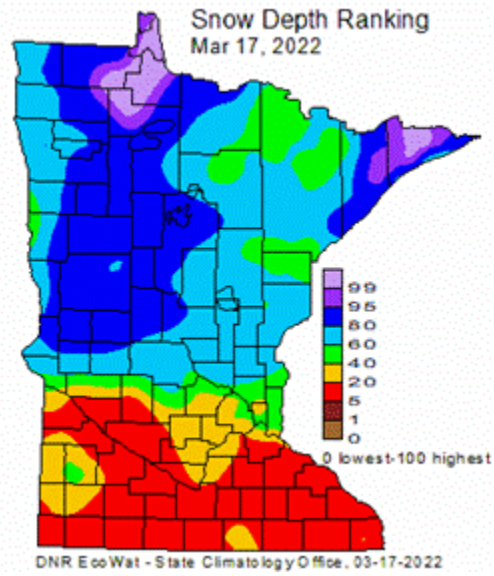
In summary, at the Pre-Spring Engagement web meeting, the Water Levels Committee summarized the factors that contribute to spring flood risk and the situation in 2022 compared to 2014.

1. High base flows across the watershed – the flows across the watershed were on the low end of the normal range following the extended drought period. Base flows did not point to a higher flood risk in 2022.
2. High water content in the snowpack – the snow water content based on National Weather Service modeled data and on-the-ground measurements was above normal but moderate, less than other recent years that did not have flooding, and much less in most locations than in 2014.

3. Frozen Ground – Accumulated temperature by the end of February was colder than normal, but not close to the cold of 2014 and indicated some increased risk of delayed ground thaw.

Taken together, the Water Levels Committee evaluated that the balance of these risk factors indicated some risk of above normal spring flow conditions, but not a *high risk* of flooding or of exceptionally high or record inflows in the spring. The Water Levels Committee emphasized that the last of the risk factors for spring flooding on Rainy Lake is the *timing and amount of spring rainfall*. This cannot be estimated in advance and would prove to be the critical ingredient in the record inflows of the spring.

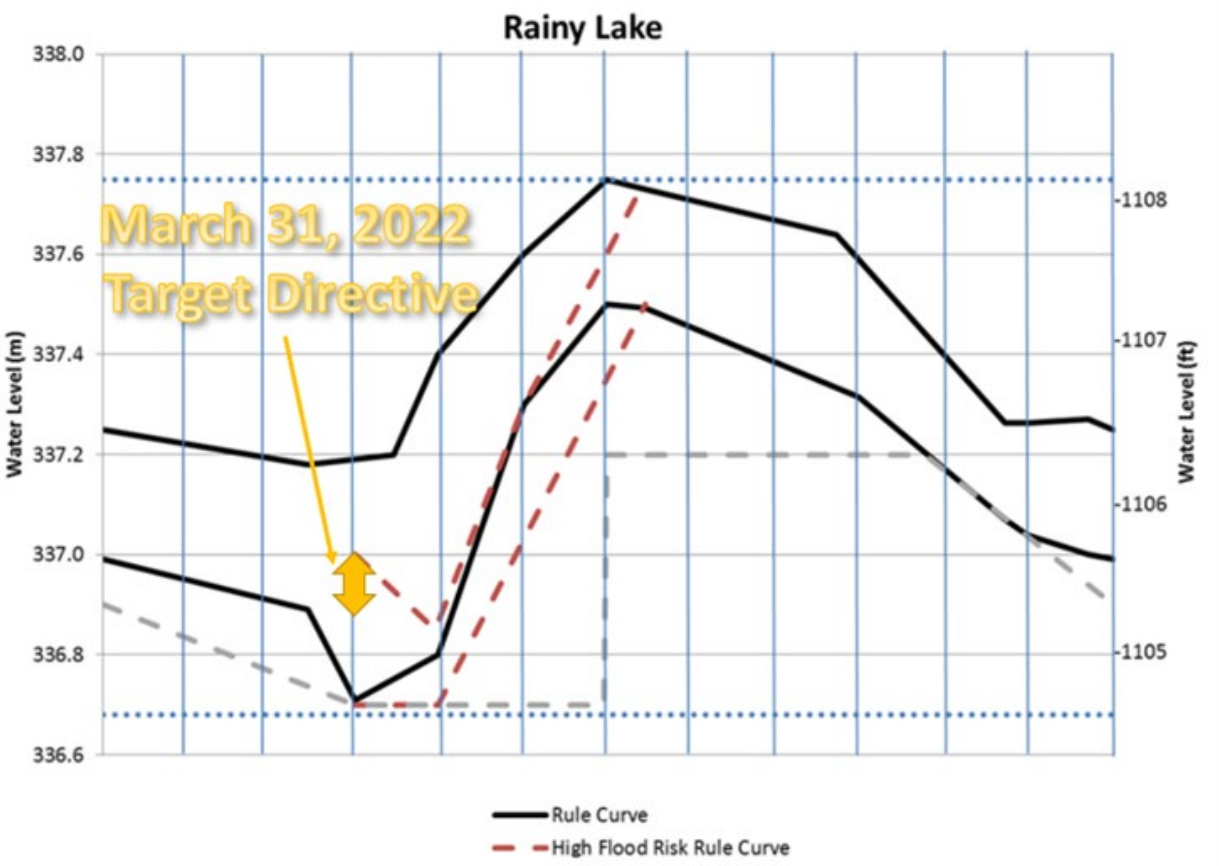
Q: Why didn't the Water Levels Committee lower the lake later in March with the extra snow accumulating?



A: The first two weeks of March saw very little precipitation across the watershed. Statistically, the snowpack depth by mid-March had returned to the normal range for much of the American side of the watershed.

There was little change in the Snow Water Equivalent estimates over this period. On-the-ground Snow Water Equivalent measurements by Ontario Power Generation at Atikokan were in line with the National Weather Service model, indicating some loss of water from March 1 to March 15, followed by some accumulation over the remainder of the month. The April 1 reading at Atikokan was 5 mm (0.2 in) higher than on March 1.

The Water Levels Committee announced on March 10 that it had directed the dam operators to target a Rainy Lake level between 336.90 and 337.0 m on March 31. The lake was lowered 10 cm (4 inches) in March as a result.



While not targeting the High Flood Risk Curve specifically, this level target range was within High Flood Risk Curve range and in the bottom half of the normal Rule Curve band for March 31. In short, the Water Levels Committee hedged against above normal spring flows in line with the basin conditions but did not identify a *high risk* of flooding as March progressed.

Q: How much lower would the level of Rainy Lake be if the Water Levels Committee had followed the High Flood Risk Rule Curve?

A: This has not yet been modeled, as the event is still happening. The Water Levels Committee will conduct a post-event analysis to answer this question. The middle of the High Flood Risk Rule Curve on April 15 was approximately 20 cm below the actual level on April 15, 2022, and 30 cm (12 in) above the very bottom of the High Risk Curve range.

During the review of the Rule Curves from 2015-2017, extensive work was done to analyze and assess the effect of lower spring targets on peak water levels during high inflow springs. This work was reviewed on many occasions with the Citizens Advisory Group. This work included simulations of historical high flow

springs since 1950 using the new 2018 Rule Curve and the High Flood Risk Rule Curve and comparing the peaks to the existing 2000 Rule Curves.

For the 1950 event, the regular 2018 Rule Curves were found to reduce the peak level by 2 cm (1 inch) compared to the 2000 Rule Curves. The High Flood Risk Rule Curve was found to reduce the peak level by an additional 2 cm (1 in) over the regular 2018 Rule Curves. With the level in 2022 exceeding the 1950 peak on Rainy Lake, the difference between the normal 2018 Rule Curve target and the use of the High Flood Risk curve is likely less than 2-4 cm (1-2 in), but further analysis will be needed to verify this. However, it is certain that the High Flood Risk Rule Curve would not have prevented or significantly reduced the 2022 flooding of Rainy Lake.

It may be difficult to understand how having the level up to 30 cm (12 inches) lower on a lake as large as Rainy Lake could not substantially reduce the peak. There are two key points to consider. The first is the extreme inflows to the lake over the April-May period, a new record and nearly four times the flow normally seen in this period. Between April 15 and Jun 13, enough water flowed into Rainy Lake to fill the equivalent of the storage at the very bottom of the High Risk Flood Curve (30 cm or 12 in) on average *every two days*, or 30 times over these 60 days. This is simply an enormous volume of water, unprecedented since records began.

The second, and more important, factor is the constrained outflow from Rainy Lake. When the Rainy Lake dam is not backing up water to the lake, the outlet near Rainier / The Point limits the rate of flow out of the lake into the upper river (see fact sheets and videos for more details). On April 15, the maximum outflow from the middle of the High Risk Rule Curve band is 25% less than if the lake is in the middle of the regular Rule Curve. The higher lake level drives higher outflow. If following the lower target, each day the level rises a little faster than if following the higher target, and this happens day after day until the two are very close together. This is generally true of outlet-limited lakes, including Lac La Croix, Namakan Lake and Lake of the Woods, and is why in the 1950 flood simulations, the High Flood Risk Rule Curve only reduced the peak 2 cm (1in) compared to the normal 2018 Rule Curve.

Q: What actions did the Water Levels Committee or the IJC take to address the high water?

A: Given the extreme, record inflow, no action at the dams could be taken to prevent the flooding on the Namakan Chain of Lakes or Rainy Lake. As inflows quickly picked up in mid-April and the likelihood of flooding increased quickly, the focus of the Water Levels Committee was on ensuring that the dam operators

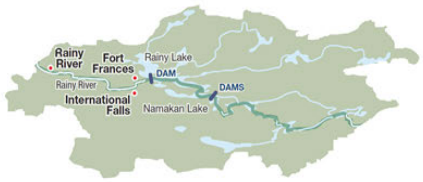
increased flow according to the IJC Order, and in sharing key hydrologic and forecast information with the agencies responsible for flood forecasting in Ontario and Minnesota.

At Namakan Lake, all logs were pulled from the two dams by April 26, when the level was well below the All Gates Open level for that lake. At Rainy Lake, gates were opened as the lake level rose, adding flow to match the natural outflow capacity of the outlet of the lake (for more information on the limitations of outflow from Rainy Lake see this factsheet and a series of three educational videos). All gates at Rainy Lake dam were opened by May 5, again, well before reaching the All Gates Open level. With all gates and sluices fully opened at the three dams, there were no additional actions that the dam operators or the Water Levels Committee could take to pass additional water. The rate of water released from both lakes steadily rose as the water levels of the lakes increased but remained well below the inflow rates as week after week of above-average precipitation continued to fall. The average inflow rate to both lakes for the April 1-May 31 period was the highest on record.

The Water Levels Committee Engineering Advisors worked closely with Ontario and the US National Weather Service to provide advice on forecasts for the levels of both lakes three days a week. At the end of May, the U.S. Co-Chair of the WLC and local US member visited with officials and community members around International Falls. The WLC and IJC representatives, including a U.S. Commissioner, also traveled through the larger basin to meet with affected residents and community officials during the week of June 6, 2022. Local WLC members have been in regular contact with affected residents, providing information and answering questions.

Q: Where can I find the latest news on weather forecasts and flood information?

A: The US National Weather Service and the Province of Ontario are maintaining information through their websites. The Canadian Lake of the Woods Control Board also has been posting updates on its website Notice Board, and provides updates to recent outflows and water levels throughout the basin on their water flow data page.



Factsheet #3

Title: Control of Outflow from Rainy Lake

Background

The water level of Rainy Lake rises or falls according to the balance of flow into the lake (inflow) and out of the lake (outflow). As with any container of water, like a bathtub, if water enters faster than it exits, then the water level rises. If water exits faster than it enters, the water level drops.

When inflow is much greater than outflow, the lake level rises swiftly and there is a risk of reaching high water levels. This risk exists because there are natural and artificial features below the outlet of Rainy Lake that limit how fast water can flow. This factsheet explains what these limitations are and describes how the International Dam downstream of the outlet of the lake can and cannot be used to adjust the water level of Rainy Lake.

Location and Description of Key Features

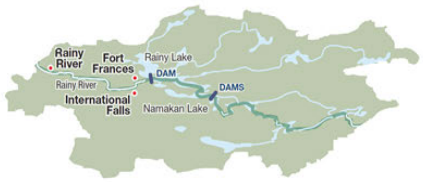
Rainy Lake is a boundary water between Canada and the United States. Approximate ¾ of the lake is in Ontario, and ¼ in Minnesota. The sole outlet for water flowing out of the lake is at the southwest corner of the lake, below the Ranier railway bridge. Water can also exit the lake through evaporation.

At the Ranier railway bridge, the outlet of the lake is relatively narrow and the channel is deep. Supporting the bridge is a series of piers which are fixed in the river bed. A short distance downstream of the bridge is the Ranier Rapids, where the river bed rises steeply. These features - the piers, the narrow channel, and the changing bed depth - all restrict the flow of water out of the lake.

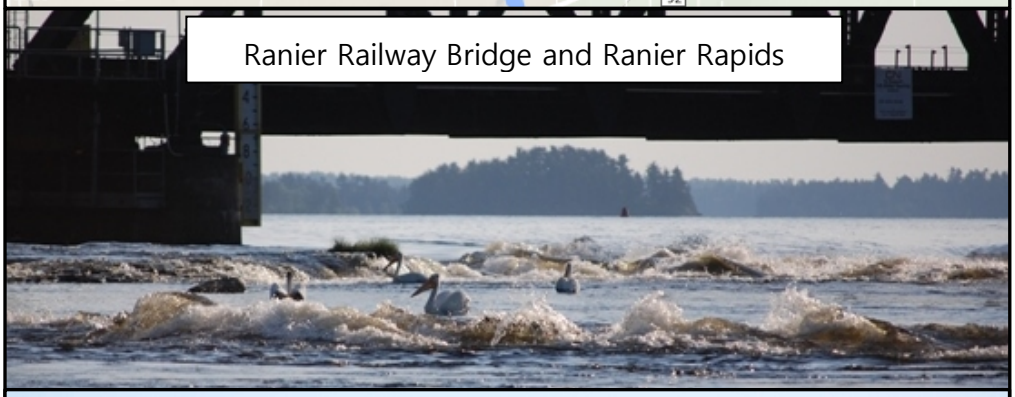
About 400 yards downstream of the railway bridge, near Seven Oaks and the Point, Ontario, is another area where the uneven river bed and narrow width restrict the flow of water. Downstream of this area the river channel is relatively wide and the bed slope changes gradually until reaching the international bridge between Fort Frances and International Falls. This is the site of the former Koochiching Falls, which was submerged by the building of the dam. Here again, the narrowing channel and the river bed features of the former falls restrict the rate of flow through this area.

The International Dam

The International Dam, completed in 1910, spans the Rainy River between Fort Frances and International Falls, just below the former Koochiching Falls. Water can pass through the dam in several ways. First, both the American and Canadian sides have powerhouses, where falling water powers turbines to generate electrical power. The maximum amounts of flow and power that can be generated are both dependent on how far the water drops from above the dam into the river below. The greater this height, the more flow that can be pushed through the turbines.

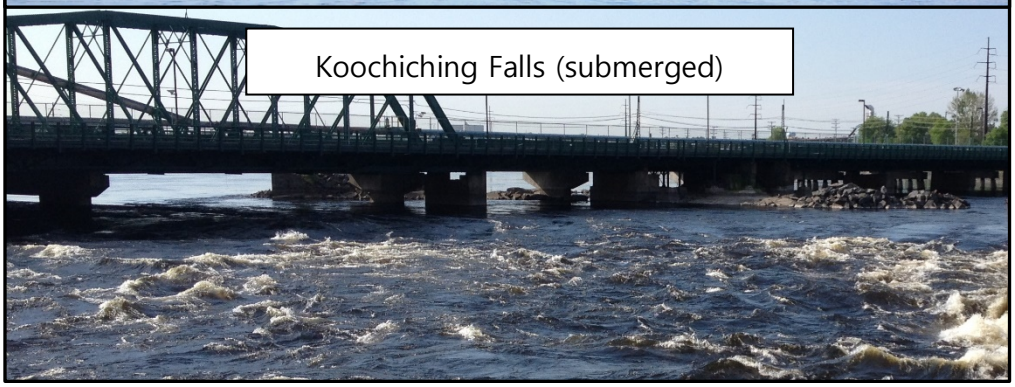


Upper Rainy River Channel

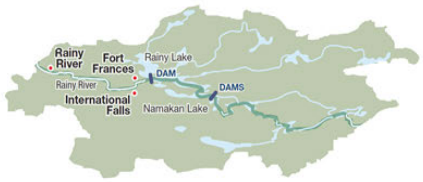


Ranier Railway Bridge and Ranier Rapids

The Point (Seven Oaks) Restriction



Koochiching Falls (submerged)



When the turbines are running at maximum flow, outflow can be increased by passing water through spill sluices. There are ten sluices along the center of the dam on the Canadian side, and five additional sluices at the head of a canal that separates the Canadian powerhouse from the shore. Flow through all of the fifteen sluices is controlled by manually operated gates that can be set either to be fully opened or fully closed.

When the water level in the upper river gets extremely high, the dam is designed to allow for water to flow over a spillway built into the center of the U-shaped dam. This has happened in only two years over the past century, 1950 and 2014.

Flow Control

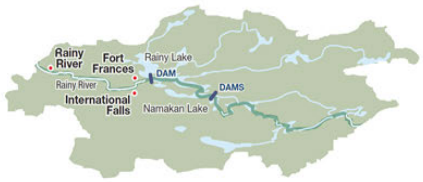
Under normal flow conditions, the operators of the International Dam can raise or lower the level of the Rainy Lake. This is done by adjusting the flow so that water is leaving the lake faster than it enters (to lower the level), or so that water is leaving the lake more slowly than it enters (to raise the level). There are limits on how fast the lake can be raised or lowered however, and these limits are related to how fast water is entering Rainy Lake.

When raising the lake level, the flow past the dam could, in theory, be reduced to zero (in practice, the International Joint Commission requires minimum flows for the river downstream). With zero outflow, the lake will rise only as fast as water is supplied from tributaries into Rainy Lake or direct rainfall on the lake. When raising the lake level, the control on the outflow from the lake is at the dam. As the water backs up from the dam along the upper Rainy River, the restrictions at Koochiching Falls, the Point, and Ranier Rapids are submerged.

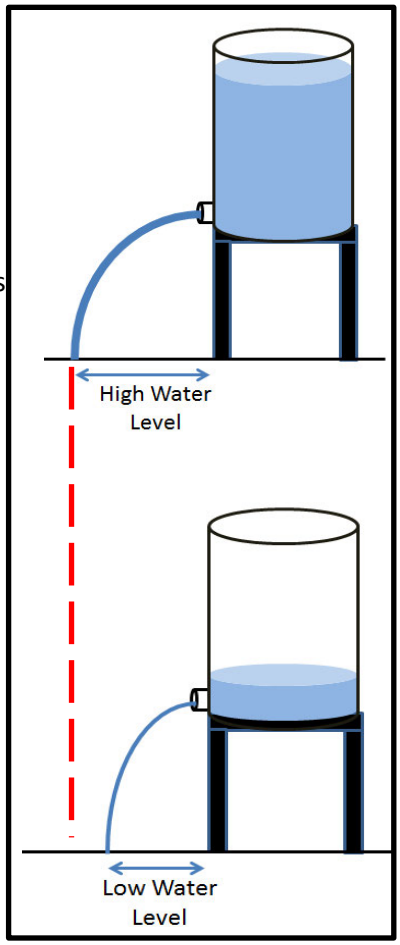
Under normal conditions, lowering the lake level is simply the reverse of raising it: flows are increased out of the dam (through turbines or gates) and the water level in the river between the dam and the lake drops. As long as water is leaving the lake faster than it is flowing in, the lake drains and the water level falls.

There is a limit, however, to the maximum rate of flow out of the lake, and this limit changes with the lake level. The higher the lake level, the greater the maximum flow rate out of the lake. This is because passing flow out of the lake, under the railway bridge, through the constrictions at Ranier Rapids and the Point requires energy. This energy comes from the height of the water in Rainy Lake. To understand why, consider the example of a large container of water with a spigot at the bottom, for instance a barrel or a water cooler. If the container is full, opening the spigot will release a strong stream of flow. However, as the water level above the spigot falls, this stream gets weaker and weaker. When the water level is nearing the bottom of the barrel, the stream is just a dribble – the low water level does not provide the energy to push flow out as quickly as it did when full.

Outflow from Rainy Lake is like that from the barrel, with the outlet under the railway bridge and through the restrictions at Ranier Rapids and the Point being the spigot. For a given lake level, there is a maximum flow rate that can be pushed through this area. Downstream at the dam, flows can be



increased through the turbines or by opening gates to match this maximum flow out of the lake. What happens if the maximum flow out of the lake is already being matched at the dam and more gates are opened? This would increase the flow out of the river above the dam for a short while, but since water is passing through the dam faster than it is arriving from the lake, the river is starved of water and the water level near the dam drops. This has no effect on the rate of flow out of the lake – the lower river level at the dam does not draw water out of the lake at Ranier any faster. The lower river level does, however, hamper the flow through the powerhouses and reducing it too much can risk damage to the turbines.



When wet conditions develop in the spring it is not uncommon for the maximum outflow rate from the lake to be less than the rate of water flowing into the lake from all the tributaries. In such situations, the lake level always rises. The best that the dam operators can do in such situations is to keep opening gates as the lake level rises to match the maximum outflow. Only once the level of Rainy Lake has risen to the All Gates Open level (337.90 m or 1108.6 ft) is having all gates open necessary to efficiently pass the maximum flow out of Rainy Lake. Even with all gates open, the lake level will continue to rise until the outflow from the lake matches the inflow to the lake, at which point the lake level will be stable. The lake will only start declining once the inflows drop to be less than the maximum outflow.

Visualizing Outflow Controls

Since 2010, the IJC has funded a series of detailed hydraulic investigations of the outlet of Rainy Lake and the upper Rainy River from Ranier to the dam. This included the development of a complex hydraulic model of the river. Based on this work, an interactive animation has been developed as part of this work which allows the user to adjust the number of open gates at the dam and to see the effect this has on the flow out of the lake and out of the river. The Rule Curves Study Board invites you to use this tool to explore the relationships between lake levels, river levels, dam gates and flows along the upper Rainy River. It is available on the IJC website.

Conclusions

The control of flow out of Rainy Lake is a complex problem. Despite this, under normal conditions, the International Dam can be effectively used to lower or raise the level of the lake. The maximum flow out of the lake is, however, limited by natural channel features in the upper river and is directly related to the level of the lake. Under extremely wet conditions, particularly in the spring when the level or Rainy Lake is relatively low, lake levels rise uncontrollably. Only with declining inflow will the lake level eventually stabilized and then fall.

September 19, 2022,

IRLWWB Co-Chairs Michael Goffin and Col Karl Jansen

Re: Community Advisory Group Recommendations following the 2022 basin Flood Event

Dear Mike and Karl,

On behalf of the CAG we thank the Water Levels committee of IRLWWB for their efforts related to this past summers flood event, and for the opportunity to provide comments for consideration in its post flood report.

Our group met on August 14th to review our observations on the event and discuss recommendations/advice we might have for the board in this regard.

The CAG observed that generally there seemed to be a greater understanding among basin residents of the extraordinary events that lead to this flood. (Especially compared to the 2014 flood). The unprecedented/widespread damage as well as the associated cumulative stress on residents was noted, as was the fact that, even as we write, efforts to recover from the impacts are still underway for many. The limited scope of Government flood aid programs has led to additional frustration as we move deeper into the recovery stage.

The tireless work of volunteers, including unincorporated fire departments, as well as the assistance of local businesses, the National Guard on the US side, and the Ontario Fire Rangers in Canada were thankfully recognized by residents. It was also noted that, unlike the 2014 flood, sandbags were much more readily available to residents who needed them. Perhaps with recognition of the potential of increased flood frequency due to climate change, the CAG was gratified to hear about residents and businesses discussing plans to adapt and make changes to ensure future asset resilience.

Despite some of these positive observations the CAG notes that challenges, especially in the area of public information/communications were once again evident during this emergency event. Use of the National Weather Service for flood forecasting was seen as a positive for example, but it was not widely publicized to residents, especially on the Canadian side of the border. All too often during the event, our members heard questions from the public regarding areas like dam management, flood forecasting, and roles and responsibilities that the CAG feels could, and should have been proactively communicated through a recognized source. The lack of proactive public communications lead in some cases to misinformation, and left many feeling “on their own” through the event.

Consistent with our role to provide advice to IRLWWB and in response to what we heard during and after the flood event, the CAG respectfully submits the following recommendations for Board consideration:

Recommendation 1: The IRLWWB ask the IJC to urge governments to establish a shared, multi-agency information officer role(s) for future basin flood events such that all agencies with responsibilities, including the IJC may communicate information proactively to the public by means of radio/print and appropriate social media through a recognized single source.

1) a: The board investigate the development of a “watershed app” that provides one click access to watershed related information, including agency contact information by geographic responsibility within the basin

Recommendation 2: The IRLWWB Water Levels Committee investigate establishing an “emergency rule curve” that would result in Rainy and Namakan lakes controlled to a more balanced flood level (perhaps controlling to the same delta level compared to the 2014 peaks) during future flood events. It is widely believed that outflows from Namakan to Rainy Lake continued at maximum despite Namakan falling below flood levels and Rainy Lake continuing to rise.

Recommendation 3: The IRLWWB urge the IJC to conduct a preliminary feasibility study to estimate the cost and environmental impacts of an emergency floodway constructed on the Canadian (Frog Creek) or American side of the watershed.

Recommendation 4: The IRLWWB work with the Duluth National Weather Service to investigate ways in which the service can add value to its existing forecasting for future flood events (additional information, longer range forecasting etc.)

Recommendation 5: The IRLWWB ask the IJC to urge governments to ensure that any future plans to replace the Ranier rail bridge are designed to minimize impacts on flows

Recommendation 6: The Water Levels committee of the IRLWWB consider reviewing its flood curve decision process to allow for a decision to approve the flood rule curve later in the spring period or to provide additional updates to the public as the freshet nears. At a minimum, additional updates would demonstrate that the Water Levels Committee remains engaged throughout the spring and belie the notion that the committee was making a decision in mid-March and making no effort to adjust to changing conditions.

Once again, thanks to the Water levels committee for their efforts during this difficult time.

Please do not hesitate to contact either of us to discuss the matter further,

Sincerely,

Doug Franchot and Matt Myers,

Co-Chairs IRLWWB CAG

Appendix I- Public Comment Summary

A draft of the 2022 Post Flood Report was released for a 25-day public comment period to solicit public feedback and document interests and concerns in the basin. There were 5 total submissions during the public comment period. Comments came in the form of official letters from the International Rainy-Lake of the Woods Watershed Board's Community Advisory Group and Rainy Lake Property Owners Association, emails to the Water Levels Committee Engineering Advisors and co-Chairs, and a handwritten submission to the Water Levels Committee members in the basin. This appendix serves to document, summarize, and provide a response to some of these public comments.

The common themes in public feedback were a desire for a plain language summary of content, expansion on resiliency solutions in the basin, concerns over the proposed CN Rail bridge modification project, need for lessons learned and recommendations in the report, and expansion of report to include Lake of the Woods, ecological impacts, and local government response during the flood. The desire for a plain language summary or better explanation of graphs and technical terms is merited. The Post Flood Report serves as a reference document to understand the conditions that lead to the 2022 flood and regulation actions taken before and during the event. The intended audience of the 2022 Post Flood Report has a wide range of technical background and a plain language, high level summary of the report has been developed as a companion document to the finalized report.

Following the recommendation of the Rainy Lake Property Owners Association, links to authoritative information on recurrence intervals on Rainy Lake have been included in Section 8 of the Post Flood Report. There is an opportunity to explore what flood and drought resiliency looks like in the basin through community workshops that could fall under an International Watershed Initiative project or local programs in the basin. Regarding adaptive management and climate change in the basin, there is ongoing work in adaptive management under the Adaptive Management Committee (AMC) of the International Rainy-Lake of the Woods Watershed Board (IRLWWB) to review and ensure that the 2018 rule curves perform as expected. The AMC is also responsible for overseeing the IRLWWB's implementation of the International Joint Commission (IJC)'s climate change adaptation guidance framework. *An Update Report on Climate Change Assessment Activities for the International Rainy-Lake of the Woods Watershed Board* (Newton, 2021) was prepared in January 2021 that provides background on the IJC Climate Adaptation Guidance Framework and an update on implementation by the IRLWWB and AMC.

Concerns over the proposed CN Rail bridge modification project at the crossing of Fort Frances, ON and Ranier, MN continued to be raised during the public comment period of the 2022 Post Flood Report. As stated in the report, the WLC brought the proposed project and public concerns to the IRLWWB and International Joint Commission. Individual governments (U.S. and Canada) are responsible for their own assessments of the project's potential hydraulic impacts and how those impacts could trigger the Boundary Waters Treaty. Public concerns of the proposed project continue to be passed on to governments.

As stated earlier, the 2022 Post Flood Report intended to describe the hydrologic conditions that lead to the 2022 flood and the actions taken by the Water Levels Committee. Inclusion of Lake of the Woods, and other basin impacted by the flood, in the 2022 Post Flood Report is outside the mandate of the Water Levels Committee, as the International Joint Commission Order only authorizes the Water Levels Committee to oversee operations of water levels for Rainy and Namakan Lakes. To better clarify the authorities of the Water Levels Committee and scope of the 2022 Post flood report, the objectives of the report and the mandate of the Water Levels Committee are clearly stated in the final version of the report.

Although the 2022 Post Flood Report mentions ecological impacts and local government/community responses during the flood, these topics are outside the representation and expertise of the Water Levels Committee. Supplemental reports on the ecological impacts from the 2022 flood, including aquatic vegetation, wildlife, and water quality would be beneficial for the basin. Such a report could be completed by natural resource agencies at the local, state, provincial, and/or federal level.

There are still questions on the capabilities of conveying water through the basin during floods, particularly through Rainy Lake. It is understood that there is a natural flow constriction at the outlet of Rainy Lake flowing into the upper Rainy River at the CN Rail bridge crossing between Fort Frances and Ranier, but there is still some misunderstanding how that constriction controls and impacts outflow at different water levels. During the 2017 Rule Curve Review, the International Rainy and Namakan Lakes Rule Curves Study Board developed a series of fact sheets. The third fact sheet "Control of Outflow from Rainy Lake" explains the limitations of flow below the outlet of Rainy Lake and describes how the International Dam downstream of the outlet of the lake can and cannot be used to adjust the water level of Rainy Lake. This fact sheet is included in the Post Flood Report under Appendix G.

References

Newton, Teika. January 2021. *An Update Report on Climate Change Assessment Activities for the International Rainy-Lake of the Woods Watershed Board*. International Rainy-Lake of the Woods Watershed Board. https://www.ijc.org/en/rlwwb/update-report-climate-change-assessment-activities-international-rainy-lake-woods-watershed

March 31st, 2023

TO: Water Levels Committee Co-Chairs Megan Garner and Col Eric Swenson

Re: Community Advisory Groups input to Draft Post Flood Report

Dear Megan and Eric,

This letter and attachment convey the comments of the CAG on the WLC draft Flood Report. The 2022 flood, record setting on Rainy Lake and near record setting on Namakan, had a major impact throughout the watershed and our communities have expressed great interest in the follow up of the WLC and the board. This Flood Report is a key part of that expected follow up, and we are delighted to see such an impressive document, and to have this opportunity to comment on the draft.

The CAG wants to recognize the outstanding work of the WLC both before and during the flood, even if that effort may not have been fully appreciated by all in the watershed. Indeed, some of our comments are submitted in hopes of raising the level of awareness on the part of the public; awareness which we believe will result in a greater understanding of and appreciation for both the process and the efforts of the WLC and, by extension, the full board.

These comments represent input from the full CAG. The CAG co-chairs encouraged CAG members to submit comments individually if they desired, but at the same time felt a single compilation was called for, given some larger, common topics that our review and discussions have identified.

During our review it became apparent that this is really a two-part discussion. The first part is memorializing the flood event and the WLC's process and efforts, the what and why, if you will. The second part concerns lessons learned and recommendations going forward. The first part is very clearly within the charter of the WLC. Some of the lessons learned and recommendations also apply directly to the WLC, and in fact some have already been implemented for the 2023 freshet. Others, however, seem to be beyond the purview of the WLC and worthy of attention by the full IRLWWB and, possibly, other agencies in the watershed. Given the historic nature of this flood and the opportunity that now exists, we strongly recommend an after-action review process be conducted. One that would look at lessons learned from a holistic perspective, develop recommended actions, and identify which agencies are best positioned to implement them.

Finally, the draft report and our CAG comments both recognize resiliency as a critical strategy going forward. In our minds, this raises the question of the role the IRLWWB can or should play in helping build community resiliency. While we understand this may be seen as outside the Board's mandate, we also see an expectation in our communities that the IRLWWB and the IJC will play an important role in reducing the impact of future flooding events, including efforts to build resiliency. We think it important that the board get ahead of this issue, proactively decide on a role, and communicate that position clearly to the public, (even if the position is that we have no role).

We trust you will find these comments constructive and hope they represent the start of further discussions in this regard.

Respectfully,

Matt Myers and Doug Franchot

Co-chairs, IRLWWB-CAG

CAG Input to 2022 Draft Post Flood Report

The CAG appreciates the opportunity to provide input to this draft report, and the work done to develop it to date. It's an excellent resource of technical data, and represents a comprehensive summary of what actually occurred to cause the flooding in the Namakan/Rainy Lakes portion of the watershed.

Having said that, our group has made the following common, general observations about the draft document:

- The fact it deals with just the Rainy lake/Namakan portion of the basin flooding is problematic, and will likely be confusing to many.
- The draft does not address lessons learned and what actions are being taken now and what future actions are being contemplated to improve the basins' ability to deal with future flooding.
- It comes across as somewhat "defensive", and in our view, "over focuses" on the WLC Spring 2022 target selection.
- It's quite dense and thus, is more characteristic of a document written for internal, versus public consumption.
- The report is light on the extent, duration and nature of flood damage that occurred throughout the entire basin.
- Flood resiliency and adaptive management are introduced as topics, but the report spends very little space on either of these very important areas - especially in the context of our changing climate.

As a result of polling CAG members and discussing common observations, the CAG submits the following suggestions for consideration/incorporation into the final report:

Report Focus

The final report would benefit from clearly stating its objective(s) and scope. The mandate of the IRLWWB Water Levels Committee should also be stated up front (eg. primary focus on those portions of the Rainy/Lake of the Woods watershed upstream of the Fort Frances-International Falls Dam). It is unclear whether the report is intended as a post flood report for the entire watershed (as the CAG suggests it should be) or whether it is strictly confined to Namakan and Rainy Lakes. If it is not intended to cover the entire watershed, then this should be explained, as it will receive wide readership throughout the Region. Regardless of the area the report intends to cover, the CAG believes it important to include a discussion with respect to how the entire basin is managed in a flood event, the coordination with other operators and boards, and how this might be improved in the future.

The draft report does a good job in showing how the flood event of 2022 was caused by meteorological events beyond our control and how resulting water levels dwarfed our abilities to deal with them. But the report is lacking in recommendations or lessons learned from this experience that could better enable us to prepare for future flooding events. The CAG believes that the final report should also aim to address the topic of lessons learned; dedicating a section to what changes are being made, and what actions are being implemented (or are being considered), to improve in the future. *Providing a summary of public engagement and what was heard, is of little value if it's not immediately followed up with what will, and will not be done, as a result.* If it is determined that lessons learned are outside the scope of this

report, the CAG strongly recommends that an after-action review be conducted and a separate lessons learned document prepared and shared, as soon as possible.

The current draft reads as if the main focus is to prove that the spring decision would have had an insignificant effect on flood severity and duration. Although true, the CAG does not believe this topic should be a main thrust of the report and recommends the final report strike a better balance between defending (or just reporting on) the spring decision and how decision making may be improved in the future.

Readability

The CAG finds the current draft dense and more characteristic of a technical internal document, rather than one designed for public consumption. A better explanation of graphs and figures, a reduction in the use of acronyms and an increase in laymen's language would improve the readability of the report immensely. In addition, much of the weather, climate and hydrologic data could be moved to an appendix. In the alternative, we suggest that a companion summary document written in laymen's terms accompany the final report.

Extent, Duration and Nature of Flooding

The CAG believes the current draft inadequately describes the scale of the event, and thus has the potential to irritate many readers whose summer was lost due to the "great flood of 2022". Readers across the watershed will want to see their experiences reflected in the report and more space needs to be dedicated to a full description of the emergency, its historic nature, and its impacts, closer to the front of the document. The flood was a major event for most communities and property owners not only on Namakan and Rainy lakes but also around Lake of the Woods and downstream on the Winnipeg River. In Kenora, both streets and properties located in low lying areas, especially around Laurenson's Creek, were flooded and remained so throughout most of last summer. Abnormally high waters in the Black Sturgeon sub watershed which empties into the Winnipeg River just north of Kenora, led to flooding of large areas within the city boundaries, forcing the evacuation of several hundred rural residents and municipal road closures. Many residents worked tirelessly to limit damage to property only to have their efforts 'blown away" by significant wave damage caused by high wind events that were also part of the story of damage. Speaking to the number of high wind days and their impacts when describing damage is appropriate. Brief mention should also be made of flooding which also occurred in adjoining areas east and north of Lake of the Woods, especially the southern portions of the English River watershed. This would help to frame the flooding event and show that it was not localized to the Rainy River watershed alone but to a much larger geographic area including other watersheds which were exposed to the same meteorological events during the winter and spring of 2022. Brief mention of the contribution of "rain on snow" events is also recommended.

While flood damages on man-made structures are probably at the forefront of most people's minds, the 2022 flooding event likely had significant ecological impacts on these systems. Immediate impacts which led to water bird nesting and wild rice crop failures have been noted, but these can occur at higher water levels within the normal operating band. Little or no mention is made in the report of potential long-

term impacts of the abnormally high water levels and flow on the physical environment. Examples could include shoreline destabilization, bank scouring, increased erosion, long term changes in water quality and increased distribution of aquatic invasive species to name a few. These are all areas within the IRLWWB's terms of reference but there is no mention of an intention, or commitment to evaluate long term impacts as part of the flood post assessment.

CAG Post Flood Recommendations to the IRLWWB

The CAG appreciates the work of the WLC in considering its recommendations but also believes the entire suite of post flood recommendations it made to the IRLWWB should be fully addressed within the post flood report. The recommendations reflect many of the thoughts and ideas of basin community members most affected by this event. In the interest of transparency and responsiveness, we believe it important that all recommendations receive a response through the report, and where a decision has been made not to accept a recommendation, sufficient rationale provided.

Adaptive Management, Flood Resiliency, and Climate Change

Both flood resiliency and adaptive management are introduced as topics in the draft but it spends very little space on these important areas. The CAG believes the IRLWWB can *and is* playing a role in investigating and making recommendations with respect to adapting to our changing climate. Highlighting what the adaptive management committee (for eg) is, and plans to do, should be an important part of this section. (Flood visualization modelling, assisting in redefining hazard land elevations etc.)

Similarly, the report indicates "it is imperative that the community focuses on resiliency" but offers little in the way of information or resources to this end. Showing a willingness to participate in, and or facilitate evaluations of the watershed to improve resiliency, and providing information/resources to readers would go a long way to improve this section of the report.

The CAG also believes the post flood report represents an opportunity to highlight the impacts of our changing climate and the probability of increased flood events. Section 7 of the report should be renamed "Flood Resiliency, Adaptive Management and *Climate change* and include information and a discussion regarding climate change forecast/predictions and modelling.

Other

The figure on Pg. 19, Fig. 16 & 17 needs to be explained – specifically, why was there a lag between fully opening Namakan & Ft. Frances/International Falls dams once inflow surpassed the maximum outflow capability. From the figures, it would appear that the Fort Frances/IFalls dam was not fully opened to allow maximum discharge until May 5, almost two weeks after this had occurred at the Namakan outlets (April 25/26).

"State of Nature" needs a description and should be highlighted. This result (p. 31) demonstrates simply that nothing could be done to prevent the record flooding.

Rainy Lake Property Owners Association
PO Box #484
Ranier, MN 56668
Email: info@rlpoa.org

March 28, 2023

Attn: Comments - 2022 Post-Flood Report
International Rainy-Lake of the Woods Watershed Board
U.S. Section
1717 H Street NW, Suite 835
Washington DC 20006

Members of the International Rainy-Lake of the Woods Watershed Board:

We are pleased to submit the following comments on the draft "2022 Post Flood Report: A report on High Water Levels in the Rainy River Basin," recently issued by the Water Levels Committee (WLC) of the International Rainy-Lake of the Woods Watershed Board. Our membership provided input over several weeks, and the comments have been consolidated and reviewed by our board. We offer these comments on behalf of our Association and its members.

In general, the draft report accurately documents and summarizes the major events of late 2021 and through the summer of 2022. It is essential reading for anyone interested in the watershed and those affected by the record flooding of 2022. However, our review of the report identified three general categories of concerns, which are detailed below:

Improving Water and Flood Management

1. In early March 2022, the WLC met in accordance with the procedures outlined in the 2018 Rule Curve Order. As described on page 17 of the draft report, the RLPOA provided input, raising concerns about the potential consequences of a cold winter, a large and wet snowpack, a projected late ice-out, and the resulting risk of overlapping spring melt and rains. The RLPOA expressed concern and urged caution. However, the WLC did not act upon this input and instead implemented the standard rule curve rather than the alternative "high flood risk rule curve" for dam operations.
   While the report offers context for this decision, and we acknowledge that the impact of this choice was overshadowed by the magnitude of subsequent events, is also clear the WLC did not adequately address the changing signals indicating a high water year. This highlights the need for reforming the early March meeting process to ensure better responsiveness to potential high flood risk indicators.

   Recommendation: The RLPOA urges the IRLWWB to adopt the changes proposed in Section 5 of the draft report. This includes transitioning from a "High Flood Risk Rule Curve" to a data-driven and ongoing "Spring Regulation Plan" that is

based on actual ground conditions rather than fixed calendar dates. To implement these changes effectively, they need to be supported with the necessary resources for improving flood forecasting, and for consultation and communication with local stakeholders.

2. As detailed on page 21 of the draft report, the RLPOA submitted a letter to the WLC on June 30, 2022, requesting a temporary Order. The letter proposed a strategy to coordinate or "balance" water level management between Namakan Reservoir and Rainy Lake to accelerate recovery with minimal side impacts. The Order issued by the IJC on July 5th brought measurable benefits to the community.

Since then, the Community Advisory Group has advocated for a "balanced" approach to managing emergency water levels in the two lakes. This approach is discussed on page 25 of the draft report and emphasizes the importance of coordinating water level management to minimize negative impacts and promote a more efficient recovery process for affected communities.

Recommendation: The RLPOA urges the IRLWWB to elevate the Temporary Order to permanent status so it is ready for use by the WLC in emergency conditions. This would streamline the decision making process in future events, and provide local communities with improved transparency and assurance regarding emergency water management during an ongoing flood emergency.

3. The report highlights the importance of improving communication and coordination with local agencies during flooding events. In 2022, local communities experienced the advantages of enhanced outreach and coordination compared to the 2014 event. However, the draft report could provide a more comprehensive description of the role played by local responders in 2022, specifically Koochiching and St. Louis County, and how social media was utilized to help the community react to forecasts.

Additionally, some Canadian members of the Association have noted disparities in local efforts across the border. It is essential for the report to address these differences and emphasize the need for cohesive, collaborative actions between communities on both sides of the border to achieve more effective and efficient responses to flooding events.

Recommendation: Modify the draft report to specifically describe the role of local responders in 2022, particularly Koochiching and St. Louis County, and the role of social media in helping the community respond to the forecasts, and any disparities in community response.

Preserving Conveyance at the Headwaters of Rainy River

1. The draft report thoroughly discusses the root causes of Rainy Lake flooding, which are primarily attributed to limited conveyance capacity at Rainy River's

headwaters. These conveyance limitations are partly due to naturally formed waterways, and partly due to man-made constrictions at the CN rail bridge located between Fort Frances, Ontario, and Ranier, Minnesota. On page 28, the draft report mentions the proposed CN rail bridge project between Fort Frances and Ranier could exacerbate future flooding events. However, the report does not provide guidance on addressing this challenge.

The RLPOA's stance is that the uncertainty surrounding this issue, stemming from CN's lack of public engagement and the International Joint Commission's absence of communication regarding its authority in the matter, is a major concern for Rainy Lake's future water management and flooding mitigation. It is crucial for the report to address these concerns and emphasize the importance of communication and stakeholder engagement to effectively manage and mitigate flooding risks on Rainy Lake.

Recommendation: The RLPOA asks for the final report to include a description of what legal authorities apply to the CN rail bridge project under the Border Waters Treaty, what agencies in Canada and the U.S. should be engaged in the review and regulatory approval of the project, and define the scientific and engineering standards that should be applied to ensure conveyance will not be diminished at the headwaters of Rainy River.

Improving Resilience

1. Section 7 of the draft report, "Hazard Management and Resiliency," provides thoughtful insights. The Association acknowledges that flooding is unavoidable in years when inflows, like those in 2022, vastly exceed the maximum outflow capacity at Rainy River. Future flooding events are an inevitable outcome of uncontrolled inflows and restricted outflows. The challenge for local communities lies in identifying modifications in public and private infrastructure that enable effective, environmentally responsible, and affordable mitigation of the impacts of future flooding events.

   Significant investments are required to achieve these goals, and they will not materialize without proactive public leadership. While an exhaustive discussion may be beyond the scope of the draft report, it is crucial to recommend steps that could pave the way for improved outcomes when flooding occurs. By emphasizing the importance of public leadership and outlining potential steps, the report can contribute to developing more resilient communities.

   Recommendation: The report should recommend that IRLWWB describe the conditions needed for public and private investment in more resilient infrastructure. The IJC/IRLWWB, perhaps in collaboration with other agencies, can contribute with projects such as providing authoritative information on lake level recurrence intervals to guide private dock and shoreline construction, providing support for demonstration projects on flood barriers as alternatives to sandbagging, and workshops on best practices for home and utility construction in flood areas.

2. The final version of this report is essential for preparing and mitigating the effects of upcoming flooding events. However, in its current form, the lessons learned from 2022 and the recommendations for change are scattered throughout the body of the report and not effectively highlighted in the Executive Summary.

> **Recommendation**: To ensure a comprehensive understanding for a wider audience, the report should be restructured to emphasize lessons learned, areas of improvement, effective actions, and key recommendations. The Executive Summary should be expanded to include proposed changes, such as the Spring Regulation Plan, the value of a Temporary Rule Curve Order, the significance of the CN rail bridge project, and the role of the IRLWWB/WLC in promoting more resilient infrastructure.

Thank you for this opportunity to provide comments on the draft report. We hope these comments are useful to you, and we would be glad to engage further if there are questions or concerns about these comments.

Respectfully submitted on behalf of the RLPOA Board of Directors,

Eric Johnson, President
Craig McKenzie, Vice-President
Shawn Mason, Treasurer
Dale Johnson, Secretary
Rob Kirk, BOD
Georgia Growett, BOD
Doug Johnson, BOD
Ann Molyneux, BOD
Lindy Larsen, BOD
Tom Dougherty, BOD
Jeff Kantor, BOD

Subject: [Non-DoD Source] FW: Comments on the 2022 Post Flood Report
Date: Monday, March 13, 2023 10:42:12 AM

Sent: Saturday, March 11, 2023 3:59 PM
.Subject: Comments on the 2022 Post Flood Report

Dear Ms. Moore,

By in large I feel your team did a great job with the Post Flood Report as far as it went. However, I have a few comments concerning topics that should have been addressed;

First, I feel that the various lake commissions are reactive and not anticipatory. By this I mean they all wait until the lake levels are rising (or falling) before taking action when, in fact, they should try to be ahead of the game. For example, the Colorado Lows which triggered the 2022 flood were known to be on the way and some sort of anticipatory action should have been taken or at least considered. Using radar and surface monitoring, the amount of incoming rainfall (or snow) should have been known days ahead of time and taken into consideration. When a low pressure system, such as what developed and headed to the watershed occurs at home, our local weather stations always give a 2-3 day warning of the amount of rain that is anticipated and whether or not there will be local street flooding. Why the various lake commissions did not anticipate this is unknown to all of us who have homes in the area. Is there not a NOOA weather person on the board to advise as to expected rainfall? Are the commissioners afraid of making the wrong call?

Second, modeling is mentioned several times in the report but it is always after the fact (reactive again). The first Colorado Low dropped 2-3 inches of rain/snow over the watershed. Why was this not put into the basin wide model to see what the effects would be on the snow and ice levels already in place?
In fact, it was not until mid April and the addition of the second Colorado Low and 3-4 more inches of rain that the Rainy Lake dam went from 4 to 5 gates open. Then, to make matters worse, all gates were not open until a whole month after the first Colorado Low entered the area. I begin to question as to whether the commission actually has a model for relating rainfall to rising lake levels. For example, during normal times and given a two inch rainfall over the watershed, will your model indicate how quickly the lake will rise and by how much? All indications from this report and the one for the 2014 flood suggests no as the answer. Thus the question, why not! Perhaps you need a more sophisticated model.
Many home owners ask the question, “Why did they not open the gates sooner”. An exercise that would be useful would be to take the data on page 20, Figure 17 and open all the gates when the first 2-3 inches of rain fell on the watershed in early April instead of waiting until the second week in May. We still would have had a flood but how much would the chart change? This should have been in the report since it would have answered many questions. Instead you talk about the rule curve and gate openings which has nothing to do with the actual flooding.

Third, and most important, there is no recommendation in the report for improving on the water flow in times of excessive rainfall. Why was this not included? It appears as though you are saying "Tough Luck Everyone"! We had the flood of 2014 and now 2022, if there is another one within that same time frame things are going to get nasty between the homeowners and the lake commissioners so why not head it off with possible solutions?

Fourth, Possible solutions;

A, Transition from a reaction based agenda to an anticipation based agenda and using modern modeling to try and get ahead of rising or falling lake levels. Maybe it is time to consider using artificial intelligence (AI) and relieve the commissioners of their wavering? Even if it would not have made much of a difference, it shows to the public that you are trying to do something different.

B, Conduct an engineering study to determine what size of diversionary channels would be needed to bypass the dams at Namakan, Rainy, Lake of the Woods and Lake Winnipeg to adequately make the inflow and outflow rates the same during flood situations. Lake Winnipeg already has two such channels but they were unable to handle the 2022 flood and obviously need to be enlarged. With the paper mill gone across from the dam for Rainy Lake there exists a great location for such a channel. This engineering study would not cost much since you already have the inflow and outflow data from the 2022 flood, you already have the engineers and, once again, it show to the public that you are looking for solutions.

C, Finally, since all four lakes are interconnected a cost estimate of constructing each of these diversionary channels would undoubtedly be prohibitive. However, once again, it would show to the public that you are trying to solve the problem.

Hope to hear from you,

Joseph Gauss

March 13, 2023 DAVE AUSTIN

Committee Members; for Public Comment Period

I want to thank Pam Tomeri for supplying me with a printed copy of the "Draft" 2022 Post Flood Report. I am a property owner on Rainy Lake with properties in both Ontario and Minnesota, and am a newcomer to having any public involvement or comments to make regarding the 2022 flood. Prior to reading the report I attended the public meeting in Intl. Falls and left it feeling slightly discouraged and still skeptical. Reading the draft report alleviated some of those feelings but still left some questions that I feel are unanswered. I offer several questions.

1) Much is shared in the report about the nearly unprecedented rainfall experienced in April/May 2022. A very similar amount of rain fell in 2001 and though the report lists it as a flood year I do not recall that it approached anything near 2022 or 2014 or 2002. What were the factors that did not create a catastrophic flood that year?

2) I have skepticism of the modeling procedure. I believe the model is highly constrained and thus fails to explore and reveal its power. The beauty of a model is that it is just a simulation, its not real, thus constraining it hides potential remedies for what was very real... the flood. Limiting action to a March 10 date constrains the model. The presenter at I. Falls said that considering earlier intervention would be irresponsible. The committee may feel that is correct but what would have been the result if we ask the model to perform some possibly "irresponible" or "We'd never do that" types of strategies?

- what if the reservoirs were lowered in Jan + Feb to the bottom of the curve (not below)? What would have been the result? What would it cost to ask the model? If the simulation I ask for shows a significant difference from

the actual flood, then the often spoken or implied opinion "there is really nothing we could do", would possibly need to be modified. Is anyone else curious?

3) My final question is in regards to the consensus of opinion which seems to come from the committee. Do any committee members express doubt or skepticism? Is a minority opinion ever considered or published? Skepticism is one of the essentials of science.

Many of us became very accustomed to not having severe floods for 50+ years. Strangely since mild curve changes we have experienced worsening flooding too often. My buildings are all above any dangerous flood elevation but many homes cottages and businesses were built during those 50 comfortable years, assuming the lake levels would be controlled. The tone of the draft report is: "Flooding is inevitable, get used to it." That is discouraging and somewhat disingenuous. The last word may be too severe.

Subject: [Non-DoD Source] 2022 Post Flood Report

Eric and Megan,

Hello, I'm Brian Harmon, head of natural and cultural resource management at Voyageurs National Park. I didn't have an opportunity to connect with you at the watershed forum, so this email will have to do by way of introduction.

I've just skimmed through the draft 2022 Post Flood Report (which I've been very much looking forward to). It's an extremely important document for history and is rich in technical detail. But … it reads like something written by experts for experts (including the FAQ section). It is not, I think, what many people are looking for, which is:

A concise, plain-language, description of

- **what happened**
- **why it happened**
- **what could have been done differently**
- **what would have happened if things were done differently and**
- **why different actions would only have had slightly different results from what actually happened**

That information is in the report, true, and I'm a nerd enough to dig for it and parse the wealth of details. But the report is not friendly for a lay reader. I'm concerned you're missing a giant opportunity to really connect with people impacted by the flood.

I'm not suggesting you change the report, but I am suggesting that if you want the general public to understand what you understand about the flood, this report is not the vehicle to use.

I think a 3-5 page document, with a handful of key graphs labeled and captioned in non-technical language, would be an outstanding compliment to the report and go very far in addressing the questions people most want answered about the 2022 flood.

Best regards,

Brian C. Harmon
Head of Resource Management
Voyageurs National Park
[redacted]

Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board

Summary of 2022 Post Flood Report

A companion document to the 2022 Post Flood Report prepared by the Water Levels Committee

Water Levels Committee of the International Rainy- Lake of the Woods Watershed Board
September 2023

Introduction

The 2022 flooding in the Rainy River basin was a disaster of historic proportions. Rainy Lake reached record- breaking water levels, and Namakan Lake ranked as the third highest levels on record. Losses from the flood were widespread and included severe damages to homes, docks, boathouses, shorelines, trees , infrastructure, and roads. Thousands of hours were spent on flood protection and mitigation such as sandbagging, berming, and pumping, as well as recovery and remediation efforts as water levels lowered to normal ranges. Many recreational and tourism operators across the region lost business or had to close due to flooding. The economic, financial, and emotional toll on the entire community was significant.

Figure 1. Flood mitigation efforts at Thunderbird Lodge in International Falls, MN

The Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board is responsible for monitoring basin conditions and ensuring the rule curves are followed under the International Joint Commission Order for regulating water levels of Rainy and Namakan Lakes. The Water Levels Committee wrote a 2022 Post Flood Report to document what caused the flood and the actions taken by the Water Levels Committee before and during the flood. In August 2022, the International Rainy-Lake of the Woods Watershed Board hosted community listening sessions in Fort Frances, ON and International Falls, MN to provide an opportunity for community members to share their views and concerns with the Board and its Committees. Takeaways from those sessions are included in the 2022 Post Flood Report, as well as an analysis of what would have happened if the High Flood Risk Rule Curve on Rainy Lake was implemented ahead of the 2022 flood. This document serves as a high-level summary of the Water Levels Committee's Post Flood Report.

Who Does What in the Basin

There are multiple entities in the U.S. and Canada involved with watershed management, in terms of ecological health and water levels, within the Rainy-Lake of the Woods watershed. The International Joint Commission is an independent, objective, and binational body established by Canada and the U.S. to prevent and/or resolve disputes under the 1909 Boundary Waters Treaty. The 1938 Rainy Lake Convention gave the International Joint Commission responsibilities to control water levels in the Rainy Lake watershed under emergency conditions. To do this, the International Joint Commission has employed water level rule curves, beginning in 1949, with regular updates to reflect current science and stakeholder benefits. The rule curves were last updated in 2018, following the release of the Rainy and Namakan Lakes Rule Curve Study report of 2017. The current International Joint Commission Order consists of rule curves for Rainy Lake and Namakan Lake. The rule curve band provides an upper and lower limit for the water elevation in the reservoir on any day of the year (lower in the winter, higher in the summer). The rule curves also establish minimum releases during low inflows and All-Gates Open levels during high inflows.

In 2013, the International Joint Commission established the International Rainy Lake of the Woods Watershed Board to assist with binational coordination of watershed management. The International Rainy-Lake of the Woods Watershed Board's mandate is to ensure compliance with the International Joint Commission's Order pursuant to the 1938 Rainy Lake Convention, to monitor and report on the ecological health of the Lake of the Woods and Rainy Lake boundary waters aquatic ecosystem, including water quality, and to assist the International Joint Commission in preventing and resolving disputes regarding the boundary waters of the Lake of the Woods and Rainy River watershed. The International Rainy-Lake of the Woods Watershed Board delegates its authority to ensure compliance with the International Joint Commission Order in emergency regulation of Rainy and Namakan Lake to the Water Levels Committee. The Water Levels Committee monitors hydrologic conditions and may provide dam operators with directions for the operation of their discharge facilities to ensure that the rule curves of Rainy and Namakan Lakes are followed.

Lake of the Woods water levels are managed by the Canadian Lake of the Woods Control Board between lower and upper elevations set by the 1925 Lake of the Woods Convention and Protocol. The International Lake of the Woods Control Board, made up of co-chairs from the U.S. Army Corps of Engineers and Environment and Climate Change Canada, approve the actions of the Lake of the Woods Control Board whenever Lake of the Woods water levels rise above 1061' or fall below 1056' elevations. Figure 2 illustrates and differentiates the binational management, especially water levels, in the Rainy-Lake of the Woods watershed. The Water Levels Committee does not have the authority to regulate water levels of Lake of the Woods; therefore, the scope of this report focuses on the flooding of Rainy and Namakan Lakes.

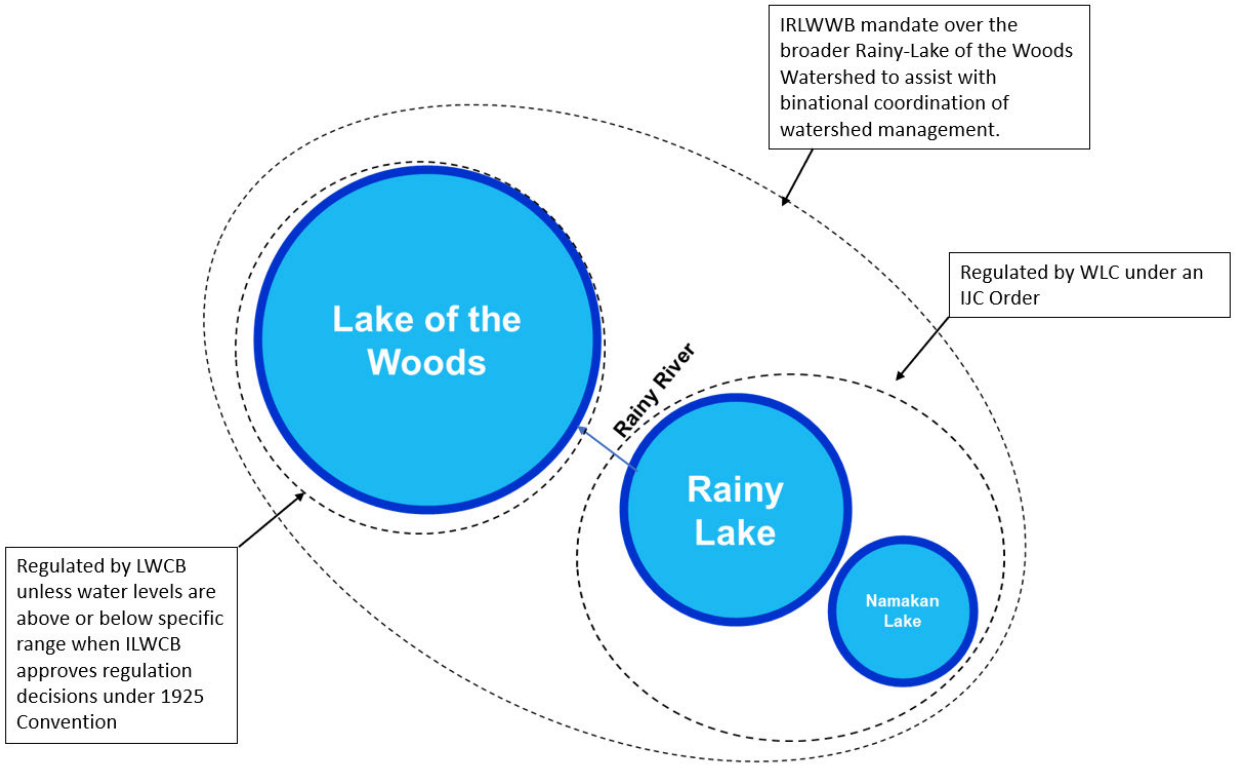


Figure 2. Roles and Responsibilities in the Rainy-Lake of the Woods Watershed

2022 Basin Conditions and Water Levels Committee Actions

Prior to the 2022 flood, the Rainy River basin experienced severe drought conditions between the spring of 2020 and the fall of 2021. This was due to consistently lower than normal amounts of precipitation for most of that period. Rainy and Namakan Lake levels were affected by the prolonged drought conditions. Namakan Lake levels were the lowest they had been since the 2000 Rule Curves were implemented (between 2000-2018). At Rainy Lake, the level dropped below the lower rule curve in July 2021 and continued to decline to its official Drought Line in September 2021. The Rainy Lake level reached its lowest level since 2003. In November, the Rainy River basin was still classified as being under a moderate to severe drought, despite slightly above normal precipitation in September 2021. From October to December 2021, average inflows into both Rainy and Namakan ranked low in comparison to the last 30 years.

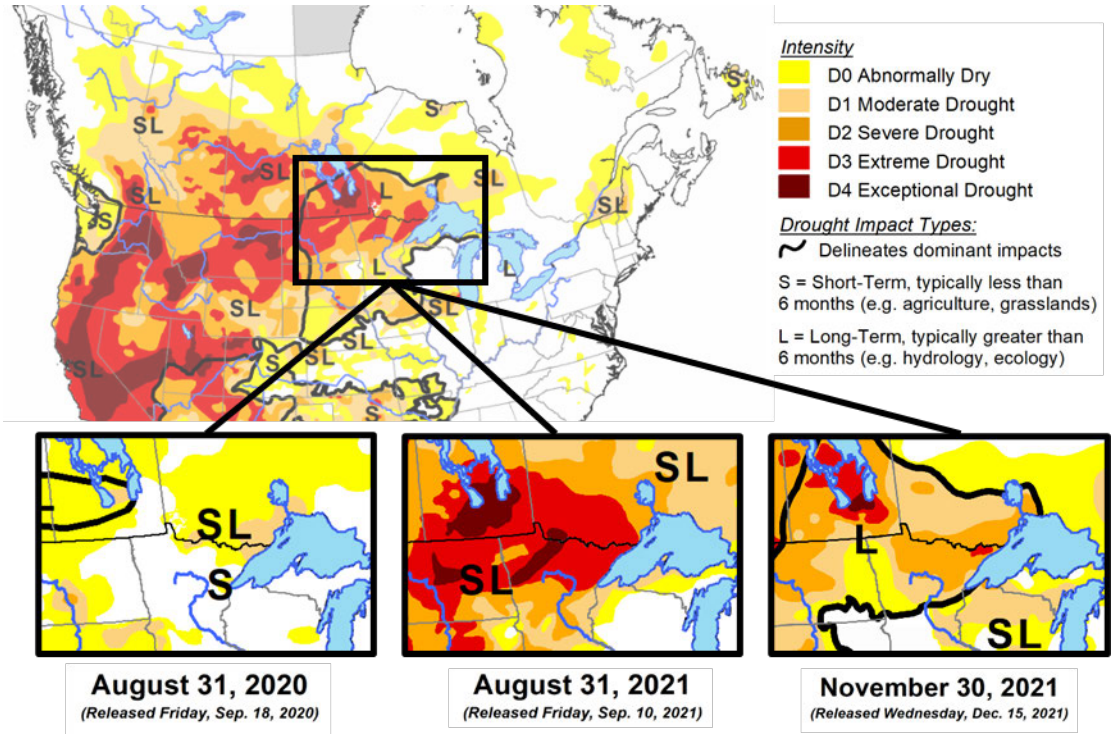


Figure 3. North American Drought Monitor Map of the Rainy River Basin (NCEI-NOAA)

From mid-February to the end of March 2022, there was above normal snow depth and snow water equivalent (SWE) measured across the Rainy River basin. SWE, or the amount of liquid water in snow, is used to better understand the amount of snow melt that will runoff into the basin. On-the-ground measurements of the snowpack water content were conducted at locations across the Rainy River watershed in late February by the US Army Corps of Engineers. Measurements indicated higher than normal snow water equivalent in general, with the highest amounts to the west of Rainy Lake in the local Rainy River watershed. The measurement at International Falls was slightly below the median while slightly above at Ash Lake. Compared to the measurements taken in 2014, values were generally less in 2022 (65% of the 2014 value at Tower, 78% at Cook, 72% at Ash Lake and 69% at Birchdale). The measurement at Ray, MN indicated higher snow water content in 2022 compared to 2014.

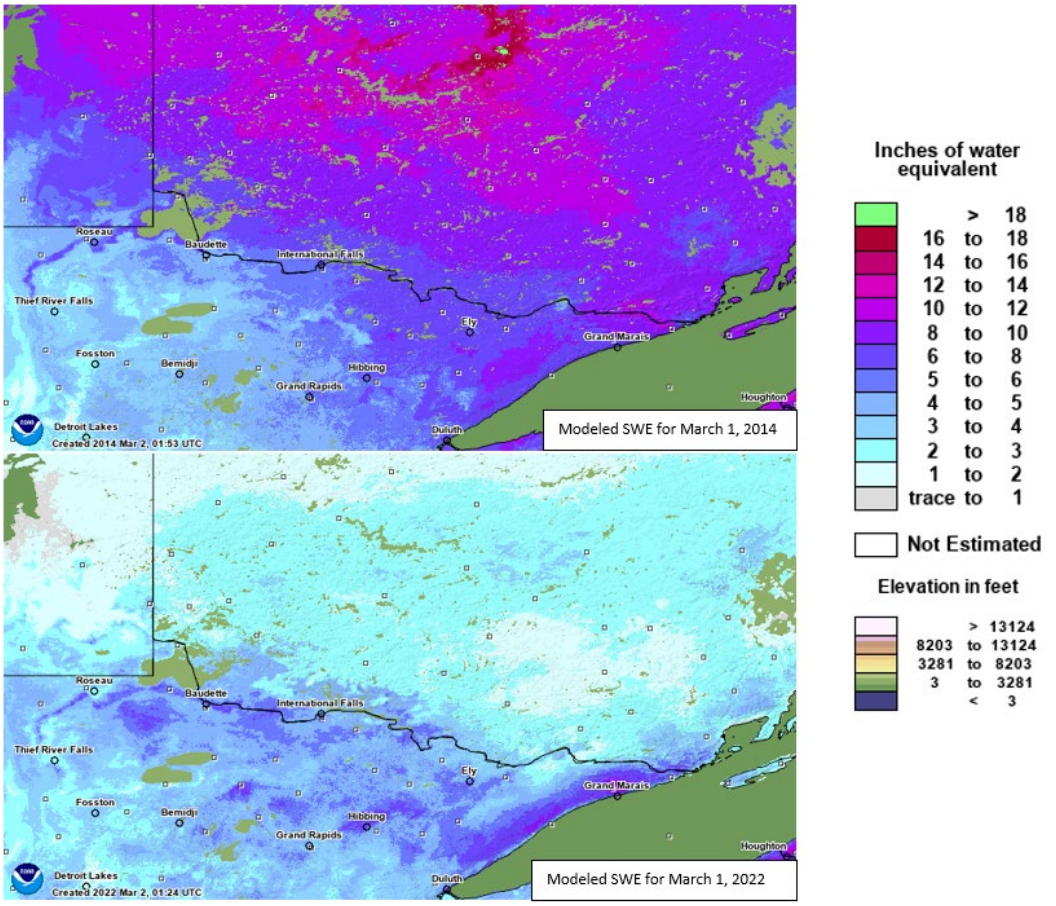


Figure 4. Modeled snow water equivalent (SWE) in March 2014 (top) and March 2022 (bottom) (NOHRSC-NOAA)

On March 10, 2022, the Water Levels Committee decided to follow the standard rule curve, instead of the high flood risk rule curve, based on the data available at the time. When making a decision on which Rainy Lake rule curve to follow, the Water Levels Committee must consider the risk of flooding as well as the risk of not refilling the lakes to their summer lake levels. Should the High Flood Risk Rule Curve (HFRRC) on Rainy Lake be implemented and forecasted flood conditions do not occur, there can be negative impacts on fish spawning, navigation, and aquatic vegetation diversity (if HFRRC is implemented every year). Current conditions that lead to the decision not to use the high flood risk rule curve were:

- The current drought status for the basin ranged from abnormally dry in portions of Canada to moderate to severe drought in the U.S. Drought conditions indicate capacity in the basin to absorb precipitation and reduce runoff.
- Base flow[1] conditions were in the low to normal range for this time of year, consistent with the drought status. The tributary flows are the best indicator of the basin hydrology and capacity to absorb spring runoff. They did not indicate a lack of capacity in the watershed and therefore did not indicate a high risk for flooding heading into the spring.

[1] Base flow is defined as the portion of streamflow that is not directly influenced by precipitation runoff.

- Overall average winter temperatures were colder than recent years, but warmer than 2014 when spring flooding last occurred in the basin. Colder temperatures accumulated over the winter indicate a delay in ground thawing is possible and therefore an increased risk of rain-on-snow runoff.
- The accumulated snowpack depth at the time of the decision was higher than normal, falling in the 80 to 95 percentile range based on historic records. Snowpack was much less than in 2014 and comparable to 2019 when normal spring flows developed. However, according to the National Weather Service, the water contained in the snowpack, the Snow Water Equivalent, was moderate, generally between 3-5 inches of water. This was less than in 2019 and much less than in 2011, 2013, or 2014 (there was no high water in 2011, or 2019, while in 2013 Rainy Lake rose slightly above the All Gates Open level and 2014 was the highest level since 1950).

Figure 5 shows the Water Levels Committee's March 31 water level targets for Rainy Lake as the range within the yellow arrows. This means operators were to achieve water levels between 336.9 and 337.0 m by March 31. While not targeting the High Flood Risk Curve specifically, this level target range was within High Flood Risk Curve range and in the bottom half of the normal Rule Curve band for March 31. In short, the Water Levels Committee hedged against above normal spring flows in line with the basin conditions but did not identify a high risk of flooding as March progressed.

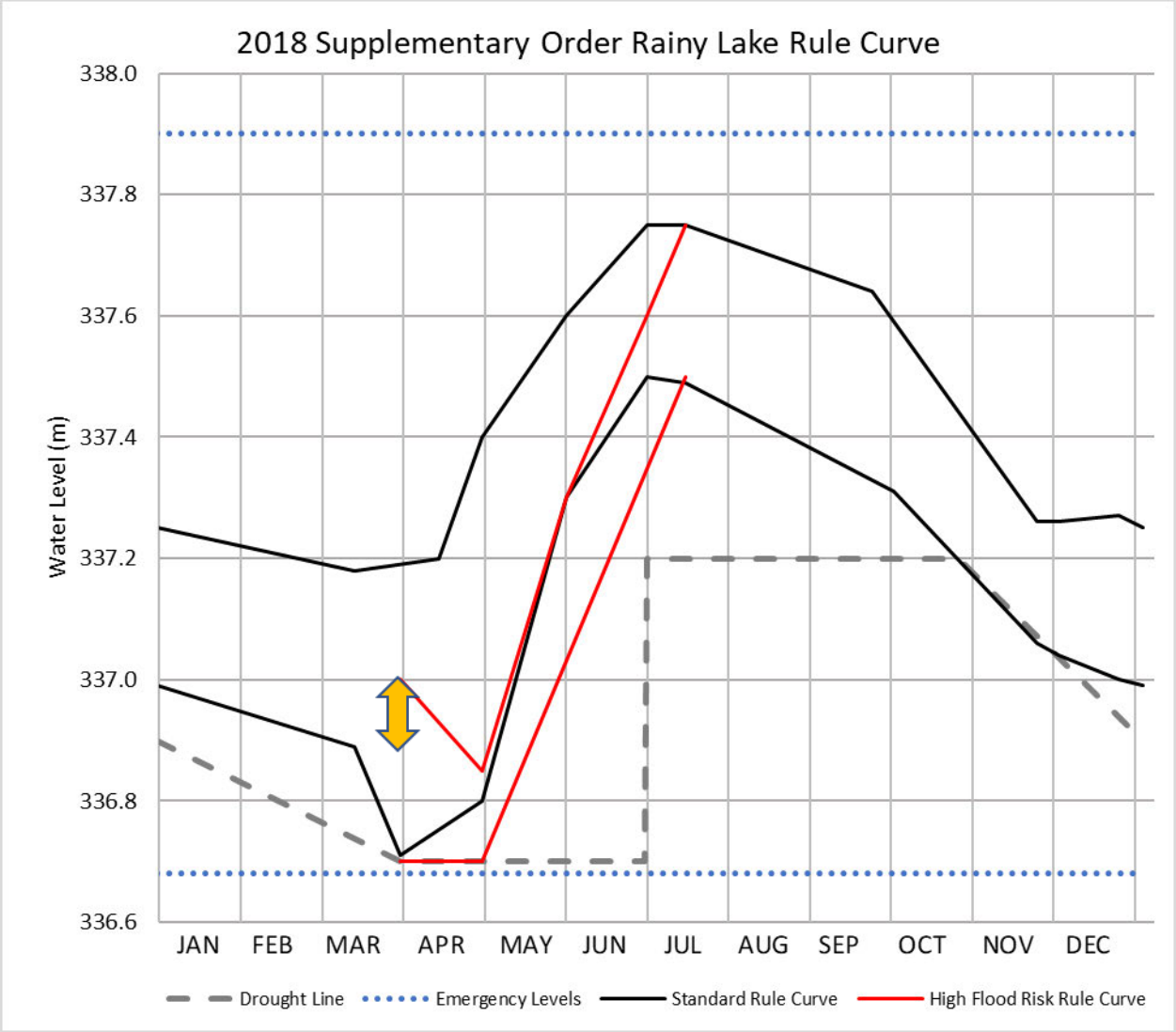


Figure 5. March 31, 2022 Rainy Lake Target under the Standard Rule Curve

On March 31, 2022, the Water Levels Committee reconvened to review basin conditions. The drought condition improved to a moderate drought on the U.S. side of the basin, and the Canadian drought index indicated similar conditions. The base flows were still within the low to normal range, and snow depth in late March ranked within the 60 to 80 percentiles (Figure 6) which was less than 2014 and comparable to 2018. Some precipitation had occurred the week prior, but the tributary flows exhibited a minimal response to the precipitation. The Rainy Lake level was within the targeted middle of the standard rule curve and at the top of the High Flood Risk Rule Curve. The Water Levels Committee decided to inform operators to continue targeting the middle of the band for both lakes.

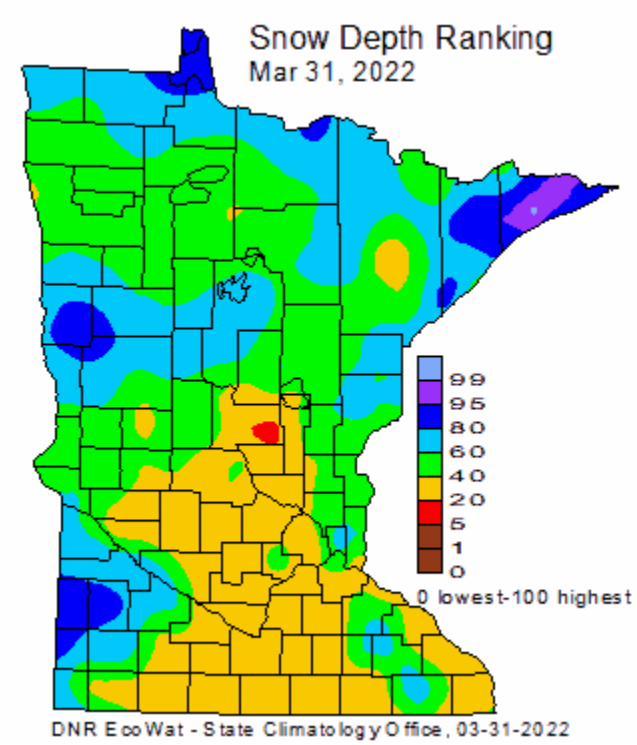


Figure 6. Snow depth ranking on March 31, 2022 (MN DNR State Climatology Office)

Conditions changed dramatically in April and May 2022 and abruptly ended the two-year drought. Precipitation was abundant and regular through the spring. In April, a series of Colorado Low systems[2] crossed the basin. Although air temperatures in the first few days were above freezing, an additional 10 cm (4 in) of snow fell over the Rainy River watershed by the end of the first week of April. Conditions in the second week of April did not improve; air temperatures continued plummeting and the Colorado Low brought widespread, heavy snowfall to the basin. Snowfall totals ranged from 30 to 70 cm (12 to 28 in). The highest amounts of snow accumulated directly over the Namakan sub-basin. This shift in weather stalled typical snowmelt in the basin. Inflows into Namakan and Rainy Lakes remained within normal ranges during these snow events, and outflows from the dams were managed to remain within rule curves.

[2] A Colorado Low is a low pressure storm system that forms in winter in southeastern Colorado or northeastern New Mexico and tracks northeastward across the central plains of the U.S. over a period of several days, producing blizzards and hazardous winter weather (NOAA).

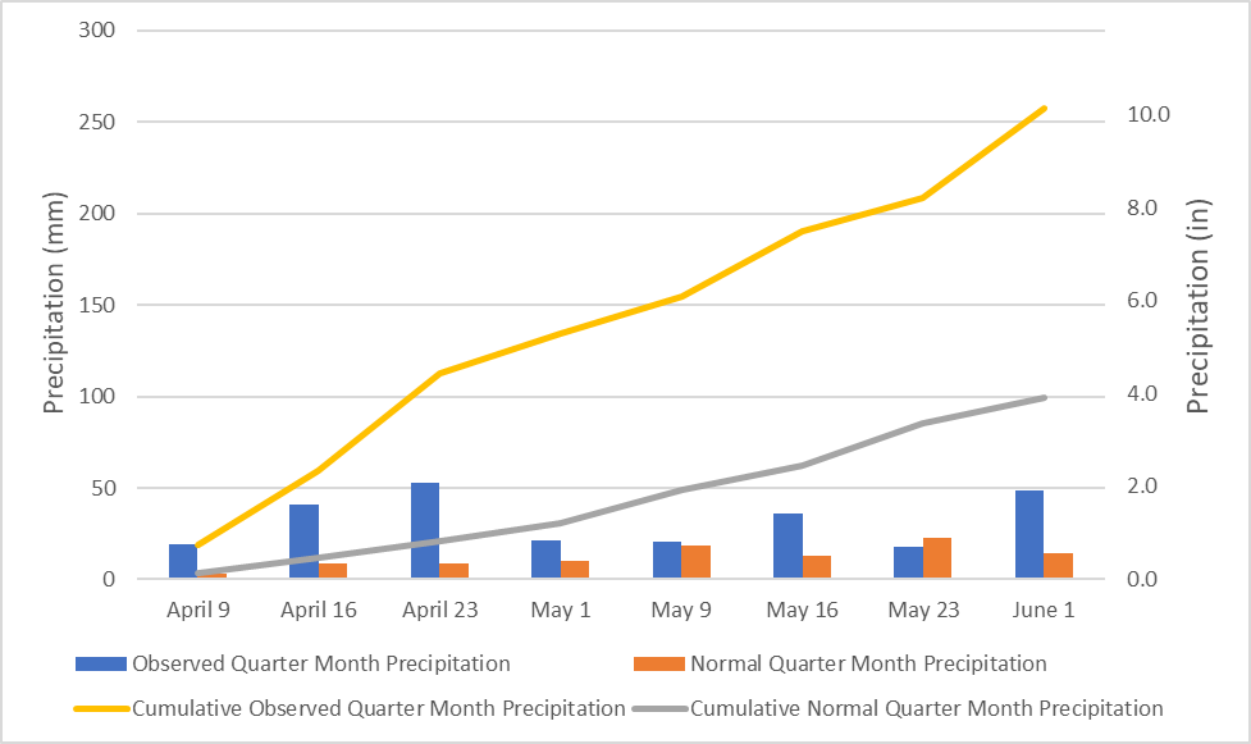


Figure 7. Rainy River Basin mean cumulative precipitation from April 1 to May 31, 2022 from Environment Canada's Regional Deterministic Precipitation Analysis

Source: Normal data 1981 – 2022 Environment Canada's Regional Deterministic Precipitation Analysis, for data prior to 1981 area-weighted average of weather station data (weather station sources include Meteorological Service Canada, NOAA, USGS)

In the third week of April, the next Colorado Low struck, causing a rain-on-snow event that resulted in an almost instant depletion of the snowpack. In response to the extreme precipitation which occurred on April 22-23, the Namakan Lake outflow was increased to approximately 280 cms (9,888 cfs), and the Rainy Lake outflow increased to approximately 740 cms (26,133 cfs) on April 25. All logs were pulled from sluices at Namakan dams on April 26 and gates at the International Falls-Fort Frances Dam were opened to maximize outflow as lake levels rose, with all the gates open on May 5. Once all sluices and gates were open at Namakan and Rainy Lake dams, there were no additional actions that the dam operators or the WLC could take to pass additional water. The rate of water released from both lakes steadily rose as the water levels of the lakes increased but outflow rates remained well below the inflow rates as above normal precipitation continued to fall on the basin.

Table 1. Timing of gate openings at the International Falls/Fort Frances Dam

Date (2022)	Gates Open
April 27	9
May 2	12
May 4	14
May 5	All Gates Open

Wet conditions continued into May, with precipitation in the form of rain. From April 1 to the end of May, the Rainy River basin had an average of 257 mm (10.1 in) of rainfall as shown in Figure 7. This equated to more than twice the average for April and May in the basin. The intensity and longevity of the spring rainfall caused flows in the tributaries of the Rainy River watershed to remain at high or close to peak levels from late April to mid-June. The Vermilion River set a new peak flow record, and many other tributaries ranked second or third for all-time high flows. The long duration of these high flows fed the inflows to the lakes and ultimately became the driving force behind the flooding.

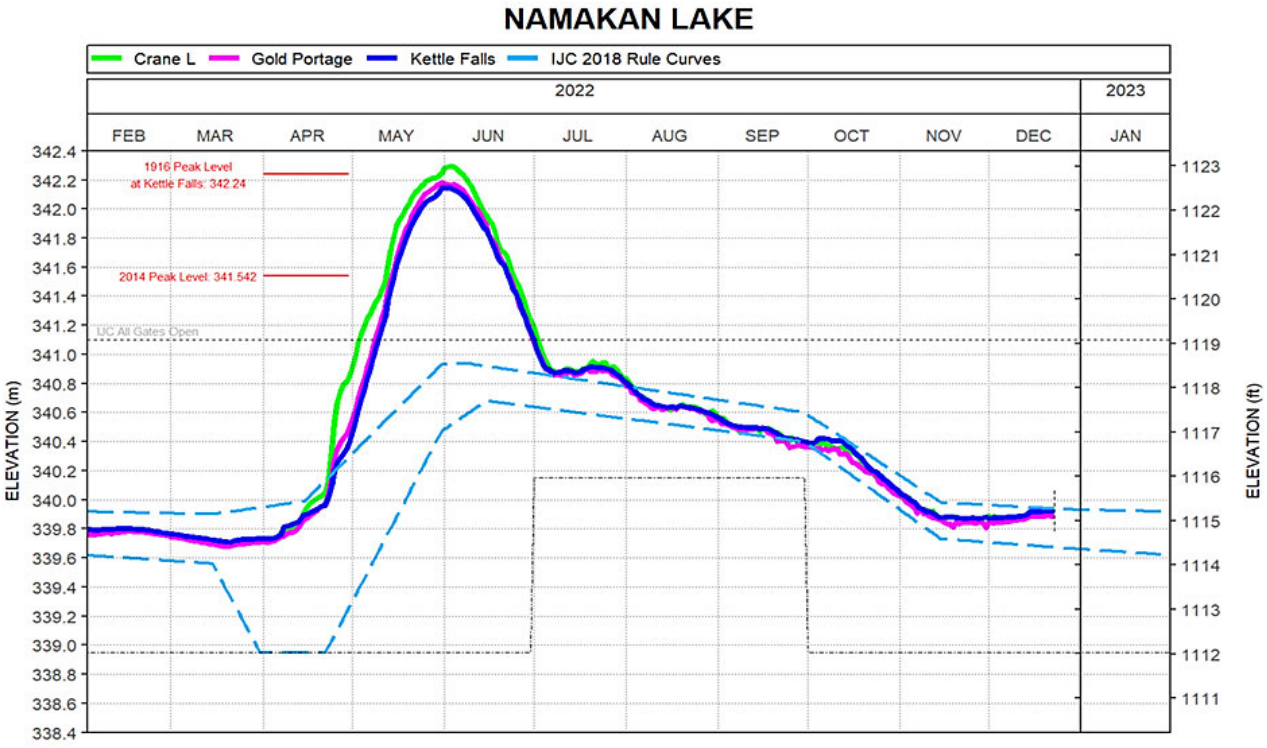


Figure 8. Namakan Lake levels in 2022 with 1916 and 2014 peak levels marked for comparison (LWCB)

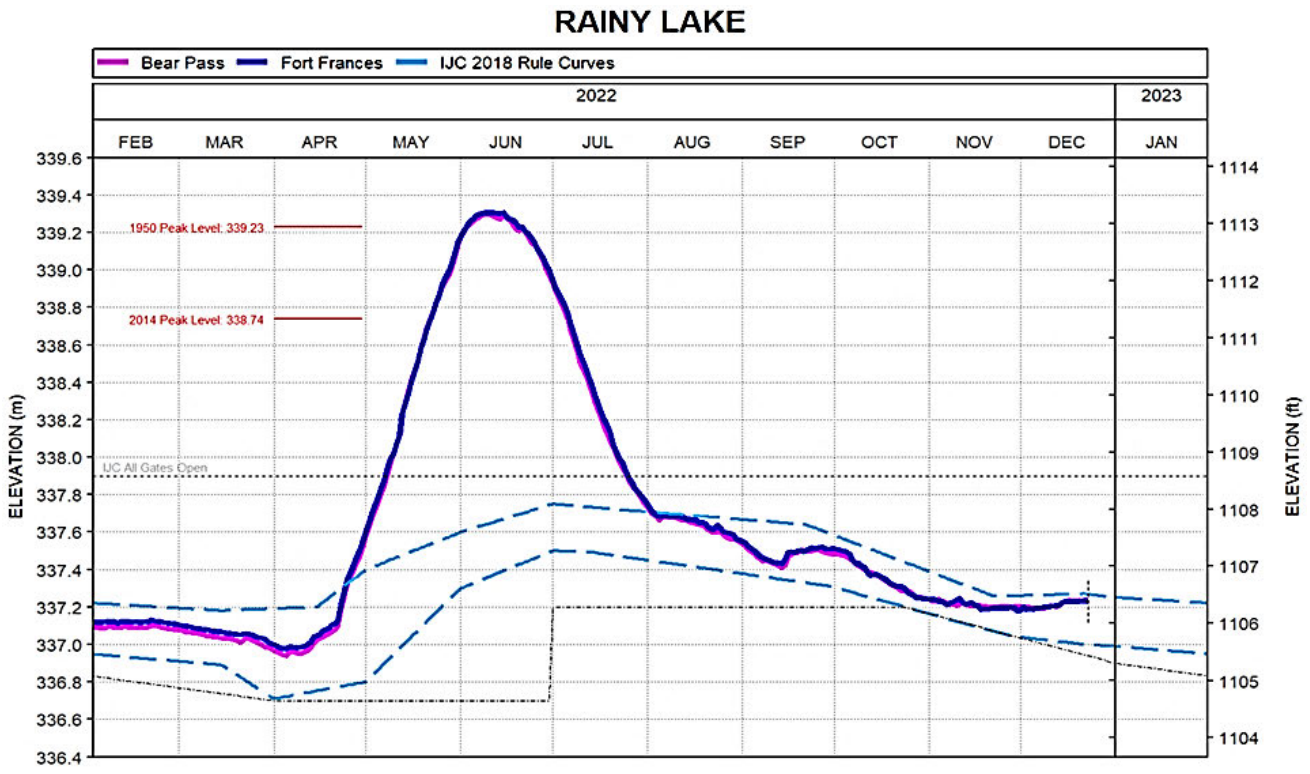


Figure 9. Rainy Lake levels in 2022 with 1950 and 2014 peak levels marked for comparison (LWCB)

The average inflow to Namakan and Rainy Lakes was the highest on record for April and May combined. The inflows for April through July 2022 were second highest only to 1950. As a result, the water level of Namakan Lake rose to a maximum level of 342.18 meters (1,122.69 feet), the third highest on record, and only 7 centimeters (2.8 inches) lower than the record level set in 1916. The water level of Rainy Lake rose to 339.31 meters (1,113.28 feet) and set a new record 8 centimeters (3.1 inches) higher than the previous level record set in 1950. Table 2 displays the top 5 highest levels for Namakan and Rainy Lakes.

Table 2. Namakan and Rainy Lake All Time Record Levels (LWCB)

	Namakan Lake			Rainy Lake		
Rank	**Date**	**Level (m)**	**Level (ft)**	**Date**	**Level (m)**	**Level (ft)**
1	1916-05-23	342.25	1,122.92	2022-06-14	339.31	1,113.28
2	1950-06-07	342.2	1,122.76	1950-07-05	339.23	1,113.01
3	2022-05-31	342.18	1,122.69	1916-06-08	339.09	1,112.55
4	1927-05-19	341.97	1,122.00	2014-07-01	338.74	1,111.41
5	1938-05-22	341.84	1,121.58	1941-10-18	338.6	1,110.95

During the flood event, the Water Levels Committee Engineering Advisors worked closely with Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (MNRF) and the U.S. National Weather Service (NWS) to provide guidance three days a week on forecasts for the levels of both lakes. The Lake of the Woods Control Board (LWCB) provided the level

forecasts and communicated them through the NWS's Rainy River Basin webpage, which housed current water level and flow observations, precipitation, river level, and lake level forecasts. The NWS also conducted a weekly webinar for agencies and public members to attend. The forecast and basin conditions updates and weekly meetings continued until the end of the flood event.

At the end of May, the U.S. Co-Chair and public member of the Water Levels Committee member met with local officials and community members from around International Falls. During the week of June 6, 2022, the Water Levels Committee and International Joint Commission representatives, including a U.S. Commissioner, traveled through the larger basin to meet with the affected residents and community officials. Local Water Levels Committee members were consistently communicating with affected residents, providing information, and answering questions.

As both lakes began to recede, the Rainy Lake Property Owners Association sent a letter to Water Levels Committee when the Namakan Lake water level fell below its prescribed All-Gates Open level on June 30. The letter requested that when Namakan Lake water level recedes to 1,118.8 feet (top of 1970 Rule Curve) operations on the lake should follow the 1970 rule curve temporarily to speed up the decline of the Rainy Lake in the hope that residents have access to damages and start on restoration activities. The Water Levels Committee had concerns over the risk of holding a steady Namakan Lake water level should an unforecasted precipitation event occur; however, no precipitation was forecasted for the period that Namakan Lake would be held at the 1970 Rule Curve. The Water Levels Committee also wanted to ensure residents on Namakan Lake agreed with the recommendation to hold Namakan Lake water levels steady rather than continuing to keep the water level within the 2018 Rule Curve. Following a discussion amongst the Water Levels Committee and Namakan Lake residents, the Water Levels Committee requested a Temporary Order from the International Joint Commission to hold the lake at the upper limit of the 1970 Rule Curve. An outline of the temporary target is shown as the yellow line in Figure 10.

On July 5, the Water Levels Committee received the Temporary Order from the International Joint Commission. The dam operators were directed to make a minor adjustment from the standard Namakan Lake water level target to the temporary target range from 340.90 m to 341.0 m. The target was a 10 cm (4 in) range centered on the upper level of the 1970 Rule Curves, 340.95 m (1,118.6 ft). This level also follows the top of the 2018 Rule Curve in early June, but the 2018 Rule Curves drops gradually over the summer rather than holding flat per the 1970 Rule Curves. The temporary target resulted in Namakan Lake being approximately 5-15 cm higher (2-6 in) than it would have been following the 2018 Upper Rule Curve.

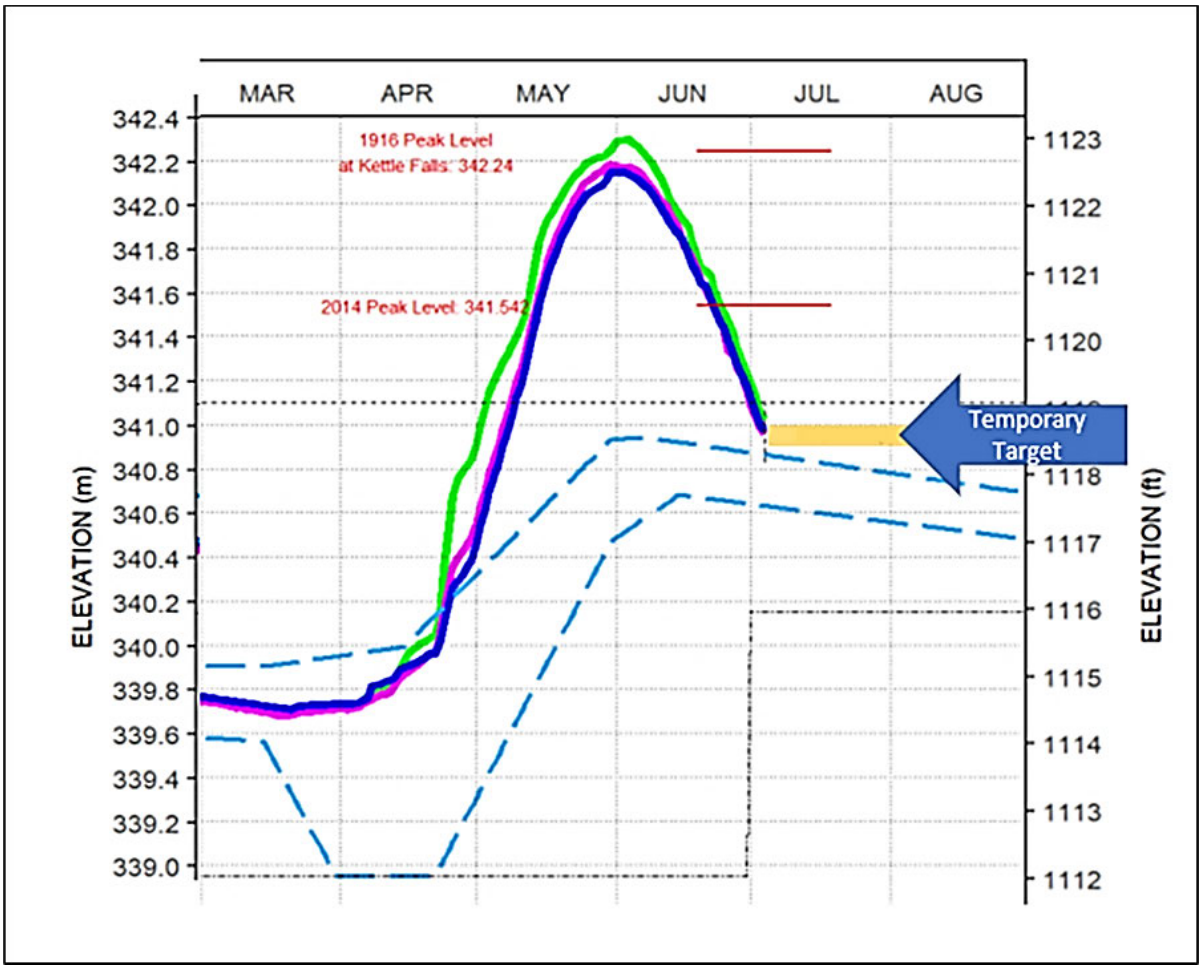


Figure 10. Water Level Target for Namakan Lake under the July 5 International Joint Commission Temporary Order, the blue dashed lines outline the 2018 rule curve, dark blue line indicates the Namakan Lake level at Kettle Falls, green lake indicates the Crane Lake level, and pink line indicates the Lake Kabetogama at Gold Portage.

On July 26, as Rainy Lake fell below the International Joint Commission All- Gates Open lake level, the Water Levels Committee advised operators to set outflows from Namakan and Rainy lakes to target the middle of their rule curves. The Namakan and Rainy Lakes returned to their standard rule curves on August 3, 2022.

During the International Rainy-Lake of the Woods Watershed Board annual basin meeting the second week of August, the International Rainy-Lake of the Woods Watershed Board and Water Levels Committee hosted two Public Listening Sessions: one in Fort Frances, Ontario, and the other in International Falls, Minnesota. A press release was posted on the International Rainy-Lake of the Woods Watershed Board's website to inform the residents about the listening sessions. The goal for each session was to provide an opportunity for the community members to share their views and concerns with the Board and its Committees. Participants were asked to register in advance and submit questions. The Water Levels Committee developed a video presentation about the 2022 flood. The video played at the beginning of each listening session and is available on the International Rainy-Lake of the Woods Watershed Board's website. The video followed a facilitated session for participants to ask questions and express concerns. As

mentioned in the Introduction, takeaways from those sessions are included in the 2022 Post Flood Report as wells as a summary of all the public engagement by the International Rainy-Lake of the Woods Watershed Board and Water Levels Committee during the flood event. The main question frequently asked was what would have happened if Rainy Lake's High Flood Risk Rule Curve was used in March 2022.

What if the Rainy Lake High Flood Risk Rule Curve was Implemented in 2022?

On March 1, 2018, the International Joint Commission signed a Supplementary Order updating the rule curves for Rainy and Namakan lakes that included broad ecological benefits while assisting in reducing flood peaks. Within the 2018 Supplementary Order, there is an alternative rule curve known as the High Flood Risk Rule Curve (HFRRC) for Rainy Lake that is designed to be used in the event forecasts predict that high inflow indicators in the upcoming spring are prevalent. During the development of the HFRRC, model simulations indicated that peak levels for moderately high inflow events could be slightly reduced by providing additional drawdown capacity on Rainy Lake in April. For extreme inflow events, the High Flood Risk Rule Curve was shown not to have the capacity to prevent extremely high levels on Rainy Lake and, therefore, cannot prevent flooding.

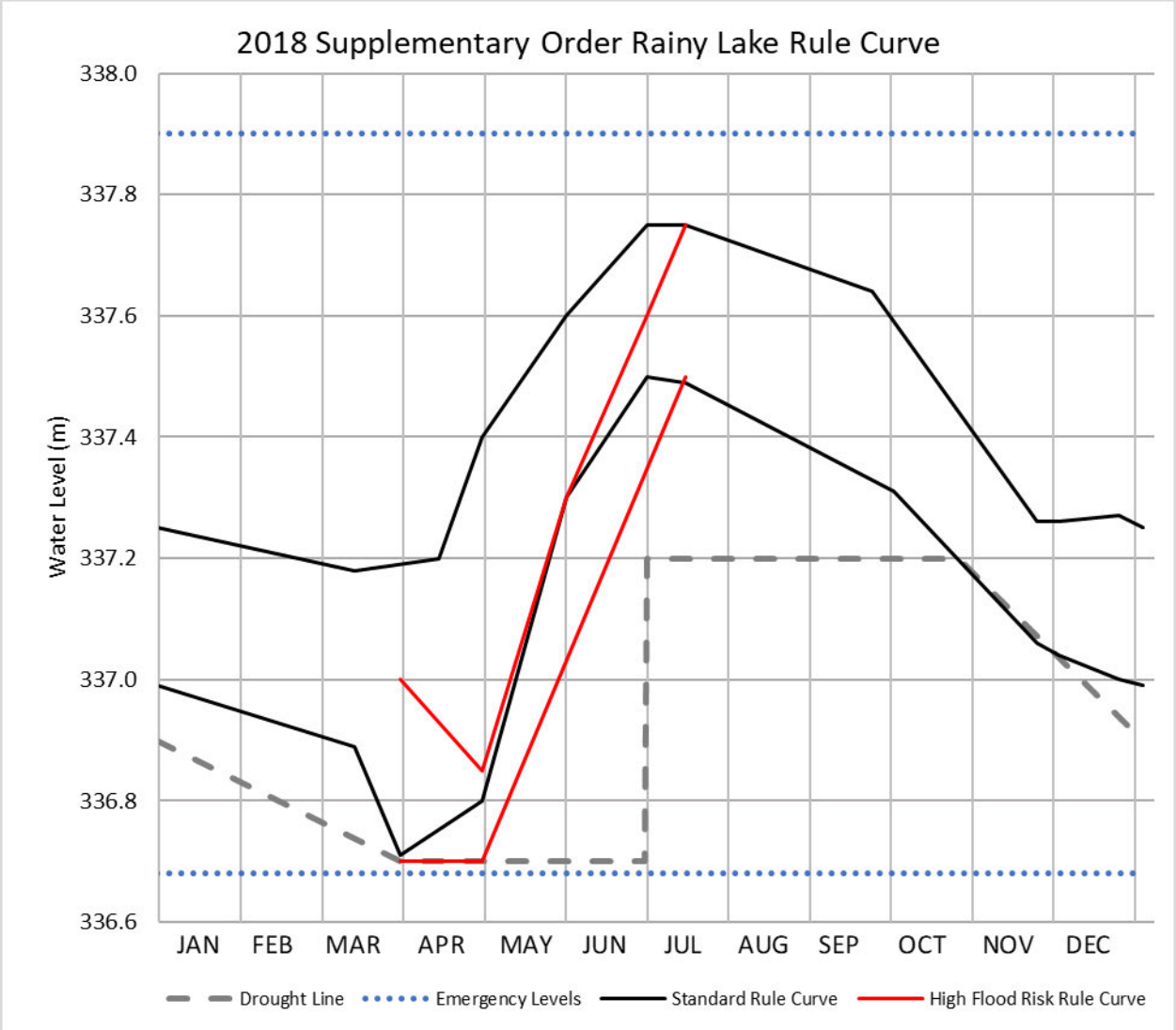


Figure 11. Rainy Lake rule curve under the 2018 Supplementary Order

During the 2022 flood, many residents in the basin raised the question on what flood impacts would have been if the HFRRC was implemented on Rainy Lake and if Namakan Lake was drawn down further before the spring runoff season. To answer this question, the Shared Vision Model (SVM) of the 2000 Rule Curve Review was used to explore what-if scenarios on Namakan and Rainy Lakes.

In the spring of 2022, the Water Levels Committee directed the dam operators to target within the 25 to 75 percent of the band of the 2018 Rule Curve on Rainy Lake. A simulation of this regulation strategy was completed, and these results can be compared to the other simulations using the 2018 Rule Curves, as shown in Table 3. The difference in peak level was 1 cm on Namakan Lake, and the level would have returned below the All-Gates Open level one day sooner. For Rainy Lake, the peak level would have been 4 cm lower and the level would have returned below the All-Gates Open level two days sooner.

Table 3. Simulated Peak Levels on Namakan and Rainy Lakes in 2022 under different Regulation Strategies using the 2018 Rule Curves.

	Namakan Lake Peak Levels in meters
Regulation Strategy	**2022**
2018 RC (between 25% and 75%) ***- used in 2022***	342.11 (42 days above all gates open level)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	342.10 (41 days above all gates open level)
	Rainy Lake Peak Levels in meters
Regulation Strategy	**2022 Peak Level (m)**
2018 RC (between 25% and 75%) ***- used in 2022***	339.21 (66 days above all gates open level)
2018 RC (bottom 25% Nam, high risk Rainy) ***- alternative***	339.17 (64 days above all gates open level)

For those impacted by flooding it is understandable that every centimeter of flood level and every day above the All-Gates Open level is meaningful, and therefore even these relatively small reductions in lake level and time are significant. However, it is key to recognize that implementing the High Flood Risk Rule Curve comes with significant risks. In the early spring the prospect of flooding is judged only based on indicators of potential, while the main driver of flooding, spring precipitation, cannot be accurately forecasted out more than a few days. Drawing down the lakes to the bottom of their rule curves based on the possibility of reducing a flood by centimeters and days in anything but the most exceptional case of potential risk is irresponsible, as the negative consequences of that action (i.e., when flood inflows do not develop) cannot be taken lightly. Spring runoff volumes help refill lakes to their higher summer water levels and lowering lake levels for anticipated runoff volumes that do not occur risk ability for lakes to remain within their rule curves. The 2017 Rule Curve Study (IRNLRCSB 2017) found that negative impacts occur to fish spawning when the HFRRC is implemented but the forecasted flood conditions do not occur. Implementing the HFRRC when flood volumes do not occur would also impact early season boating due to the low Rainy Lake levels. It was also found that aquatic plant diversity on Rainy Lake decreased, with hybrid cattail invasion worsening on Rainy Lake.

Flood Resiliency and Resources

2022 is the fourth year since 2000 where very high-water levels occurred, with the last high-water event in 2014. Rainy Lake hit record-setting water levels that were 8 cm (3.1 in) above the previous record set in 1950. Namakan Lake experienced the third highest water levels on record, just 7 cm (2.8 in) lower than the record level set in 1916. Flooding has always occurred in the Rainy River watershed and will continue to do so in the future. For shoreline structures such as docks and boathouses, there is an inherent compromise between building structures at a level that is suitable during normal water level years and also building them high enough to ensure minimal damage is sustained in times of moderately high water levels. For example, the town of Rainy River, Ontario, rebuilt a road along Rainy River to the elevation of the sand berms used in 2014 flood fighting efforts. The mitigation minimized the flood damages in 2022 though there

was still visible shoreline infrastructure damage. Unless such structures are built above the historic high-water levels, which would likely limit their usefulness in most years, they will inevitably be inundated and suffer some damage in years of extremely high inflow. When building or repairing structures that are not designed to withstand some degree of inundation, such as cabins or homes, local regulations that define hazard land elevations should be followed. The U.S, Federal Emergency Management Agency (FEMA)'s Flood Map Service Center (https://msc.fema.gov/portal/home) is the official public source for flood hazard information like maps and flood insurance studies in the U.S.

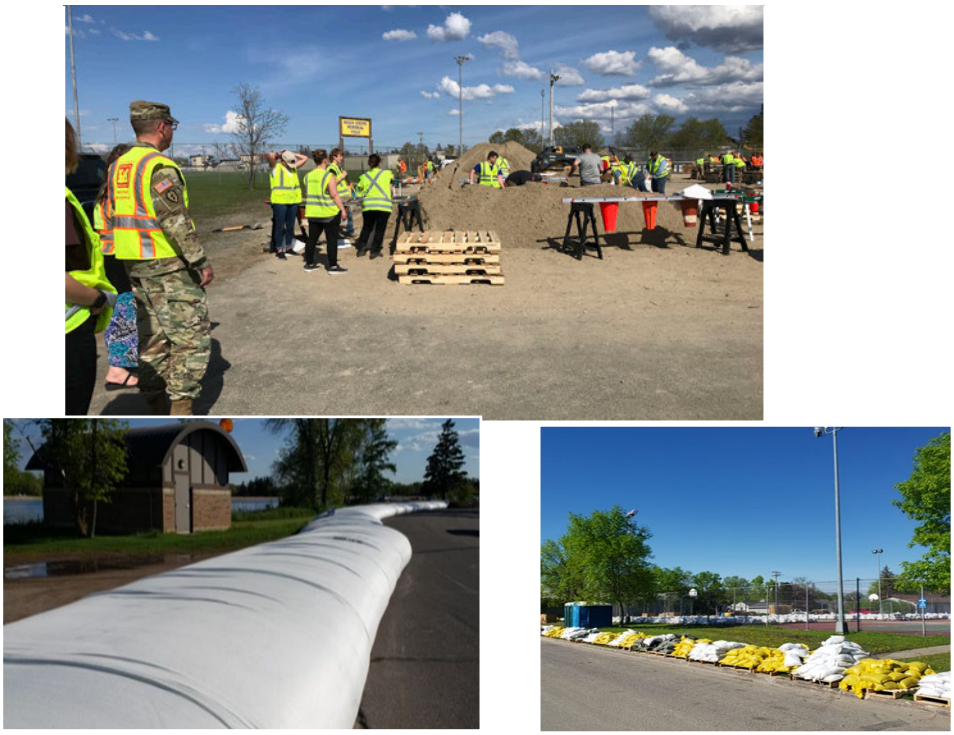


Figure 12. Sandbagging in International Falls, MN (top and bottom right photos) and flood mitigation efforts in Warroad, MN (bottom left photo).

Information about the International Joint Commission and the International Rainy-Lake of the Woods Watershed Board, including announcements for public meetings and webinars, can be found on the International Joint Commission website (https://www.ijc.org/en/rlwwb). All Water Levels Committee decisions are posted on the Water Level Decisions & Data page (https://www.ijc.org/en/rlwwb/watershed/data) within the Board's website and includes links to water level data resources, as well as websites specific to flooding and drought conditions. Of special interest on the Board's website are a series of three videos that explain the hydraulic limitations at the outlet of Rainy Lake that govern what water management is achievable during years such as 2022 (https://www.ijc.org/en/rlwwb/watershed/simulation).

The Water Levels Committee, although responsible for overseeing regulation of this transboundary basin, is not a flow-forecasting agency. Rather, those responsibilities, along with associated public safety responsibilities, lie with governments on either side of the border. In

Ontario, the Ministry of Natural Resources and Forestry, Surface Water Monitoring Centre, operates the provincial Flood Forecasting and Warning Program (https://www.lioapplications.lrc.gov.on.ca/webapps/swmc/flood-forecasting-and-warning-program/#ontarioFloodMap). Included in the information they provide are notices of flood watches and warnings and special watershed conditions statements, as well as local and provincial flood messages and information about states of emergency.

In response to the need to provide increased public information during the 2022 flood event, the United States National Weather Service created a new Rainy River Basin page on their website (https://www.weather.gov/dlh/RainyRiverBasin). The NWS basin page contains information on basin conditions and various information resources related to water level and flow conditions and water management throughout the basin, including flood briefings when flooding is forecasted.

References

Environment Canada. *Regional Deterministic Precipitation Analysis (RDPA-CaPA).* https://weather.gc.ca/grib/grib2_RDPA_ps10km_e.html

Federal Emergency Management Agency. November 17, 2022. *Flood Insurance Study Koochiching County, Minnesota and Incorporate Areas.* https://msc.fema.gov/portal/downloadProduct?productTypeID=FINAL_PRODUCT&productSubTypeID=FIS_REPORT&productID=27071CV000A

IRLWWB WLC. April 2015. *Report on High Water Levels in the Rainy River Watershed In 2014.* https://www.ijc.org/en/rlwwb/report-high-water-levels-rainy-river-watershed-2014

International Rainy and Namakan Lakes Rule Curves Study Board (IRNLRCSB). June 2017. *Managing Water Levels and Flows in the Rainy River Basin.* https://www.ijc.org/sites/default/files/IRNLRCSB_Final_Report_2017l.pdf

International Joint Commission (IJC). March 2018. *Official Compilation of the Order Prescribing Method of Regulating the Levels of Boundary Waters.* https://www.ijc.org/sites/default/files/2018-11/Docket%2050%20Official%20Compilation%20Rainy-Namakan%20Rule%20Curves%202018%2009%2013.pdf

Lake of the Woods Control Board. *Basin Data*. https://www.lwcb.ca/waterflowdata.html

MN DNR. *Weekly Snow Depth and Rank Maps.* https://www.dnr.state.mn.us/climate/snowmap/index.html

NOAA. *Interactive Snow Information*. National Operational Hydrologic Remote Sensing Center. https://www.nohrsc.noaa.gov/interactive/html/map.html

NOAA. *North American Drought Monitor (NADM).* National Centers for Environmental Information. https://www.ncei.noaa.gov/access/monitoring/nadm/maps