Lake Ontario-St. Lawrence River 2019 High Water Levels Questions and Answers

The following background paper was prepared and reviewed by staff on behalf of the International Joint Commission (IJC) and its International Lake Ontario-St. Lawrence River Board (ILOSLRB).

Over the past several months, the Board has heard from many citizens and communities and seen first-hand the devastating impacts that high water conditions in 2019 have had on shoreline properties and local economies around Lake Ontario, surroundings sectors, and on the upper and lower St. Lawrence River. The Board has taken extraordinary measures to try to alleviate impacts from these exceptional conditions, while considering the consequences for all activity sectors along the Lake Ontario - St. Lawrence River system.

While the conditions of both 2017 and 2019 were exceptional in many ways, similar high water events have occurred throughout the history of Lake Ontario - St. Lawrence River regulation and have the potential to occur again in the future. As such, the purpose of this document is to provide accurate information related to the causes of the high water levels in 2019, as well as actions taken by the Board in attempts to address these conditions through regulation of outflows. The intent is to inform shoreline residents, businesses and communities of the capacity and limitations of outflow regulation to affect conditions so that we can work collectively to identify and assess potential solutions to better prepare for the possibility of extreme conditions and high water events in the future.

Contents

Causes of the 2019 High Water Event

Question 1. What are the causes of high water levels in 2019?

Answer: Too much water entering Lake Ontario from a flooded Lake Erie, and nowhere for it to go but into a flooded St. Lawrence River.

Explanation:

These two primary factors, each stemming from above-normal precipitation, caused Lake Ontario levels to rise rapidly in the spring of 2019, eventually exceeding their record-peak of 2017, and resulting in wide-spread flooding, erosion and other high-water impacts.

Figure 1: Lake Ontario at Brighton, Ontario, 29 May 2019 (source: Lower Trent Region Conservation Authority)

The 2019 high water event was basin-wide, caused primarily by wet weather conditions across the entire Great Lakes – St. Lawrence River system. These conditions have persisted for several years and increased in intensity more recently, notably in 2017, and again during the several months of fall and winter leading up to the spring of 2019. These persistently and at times exceptionally wet conditions culminated in record or near-record high water levels and flows across the entire Great Lakes – St. Lawrence River basin.

On Lake Ontario and the St. Lawrence River specifically, after the record-wet conditions of 2017 followed by a more average spring-summer 2018, generally wet weather started again in late-fall 2018 and persisted through the spring of 2019. Similar wet conditions upstream on the upper Great Lakes resulted in record-high water levels and flooding there, and culminated in record-high inflows from Lake Erie into Lake Ontario by spring. Downstream of Lake Ontario, a late, heavy snowmelt coupled with an extremely wet spring resulted in record-high flows from the Ottawa River into the lower St. Lawrence River and rapidly rising water levels downstream. This required a significant reduction in Lake Ontario outflows and further contributed to rapidly rising water levels and eventual flooding throughout the Lake Ontario – St. Lawrence River system.

The high water levels were not caused by regulation of outflows or by Plan 2014. Water levels of both Lake Ontario and the lower St. Lawrence River would have been higher in both 2017 and 2019 had the St. Lawrence Seaway and Moses-Saunders Dam never been constructed, and the higher levels would have lasted for a longer duration.

Figure 2: St. Lawrence River at Lake Saint-Pierre, Quebec, 4 May 2019 (source: Transport Canada)

Question 2. How do high water levels on the other Great Lakes affect Lake Ontario and the St. Lawrence River?

Answer: Since water flowing from Lake Erie through the Niagara River tends to be the largest component of the total inflow to Lake Ontario, when water levels of the upper Great Lakes (including Lake Erie) are high, the flow of water into Lake Ontario also tends to be high. This raises water levels of Lake Ontario and increases the amount of water that must be released through the St. Lawrence River.

Explanation:

The Great Lakes and St. Lawrence River form an interconnected system of water bodies and river channels (Figure 3). With record-high water levels reached or exceeded across the basin in 2019, this represents an exceptionally high volume of water flowing through the system, the vast majority of which makes its way into Lake Ontario and then out through the St. Lawrence River.

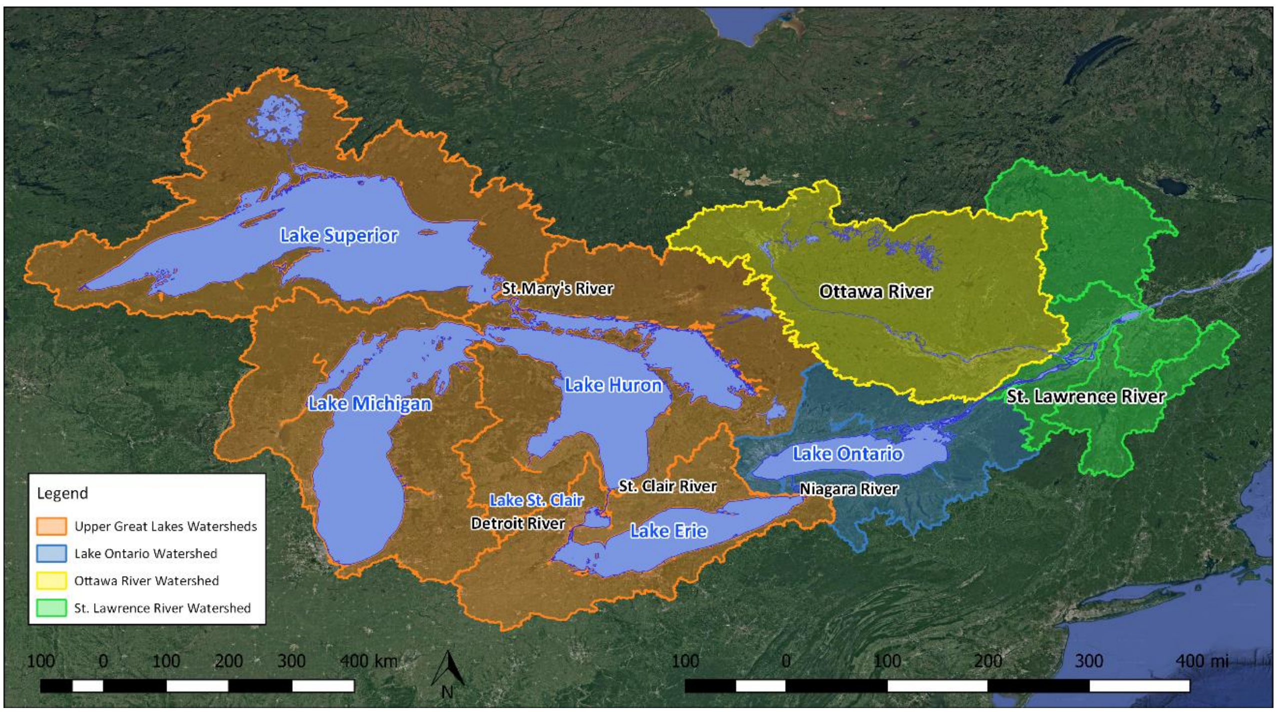

Figure 3: Map of the Great Lakes - St. Lawrence basin. Water from the upper Great Lakes basin (orange) discharges through the Niagara River and into Lake Ontario. This, plus water entering Lake Ontario from its own basin (blue), all flows out the St. Lawrence River, where it combines with water entering from the Ottawa River basin (yellow) near Montreal and other local tributaries (green), before continuing on to the Atlantic Ocean.

Starting at Lake Superior, water passes through the St. Marys River into Lake Michigan-Huron (hydraulically considered one lake due to their wide, deep connection at the Straits of Mackinac). Outflows through the St. Marys River are regulated by the IJC's International Lake Superior Board of Control (ILSBC). Similar to Lake Ontario and the St. Lawrence River, regulation of St Marys River outflows must take into consideration water levels and impacts both upstream and downstream on Lake Superior and Lake Michigan-Huron. From Lake Michigan-Huron, water flows uncontrolled through the St. Clair

River, into Lake St. Clair and then downstream through the Detroit River, which empties into Lake Erie. Water from Lake Erie flows uncontrolled through the Niagara River and Welland Canal into Lake Ontario, before eventually making its way into the St. Lawrence River on its way to the Atlantic Ocean.

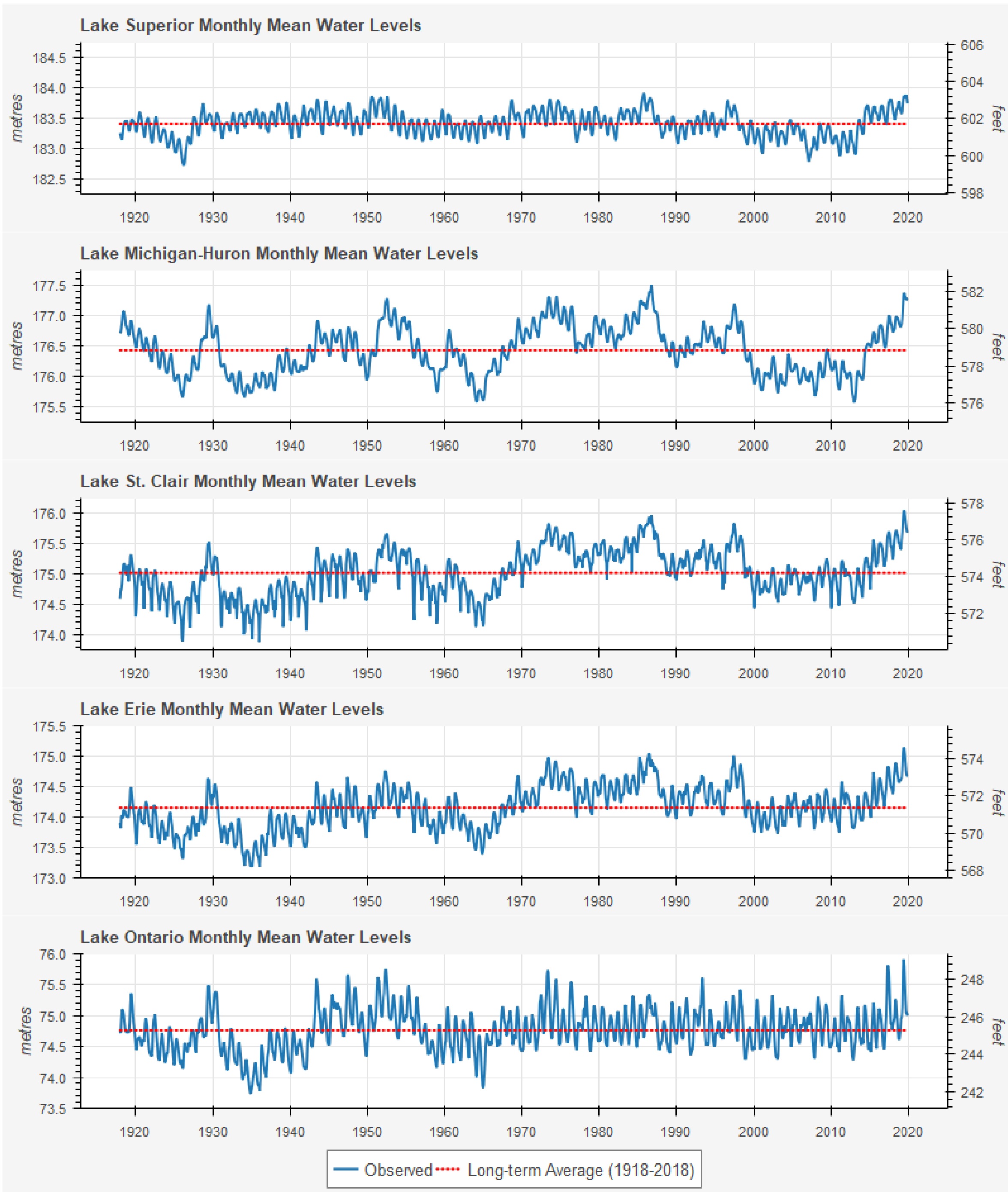

Figure 4: Great Lakes water levels show periods of highs and lows occurring throughout the past century

Water levels fluctuate naturally on the Great Lakes due primarily to weather driven variations in water supplies, with periods of high and low water levels occurring throughout recorded history (Figure 4).

Water supplies include water flowing in from the lake upstream and from precipitation (rain/snow) that falls directly on the lake and its surrounding watershed, minus the water that leaves the lake through evaporation. Water also flows out of each lake, through its outlet channel, and into the downstream water body. Over longer periods lasting more than several years, outflows tend to equal inflows; otherwise, lake levels would continually rise or fall. However, over shorter periods of days, weeks and months, differences in the amount of water entering and leaving the lakes cause their levels to rise or fall, and can result in periods of high or low levels that may persist for up to several years.

> ***What is the International Niagara Control Works?***
>
> *A partial structure exists above Niagara Falls on the Niagara River, known as the International Niagara Control Works. Operation of this structure does not change the total flow of the Niagara River and has no measurable effect on Lake Erie water levels; rather, it is used to direct water to the power plants or over Niagara Falls in order to meet the apportionment objectives of an agreement between Canada and the United States known as the Niagara River Treaty of 1950.*

After nearly 15 years of below-average water levels on Lake Superior and Lake Michigan-Huron, water levels of the upper Great Lakes started rising in 2013, and have been well above-average for several years. Then in 2019, following several months of wet weather, water levels on Lake Superior, Lake St. Clair and Lake Erie each exceeded their seasonal record-highs in early-May, prior to record-highs being exceeded on Lake Ontario in late-May. Lake Michigan-Huron was at or near record-highs since the end of May, but did not exceed them in 2019.

Whether regulated or unregulated, high Great Lakes water levels also result in high outflows. With all of the Great Lakes above or near record-highs, this represents an unprecedented volume of water in the Great Lakes system, and other than water lost to evaporation, it all eventually makes its way into Lake Ontario and out the St. Lawrence River.

Question 3. Did the outflow from Lake Erie through the Niagara River set a record in 2019 and how did this contribute to Lake Ontario's record-high water levels?

Answer: Yes, record-high outflows from Lake Erie, into Lake Ontario, occurred in the spring and were a primary cause of the record-high levels on Lake Ontario in 2019, even more so than in 2017.

Explanation:

Lake Ontario receives the majority of its water from Lake Erie - about 85 percent on average, with most of it entering from the Niagara River and a much smaller amount entering from the Welland Canal. The total flow out of Lake Erie is completely uncontrolled.

Leading into 2019, water levels of the upper Great Lakes, including Lake Erie, had been above average for several years. This was followed by generally persistent, widespread, above-average precipitation during the winter and spring of 2019, resulting in rapidly rising water levels, with the upper Great Lakes reaching levels not seen since the previous record-highs of the mid-1980s.

Lake Erie exceeded historical records starting in early-May 2019 and these record-highs continued through summer (Figure 5). This resulted in above-record inflows from Lake Erie into Lake Ontario. In terms of magnitude, inflows from Lake Erie in May 2019 alone added the equivalent of 113 cm (44 inches) of water to Lake Ontario. This is 24 cm (9.4 inches) more than the average May input, and compared to May 2017, Lake Erie added an extra 2 cm (0.8 inches) per week of water to Lake Ontario in May 2019.

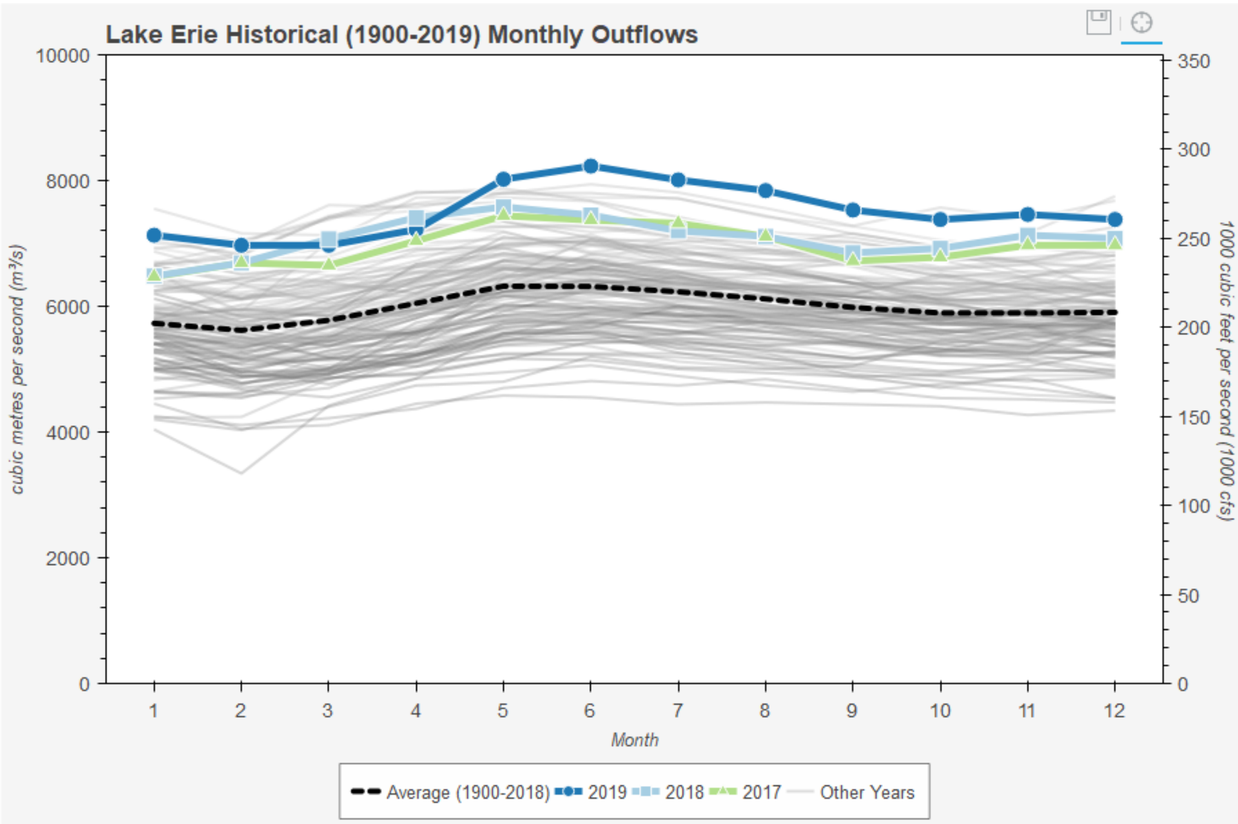

Figure 5: Lake Erie monthly mean outflows, each line representing an individual calendar year (1900-2019). Record- or near-record-high inflows were experienced throughout 2019.

Question 4. How much precipitation was received around Lake Ontario and the St. Lawrence River prior to spring 2019, and how does this compare to 2017?

Answer: While total precipitation across the Lake Ontario – St. Lawrence River basin was less than during the record-breaking January – May period of 2017, precipitation was again well-above normal and for a prolonged period, starting around late-fall of 2018 and continuing through spring 2019.

Explanation:

The most significant precipitation totals were observed along the northern and eastern shores of Lake

Ontario, and downstream along the St. Lawrence and Ottawa Rivers.

For example, from November through May (Table 1), 555.6 mm (21.9 inches) of precipitation was recorded at Toronto, ON, the 4th highest total recorded at this location over this seven-month period since 1938, while in Watertown, NY, a total of 823.7 mm (32.4 inches) was recorded during this same seven-month period, the 2nd highest total at this location since 1898. Downstream, the 717.8 mm (28.3 inches) recorded at Montreal, QC, was the 5th highest November to May total since 1942, while the 613 mm (24.1 inches) recorded in Ottawa, ON was the 7th highest on record since 1890.

Table 1: Total precipitation across the Lake Ontario – St. Lawrence River basin, November to May 2019

Location	Station Name (ID)	Period of Record	Nov 2018 - May 2019 Precipitation		Nov - May Historical Statistics		
			Total	Historical Rank	Average	Maximum	Year
Buffalo, NY	Buf. Niagara Intl (USW00014733)	1938-2019	675.1 mm (26.58 in.)	11th	557.8 mm (21.96 in.)	770.9 mm (30.35 in.)	1990-1991
Rochester, NY	Roc. Greater Intl (USW00014768)	1926-2019	499.6 mm (19.67 in.)	29th	459.7 mm (19.67 in.)	647.4 mm (25.49 in.)	***2016-2017***
Watertown, NY	Watertown, NY (USC00309000)	1898-2019	823.7 mm (32.43 in.)	2nd	576.5 mm (22.7 in.)	827.0 mm (32.56 in.)	2008-2009
Toronto, ON	Toronto LBP Intl A. (6158733)	1938-2013	555.6 mm (21.87 in.)	4th	426.3 mm (16.78 in.)	581.2 mm (22.88 in.)	***2016-2017***
	Toronto Intl A. (6158731)	2013-2019					
Ottawa, ON	Ottawa CDA (6105976)	1890-2019	613.0 mm (24.13 in.)	7th	470.3 mm (18.52 in.)	715.8 mm (28.18 in.)	1946-1947
Montreal, QC	Montreal Intl A. (7025251)	1942-2019	717.8 mm (28.26 in.)	5th	547.2 mm (21.55 in.)	745.6 mm (29.35 in.)	***2016-2017***

Other areas around the basin, particularly those to the south of Lake Ontario in the state of New York, did not see as much precipitation through the fall, winter and early-spring. For example, Rochester, NY, saw 499.6 mm (19.67 inches), which is above-average, but only the 29th highest November to May total on record since 1926. This differs from 2017, where the entire Lake Ontario, Ottawa and St. Lawrence River basin saw very high precipitation amounts over a shorter period, with many locations setting records for the period of January through May 2017.

Nonetheless, while conditions across Lake Ontario and the St. Lawrence River basins were generally wetter overall in 2017 than in 2019, inflows from Lake Erie and the Ottawa River were substantially greater in 2019.

Question 5. Did Lake Ontario total inflows set records in 2019 and how do they compare to 2017?

Answer: Yes, new record monthly inflows were set in February and May 2019, and the combination of generally wet weather and high inflows from Lake Erie caused Lake Ontario's net total supply (total inflows) to be near or above historical records for several months prior to the record-high water levels being reached in spring.

Explanation:

Water levels on Lake Ontario began rising in November 2018 in response to wet weather and rising Lake Erie levels. Net total supplies (Figure 6) to Lake Ontario in November and December 2018 were the 4th and 5th highest for those months on record, respectively.

Record-precipitation fell across the Lake Ontario - St. Lawrence River basin in 2017, but inflows from both Lake Erie and the Ottawa River were substantially greater and record-setting in 2019.

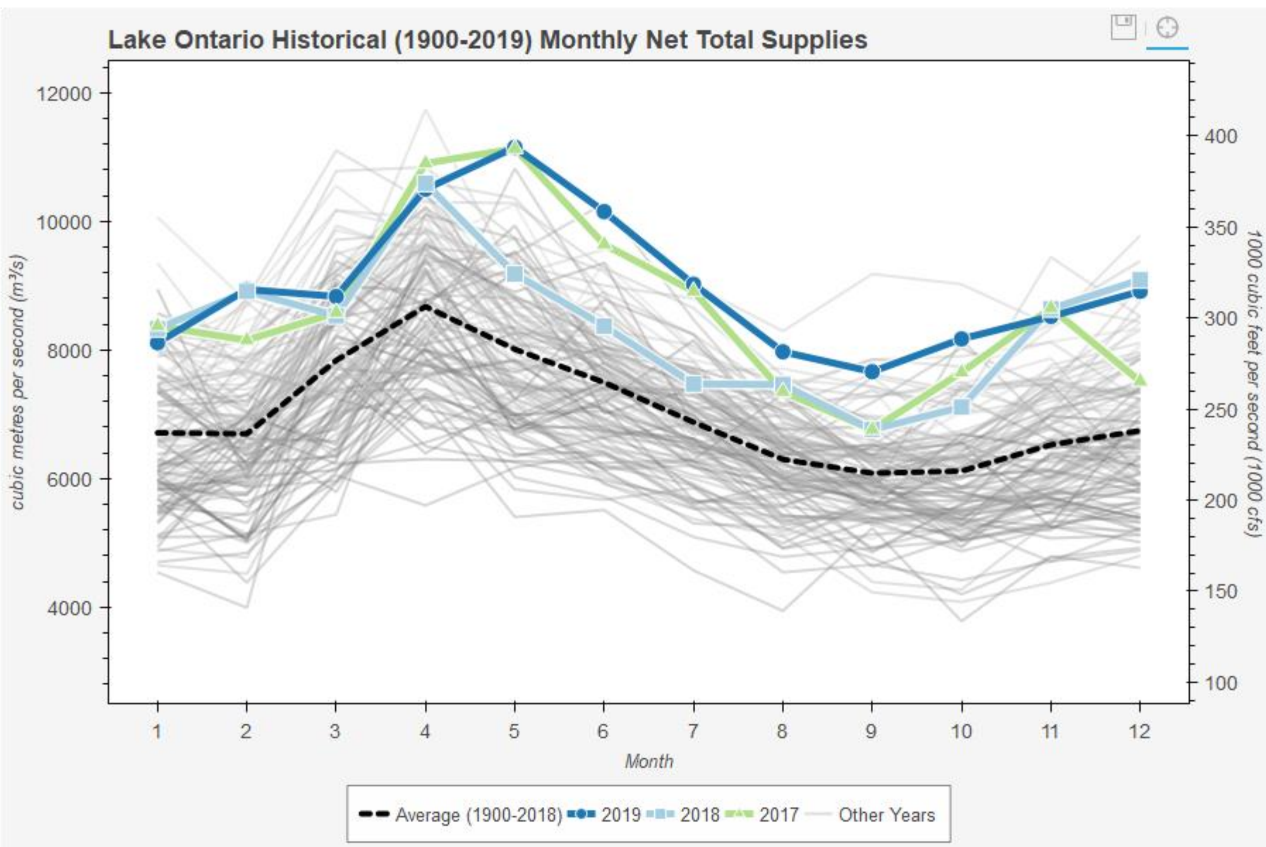

Figure 6: Lake Ontatio monthly mean net total supplies, which include inflows from Lake Erie, over-lake precipitation and basin runoff, minus evaporation. Each line represents an individual calendar year (1900-2019). Record- or near-record-high inflows were experienced throughout 2019.

January and February saw high inflows continue. Record-high net total supplies were recorded for the month of February 2019, following just one year after the previous February record set in 2018.

The spring started somewhat drier in March and early-April, but inflows from Lake Erie remained high and ensured net total supplies remained well above-average.

Table 2: Lake Ontario net total supplies (inflows): highest months recorded since 1900

Rank	Year	Month	Net Total Supply
1	1993	April	*11,700 m^3/s (413,200 cfs)*
2	***2019***	***May***	***11,150 m^3/s (393,800 cfs)***
3	***2017***	***May***	***11,040 m^3/s (389,900 cfs)***
4	1976	March	*10,970 m^3/s (387,400 cfs)*
5	***2017***	***April***	***10,830 m^3/s (382,500 cfs)***
6	1973	April	10,800 m^3/s (381,400 cfs)
7	1973	March	10,680 m^3/s (377,200 cfs)
…	…	…	…
12	***2018***	***April***	***10,550 m^3/s (372,600 cfs)***
13	***2019***	***April***	***10,500 m^3/s (370,800 cfs)***

The remainder of spring was exceptionally wet. Total inflows to Lake Ontario during April 2019 were very high, the 8th highest April on record and the 13th highest net total supply recorded in any month of the year. Inflows to Lake Ontario are typically at their annual peak in the month of April, but instead of decreasing in May, net total supplies increased. According to provisional data, May 2019 exceeded the previous record set for the month of May in 2017. May 2019 recorded the second highest total inflow for any month of the year dating back to 1900, and April-May 2019 combined are the 2nd highest two-month total ever recorded, behind only April-May 2017.

Question 6. Why did Lake Ontario start rising in November 2018?

Answer: Water levels of Lake Ontario began rising in November 2018 in response to wet weather and rising Lake Erie levels, which caused increasing inflows to Lake Ontario through the Niagara River.

Explanation:

Net total supplies to Lake Ontario in November and December 2018 were the 4th and 5th highest on record for those months, respectively.

Lake Ontario outflows, which were already well above average, also increased at the same time that inflows began to rise (Figure 7). The high outflows resulted in continued low levels on Lake St. Lawrence during this period, and yet despite the increase, outflows could not fully offset the rising inflows at that time.

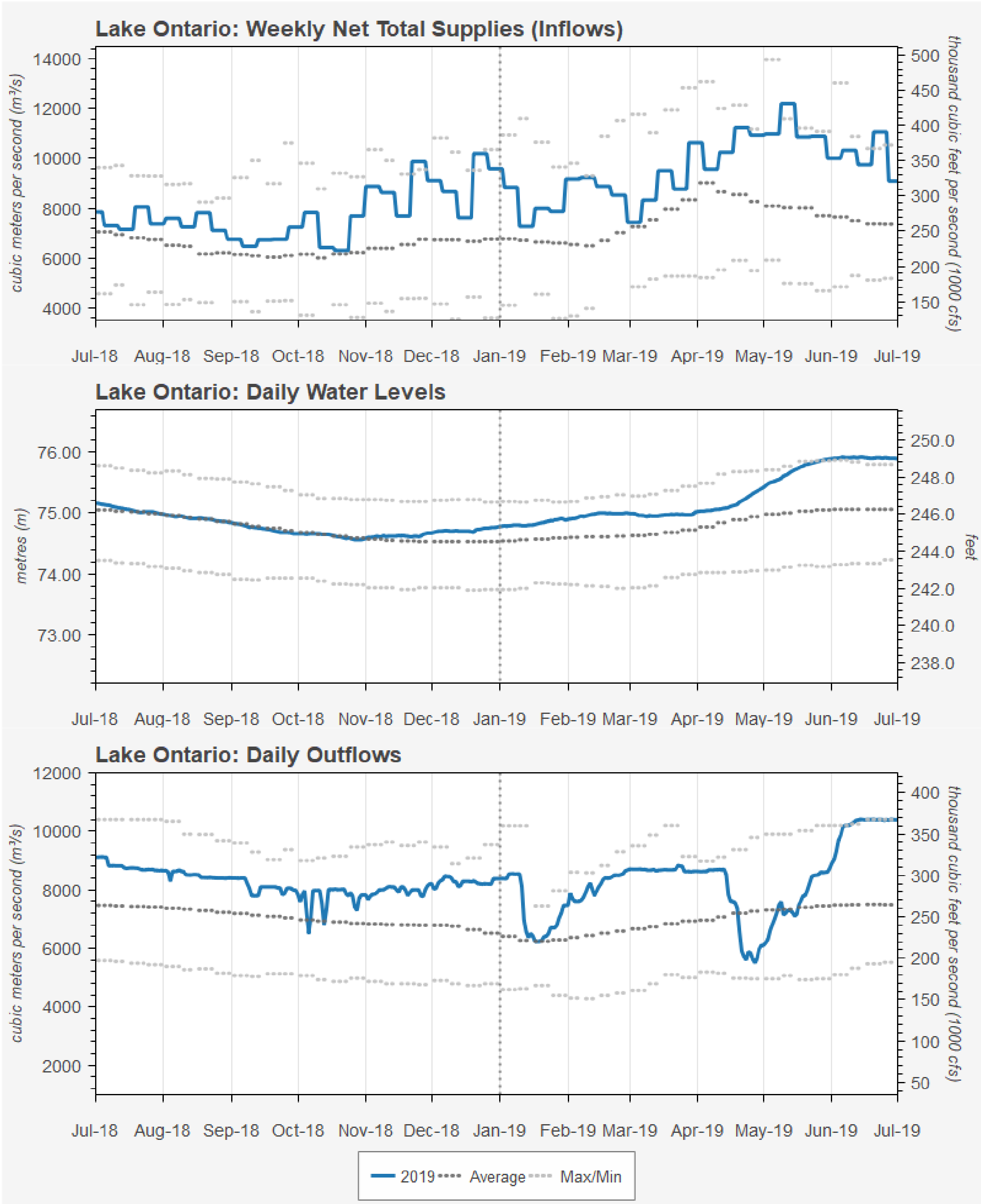

Figure 7: Lake Ontario net total supplies, i.e., inflows (top) were above average from 1 July 2018 through 30 June 2019, at times exceeding record-highs. Lake Ontario water levels (middle) were near-average during summer/early-fall 2018, but started rising in late-fall as inflows rose rapidly. Outflows (bottom) were well-above average throughout this 12-month period, except when temporarily limited by ice formation in January/February 2019 and during the record Ottawa River freshet that spring.

Outflows in 2018-2019

Question 7. Why wasn't more water released in 2018 when Lake Erie levels were high and downstream flooding wasn't an issue?

Answer: A lot of water was released from Lake Ontario in 2018 for exactly this reason, and this, along with near-average water levels of Lake Ontario, contributed to very low levels on Lake St. Lawrence during this time.

Explanation:

Prior to the record-high water levels in spring 2019, Lake Erie had been relatively high for several years, as had the other Great Lakes. Outflows from Lake Ontario have reflected this, and in fact, have also consistently been kept very high since the record-flooding of 2017, with the exception of the temporary reductions required during the springs of 2017 and 2019 when flooding was occurring both upstream and downstream.

In fact, throughout the summer and fall of 2018, while Lake Ontario levels were at or near the long-term-average, the high Lake Ontario outflows resulted in very low, and at times record-low, water levels on Lake St. Lawrence, immediately upstream of Moses-Saunders Dam (Figure 8). Click here for a video describing the effects of regulation on water levels in Lake St. Lawrence. Low levels, as well as high current velocities in this area, had impacts on recreational boaters, shoreline property owners and commercial navigation.

Figure 8: Lake St. Lawrence at Croil Island near Massena, New York, 16 September 2018 (source: ILOSLRB)

Question 8. Why wasn't more water released from Lake Ontario during the winter? Why were outflows reduced during January and February?

Answer: Outflows must be temporarily reduced nearly every winter as ice forms on the St. Lawrence River in order to facilitate the formation of a stable ice cover, which reduces the risk of ice jams and allows higher outflows to be released later on.

Explanation:

As ice forms on the St. Lawrence River, outflows can be temporarily reduced to slow down the river current and reduce the forces acting on the fragile ice cover, allowing a solid ice cover to form and stabilize. This helps reduce the risk of ice jams and limits frazil ice growth in the river that can physically block and severely restrict flows. Severe ice jams can result in immediate localized flooding and an immediate reduction in outflows. If such ice restrictions last for a long duration, outflow may be reduced for an extended period during the winter, leading to higher Lake Ontario levels heading into spring.

What is frazil ice?

Frazil ice is composed of loosely consolidated, tiny ice particles that form in flowing water. These particles can look like irregularly shaped pans of slush at the surface, and extreme cold temperatures can cause frazil to form rapidly in open areas. In deep, fast moving water, frazil ice can be transported within the water column, where it may collect and adhere to other ice particles or to the riverbed, narrowing the channel cross-section and restricting flows.

In 2019, ice began forming around mid-January and continued into February. Once ice had formed and stabilized, outflows were increased relatively rapidly thereafter. In fact, the amount of water released during the winter (from December 2018 – February 2019, combined) was relatively high historically, as only 3 years have seen more water released during these three months, those being 1987, 1997 and last year, 2018.

Question 9. Why was more water released in January and February 2018 than during the same months in 2019?

Answer: Compared to 2019, ice formed more rapidly in early-January 2018 allowing somewhat higher outflows to be released earlier on in winter, but overall, outflows were very high during January and February in both years.

Explanation:

Extreme and, at times, record-cold temperatures at the end of 2017 and start of January 2018 allowed ice to form more rapidly and earlier in 2018 than it did in 2019, and this allowed outflows to be increased sooner as well. Regardless, outflows released in January and February in both 2018 and 2019 are historically high, the 2nd and 4th highest on record, respectively (Figure 9). These high winter flows were possible due to consistently cold temperatures and the solid, stable ice conditions that this promoted. By comparison, ice formation in 2017 was much more complicated, as unusual temperature fluctuations required that Lake Ontario outflows be almost continuously adjusted to manage highly variable ice conditions in the St. Lawrence River. More information on the difficulties of ice management in 2017 can be found in the Board's report on 2017 conditions **here**.

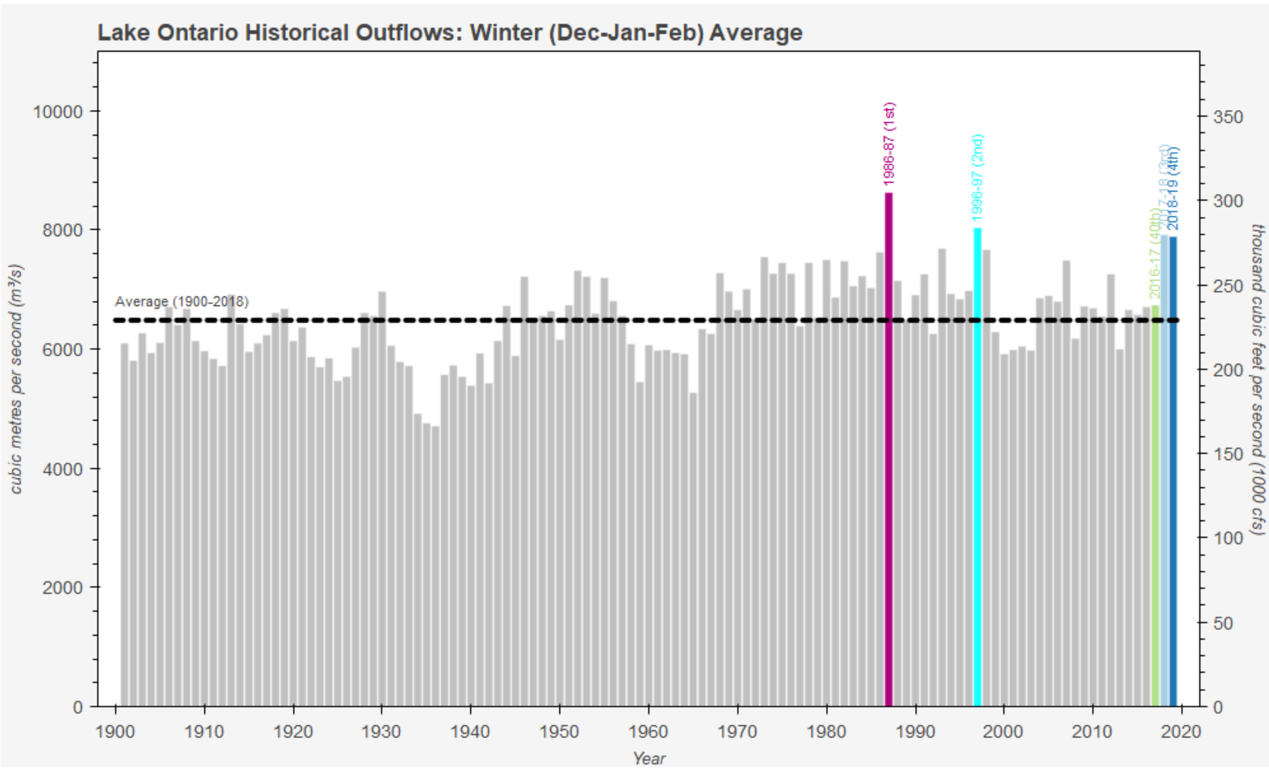

Figure 9: Lake Ontario mean outflows during winter (Dec-Jan-Feb) from 1900-2019. Outflows during the winter of 2018-2019 were on average the 4th highest ever recorded, despite limitations posed by low Lake St. Lawrence levels in December and ice conditions in January/February.

Question 10. Why were outflows from Lake Ontario reduced during the spring of 2019?

Answer: Outflows from Lake Ontario were reduced to mitigate – but not eliminate – damaging flooding in the lower St. Lawrence River during a record-setting Ottawa River freshet in the spring of 2019.

Explanation:

The Ottawa River enters the St. Lawrence River near Montreal and combines with the flow released from Lake Ontario. Each spring, milder temperatures, snowmelt and rainfall increase Ottawa River flows, and the timing and magnitude needs to be considered carefully when regulating Lake Ontario outflows to manage water levels on the St. Lawrence River (see also Question 16 and Figure 15).

In 2019, a heavy snow-pack on the Ottawa River basin lasted into mid-April as a result of colder than normal temperatures in early-spring. Major rains fell over the Ottawa River basin in late-April and continued into May. These rains combined with the rapid, late snowmelt to result in record-high runoff and flows from the Ottawa River into the St. Lawrence River, and in some places even greater water levels than those seen just two years prior during the record flooding of 2017.

Question 11. Why were outflows during the spring of 2019 lower than during the springs of 2017 and 2018 and why were they lower for so long?

Answer: Outflows from Lake Ontario were, at times, lower in the spring of 2019 because Ottawa River flows were higher (record-high, at their peak) and they lasted for a much longer duration.

Explanation:

Record-high Ottawa River flows lasting a record-duration in 2019 (Figure 10) were caused by the combination of an unusually deep, dense snowpack and a late melt, which occurred at the same time as exceptionally heavy rains in late-April and early-May.

The record-peak Ottawa River daily flow recorded at Carillon Dam in 2019 was 9217 m^3/s (325,500 cfs), higher than the previous record of 9094 m^3/s (321,200 cfs) set 8 May 2017, and more than 3000 m^3/s (105,900 cfs) above the peak daily flow recorded in 2018 of 5860 m^3/s (206,900 cfs).

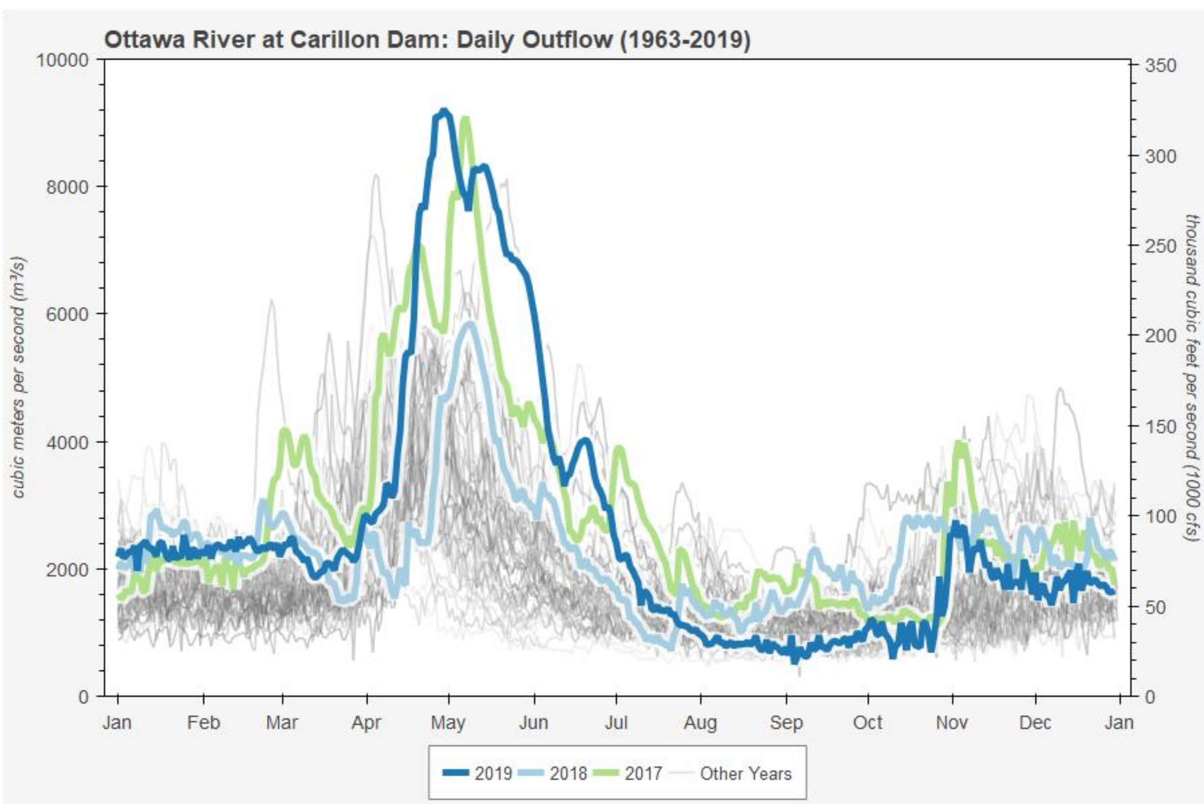

Figure 10: Ottawa River daily flows at Carillon Dam. Each line represents an individual calendar year (1963-2019). Record flows lasting a record duration occurred in the spring of 2019, all entering the lower St. Lawrence River near Montreal.

The exceptionally high Ottawa River flows in 2019 also lasted for a much longer duration. For example, Ottawa River flows were above 8000 m³/s (282,500 cfs) for 21 days in 2019, but only 6 days in 2017, and Ottawa River flows were above the highest daily flow recorded in all of 2018 (5860 m³/s (206,900 cfs) on 10 May) from 19 April to 3 June 2019, a full month and a half.

Table 3: Ottawa River flows: highest months recorded since completion of Carillon Dam in 1963

Rank	Year	Month	Ottawa River Flow
1	***2019***	***May***	***7731 m³/s (273,000 cfs)***
2	1974	May	6459 m³/s (228,100 cfs)
3	***2017***	***May***	***6138 m³/s (216,800 cfs)***
4	1976	April	5806 m³/s (205,000 cfs)
5	***2019***	***April***	***5404 m³/s (190,800 cfs)***
6	***2017***	***April***	***5340 m³/s (188,600 cfs)***
7	1979	May	5119 m³/s (180,800 cfs)
…	…	…	…
16	***2018***	***April***	***4467 m³/s (157,800 cfs)***

The Ottawa River monthly mean flows also set a new record-high for the month of May 2019, exceeding the previous monthly record in 1974 as well as the second highest on record in 2017 by more than 1000 m³/s (35,300 cfs). April 2019 was also the 5th highest month on record, and the months of April and May 2019 combined far exceed any previous 2-month period.

Question 12. How can outflows impact navigation safety?

Answer: Outflows were increased and sustained at record-high rates for an extended period in the summer of 2019 to increase the rate of decline on Lake Ontario, but this also increased the current velocity of the St. Lawrence River and increased the risks to safe commercial navigation.

Explanation:

The Board's priority in 2019 was to reduce the impacts of high water conditions on shoreline riparians, businesses and communities both upstream and downstream in the Lake Ontario – St. Lawrence River system. In doing so, the Board must consider the degree of relief that can be provided, as well as the consequences to all interests, including navigation.

Starting 10 June, as flooding conditions subsided downstream in the lower St. Lawrence River, outflows were increased above the flows that would have been prescribed by Plan 2014 in order to increase the rate of water level decline on Lake Ontario. By 13 June, outflows reached the record-high outflow of 10,400 m³/s (367,300 cfs). This flow rate was first achieved in 2017 and constitutes the highest flow ever released on a sustained basis. These record-matching outflows were maintained from mid-June through mid-August, even longer than in 2017.

When outflows are increased, this increases the velocity of currents in the St. Lawrence River. To maintain safe conditions for navigation during the sustained, record-high flows, the Seaway entities imposed speed limits, no passing restrictions and other mitigation measures.

Releasing higher outflows than those set by the Board during the summer of 2019 would have increased currents in the international section of the St. Lawrence River to an extent that would have effectively forced the stoppage of commercial navigation. This would have further impacted people's lives and disrupted the economy throughout the Great Lakes region, without providing significant additional relief on Lake Ontario.

Furthermore, the gradual decline of Lake Ontario and upper St. Lawrence River levels through the summer months caused the velocity in the river to gradually increase, even while outflow was maintained at the same record-rate. This presented additional challenges, and eventually, maintaining record-high flows was no longer safe for navigation. As a result, starting in mid-August, flows were gradually reduced to ensure safe river currents and to allow ship transits to continue.

Question 13. How effective were the deviation strategies of 2017 and 2019 compared to the strategy employed during the summer of 1993, when outflows were set at alternating rates that temporarily stopped commercial navigation?

Answer: The Board's deviation strategy in 2017 and 2019 resulted in continuously higher outflows released for a longer duration when compared to the strategy in 1993. Record-sustained outflows averaging 10,400 m^3/s (366,900 cfs) were released for 54 days in 2017 and 69 days in 2019. Compared to 1993, when outflows averaged 10,190 m^3/s (359,900 cfs) over just 23 days, the strategies employed in 2017 and 2019 allowed more water to be removed from Lake Ontario, a greater rate of lowering and more rapid relief to Lake Ontario riparians, and with fewer impacts on other stakeholders.

Explanation:

In both 2017 and 2019, Lake Ontario outflows were set higher than those released in 1993 on a weekly basis and were sustained for a longer period, while permitting navigation to continue with the Seaway's mitigation measures in place. The flow of 10,400 m^3/s (366,900 cfs) is the highest sustained outflow on record. In 2019, this flow of 10,400 m^3/s was maintained from 13 June to 21 August, and over those 69 days, this record-outflow removed the equivalent of about 3.17 m (10.4 ft) of water from Lake Ontario. This is more than the total number of days that the same record-outflow was sustained during the summer of 2017, when it lasted from 14 June to 8 August, and removed just over 2.5 m (8.2 ft) of water.

The only time higher outflows have ever been released for any duration was during the high-water event of 1993, when temporary, 24-hour flow increases from 9900 to 10,900 m^3/s (349,600 to 384,900 cfs) occurred approximately twice per week from 20 May to 11 June 1993. Over this 23-day period, outflows were increased a total of seven times and the Seaway suspended navigation during each of these 24-hour flow increases. The average outflow over the entire 23 days that this strategy was implemented in 1993 was 10,190 m^3/s (359,900 cfs), equivalent to removing 104 cm (41 inches) of water from Lake Ontario, much less than what was achieved in 2019 and in 2017, and with greater impacts on other interests.

Overall, the outflows released during the summers of 2017 and 2019 were record-setting (Figure 11). The higher sustained outflows in 2017 and 2019 were made to lower water levels in consideration of Lake Ontario and upper St. Lawrence River riparian interests primarily, but other interests throughout the Lake Ontario – St. Lawrence River system were also considered. In addition to commercial navigation, the safety of recreational boaters and other users along the St. Lawrence River would have also been impacted by a strategy involving fluctuating outflows, both in the upper and lower St.

Lawrence River. The higher temporary outflows that this strategy would have entailed would have also increased high-water impacts downstream, including flooding and erosion along the lower St. Lawrence River. Instead, the strategy in 2017 and 2019 resulted in more predictable conditions for all users, while still ensuring record-high releases and a greater rate of lowering of Lake Ontario than was achieved in 1993, and with fewer impacts on other stakeholders.

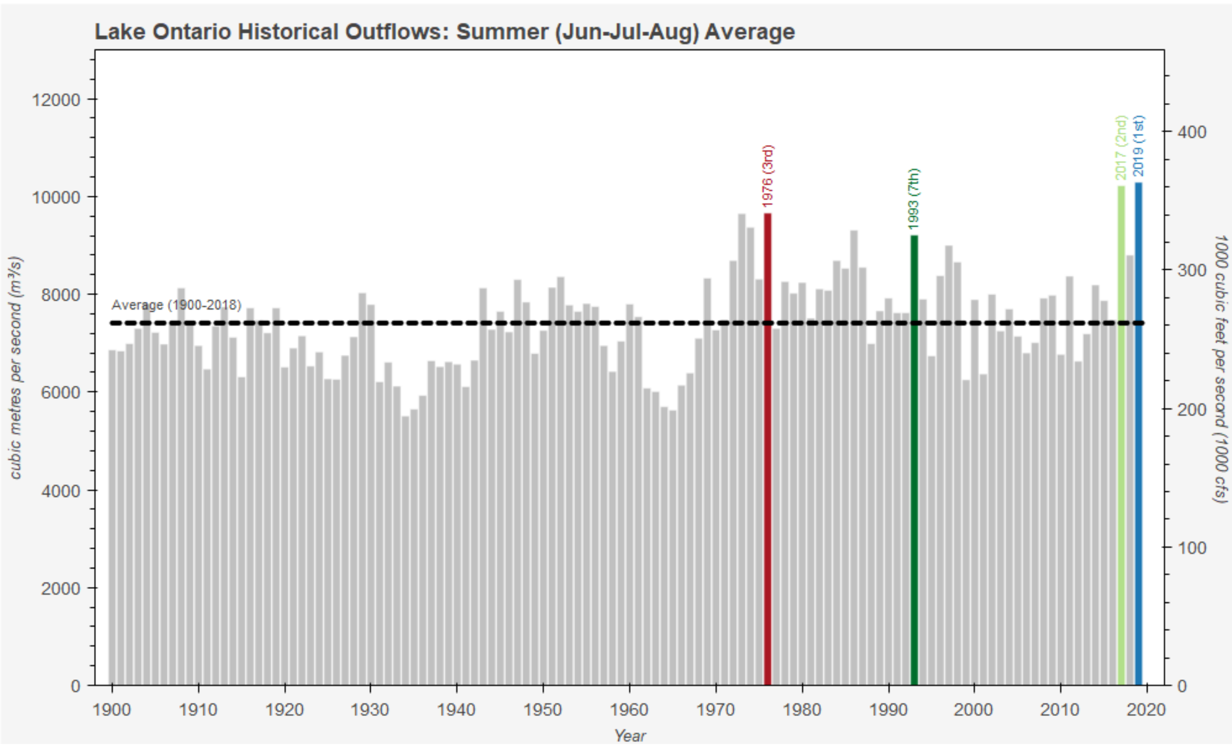

Figure 11: Lake Ontario mean outflows during summer (Jun-Jul-Aug) from 1900-2019. Outflows during the summer of 2019 were the highest ever recorded, exceeding the previous record set in the summer of 2017.

Question 14. Why were flows reduced in October for Lake St. Lawrence boat haul-out?

Answer: High outflows from Lake Ontario contribute to low levels on Lake St. Lawrence. Flow reductions were necessary to create enough depth for Lake St. Lawrence boaters to access boat ramps and lifts.

Explanation:

The extremely high outflows, especially after Lake Ontario reached lower levels in August, reduced the level of Lake St. Lawrence just upstream (west) of Moses-Saunders Dam at Cornwall, Ontario and Massena, New York. This left many boats grounded, and many marinas and boaters unable to remove their vessels prior to winter. Reducing the outflow for one weekend in the fall (12-13 October 2019) raised the level of Lake St. Lawrence sufficiently to assist with boat haul-out without any significant impact on the level of Lake Ontario.

Figure 12: Lake St. Lawrence at Long Sault, Ontario, 10 October 2019 (source: ILOSLRB)

Effects of Regulation

Question 15. Would water levels have been lower without the St. Lawrence Seaway and Moses-Saunders Dam?

Answer: No, water levels of both Lake Ontario and the lower St. Lawrence River would have been higher in 2017, 2018 and 2019 had the St. Lawrence Seaway and Moses-Saunders Dam never been constructed, and the higher levels would have lasted for a longer duration.

Explanation:

In addition to the construction of Moses-Saunders Dam and the navigation locks, the St. Lawrence Seaway project involved significant dredging in the upper St. Lawrence River. This makes it physically possible to release higher outflows now than prior to the project.

As a result, higher regulated outflows are generally released when Lake Ontario is high, prior to and following the spring Ottawa River freshet, which lowers Lake Ontario's water level. Moses-Saunders Dam makes it possible to reduce outflows to below what they would have been without the project, which reduces the peak level in the lower St. Lawrence River during the spring Ottawa River freshet.

The outflow conditions that would occur without the St. Lawrence Seaway/Moses-Saunders Dam project can be simulated using a relationship between the observed water levels and flows that occurred prior to the construction of the project (Figure 13). This relationship is known as the pre-project relation. The left plot compares the actual weekly mean outflow from 2017 through 2019 to the pre-project outflows calculated weekly for the same inflows or supplies to Lake Ontario. Similarly, the top right plot compares the weekly mean water level of Lake Ontario from 2017 through 2019 to the simulated pre-project level based on the pre-project outflows, while the bottom right plot compares the actual and pre-project weekly mean levels of Lake St. Louis.

Regulation reduces the severity of high water impacts on both Lake Ontario and the lower St. Lawrence River. In 2017 and 2019, it reduced the peak and duration of flooding; in 2018, it helped prevent flooding altogether.

As shown, the project and regulation allowed higher outflows than the natural, pre-project river channel before and after the spring. In 2019, this reduced the peak Lake Ontario level by approximately 35 cm (13.8 inches) and hastened the decline afterwards. It also allowed outflows to be temporarily reduced during the critical flooding downstream at Lake St. Louis when the Ottawa River flows were at record-highs, reducing the peak level at Lake St. Louis by over 50 cm (1.6 ft).

On its own, regulation cannot prevent flooding during periods of extreme wet weather and high inflows. However, the project and regulation do reduce the severity of high water impacts, on both Lake Ontario and the lower St. Lawrence River. During the extremely wet conditions and high inflows in 2017 and 2019, it reduced the peak and duration of flooding that occurred. In 2018, under more moderately high inflow conditions, the project and regulation were able to help prevent flooding altogether.

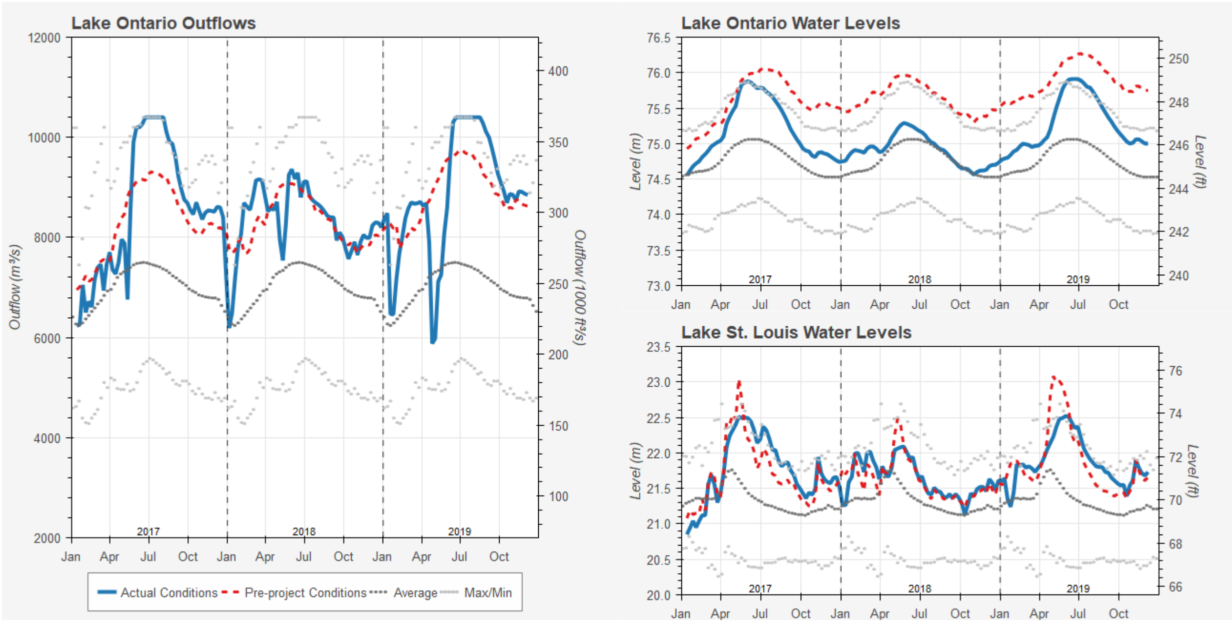

Figure 13: Actual (observed) versus pre-project (simulated) conditions from 2017 through 2019. Channel excavations during construction of the project allowed actual Lake Ontario outflows (left) to be higher before and after spring. This resulted in lower Lake Ontario water levels (top right) in general, and lower Lake St. Louis water levels (bottom right) during the spring of all three years, including 2018 when flooding was prevented.

Question 16. Did Plan 2014 cause the high water levels?

Answer: No, the high water levels were caused by wet weather and record-high inflows from Lake Erie and the Ottawa River.

Explanation:

The record-high water levels in 2019 followed persistently above-average precipitation across the Great Lakes basin that lasted several months, and which resulted in record-high inflows from Lake Erie, as well as the record-high flows from the Ottawa River system. These high inflows dictated how outflows from Lake Ontario had to be managed in 2019, and have dictated outflows in general since as far back as 2017.

During the summer and fall of 2018, outflows largely followed the Plan 2014 maximum L-limit. The maximum L-limit sets outflows at the highest rates possible in consideration of the level of Lake Ontario and the impacts that these high flows have on the upper St. Lawrence River, including increased current velocities and low levels on Lake St. Lawrence, both of which affect commercial navigation and recreational boating. The Plan 2014 maximum L-limit is based on a similar limit within the previous regulation plan, Plan 1958-D. However, the Plan 2014 L-limit allows for higher outflows than the Plan 1958-D version, as it better reflects modern ship capabilities and commercial navigation infrastructure, as well as knowledge gained through nearly 60 years of operations under the previous regulation plan.

In November and December 2018, as conditions turned wet, water levels of Lake Ontario began to rise.

As they did, outflows were also increased, again according to the maximum safe flow for navigation, which increases as levels of Lake Ontario rise. This generally continued until ice formation began. During this two-month period, outflows averaged 8120 m^3/s (286,800 cfs), the 7th highest November-December average on record (1900-present) and equivalent to removing 2.19 m (7.19 ft) of water from Lake Ontario during this time. Nonetheless, total inflows averaged 8840 m^3/s (312,200 cfs) over the same time, the 4th highest on record for November-December and equivalent to adding 2.39 m (7.84 ft), which accounts for the water level rise during this period despite the high outflows.

In the second week of January 2019, cold temperatures caused ice to begin forming in the critical areas of the St. Lawrence River. As has been done regularly since regulation began in 1960, outflows were temporarily reduced as ice formed on the St. Lawrence River to prevent ice jams that could have severely restricted flows and resulted in immediate localized flooding. These operations are done according to the I-limit of Plan 2014, which prescribes the maximum flow for safe ice formation. This rule is also based on similar rules and operational experience gained from decades operating under Plan 1958-D. This past winter, unlike the winter of 2017, the ice cover formed relatively rapidly starting on 11 January and a stable ice cover was largely established a couple of weeks later (Figure 14). Outflows were generally increased thereafter, again according to the maximum safe flow possible to ensure safe and stable ice conditions continued.

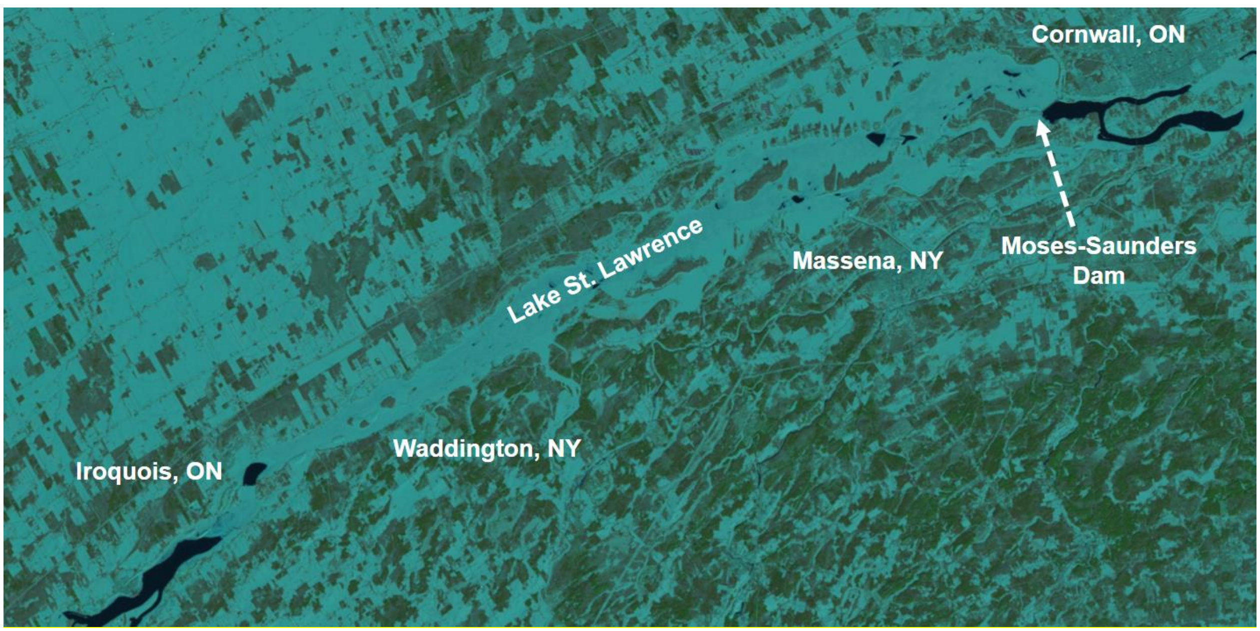

Figure 14: Lake St. Lawrence ice coverage, 2 February 2019 (satellite imagery: USGS Landsat)

Ice cover on the St. Lawrence River reduces the cross-sectional area and increases the roughness of the channel, which then also causes water levels immediately upstream of Moses-Saunders Dam on Lake St. Lawrence to drop. From February and continuing into March of 2019, outflows were increased to the maximum flow that could be released from Lake Ontario, while still maintaining minimum water levels on Lake St. Lawrence to protect municipal and domestic water intakes. These minimum levels also help ensure that the ice cover remains stable.

Despite the necessary reductions to allow for ice formation and to maintain minimum levels on Lake St.

Lawrence, outflows from Lake Ontario were very high in comparison to outflows that have been released historically during this period. The total amount of water released during the three winter months from December 2018 to February 2019 was the 4th highest on record, having only been exceeded in the winters of 1986-87, 1996-97 and recently in 2017-2018.

Outflows in March remained high and near or at the maximum outflow that would maintain minimum Lake St. Lawrence levels. Cold weather also caused ice conditions to persist somewhat later than normal. On 26 March, the St. Lawrence Seaway opened for the season, and with Lake Ontario still high, outflows began to be set according to the maximum safe flow for navigation. The outflow in March was the 6th highest on record, and despite well-above average inflows from Lake Erie, Lake Ontario only rose 2 cm (0.8 inches), the 11th smallest rise recorded during the month of March since 1900.

Cool weather and high outflows continued into mid-April. The cool weather maintained a very deep, dense snowpack in the Ottawa River basin. Starting on 14 April, milder temperatures and heavy rainfall began and persisted for several days. This rain combined with a rapid snowmelt, caused Ottawa River flows to increase to record-rates, exceeding the previous record-high set in 2017. With rising levels on Lake St. Louis due to the Ottawa River outflow, the Plan 2014 F-limit began to apply to balance high water upstream on Lake Ontario and the upper St. Lawrence River with high water downstream on Lake St. Louis and the lower St. Lawrence River.

The outflows during most of the summer/fall of 2018 and the first five months of 2019 were set according to rules of Plan 2014 – namely, the "I" (ice) limit, "L"-limit and "F" (flood) limit (a description of these limits is also available online in the Board's FAQs). These are all maximum flow limits, designed on the basis of how the Board had operated during similar conditions in the past when it often had to deviate from Plan 1958-D to achieve similar results. The maximum flow limits only apply when Lake Ontario outflows prescribed by Plan 2014 are high, and their intent is to limit outflows from being so high as to cause immediate impacts to interests within the St. Lawrence River system.

At the start of May 2019, water levels exceeded the Criterion H14 high triggers, giving the Board authority to deviate from the rules of Plan 2014. Outflows were increased throughout the month of May as the Ottawa River generally subsided (Figure 15), in order to continue balancing ongoing high water conditions in the lower St. Lawrence River with increasing water levels upstream on Lake Ontario and the upper St. Lawrence River. Beginning in June, the Board deviated from the rules of Plan 2014, and released higher outflows to provide relief to Lake Ontario shoreline property owners. Starting on 10 June, as flooding conditions subsided downstream, outflows were increased above those prescribed by Plan 2014, up to the maximum possible without stopping commercial navigation on the St. Lawrence Seaway. At this time, outflows matched the highest flows ever previously released on a sustained basis, which first occurred during the summer of 2017, and these unprecedented outflows were maintained from mid-June into mid-August 2019. Outflows were then gradually reduced as Lake Ontario levels declined, but remained 200 m^3/s (7100 cfs) above the normal maximum L-limit flow for safe navigation (Figure 16). This higher rate of outflow enabled continued lowering of Lake Ontario, while also maintaining safe conditions in the St. Lawrence River.

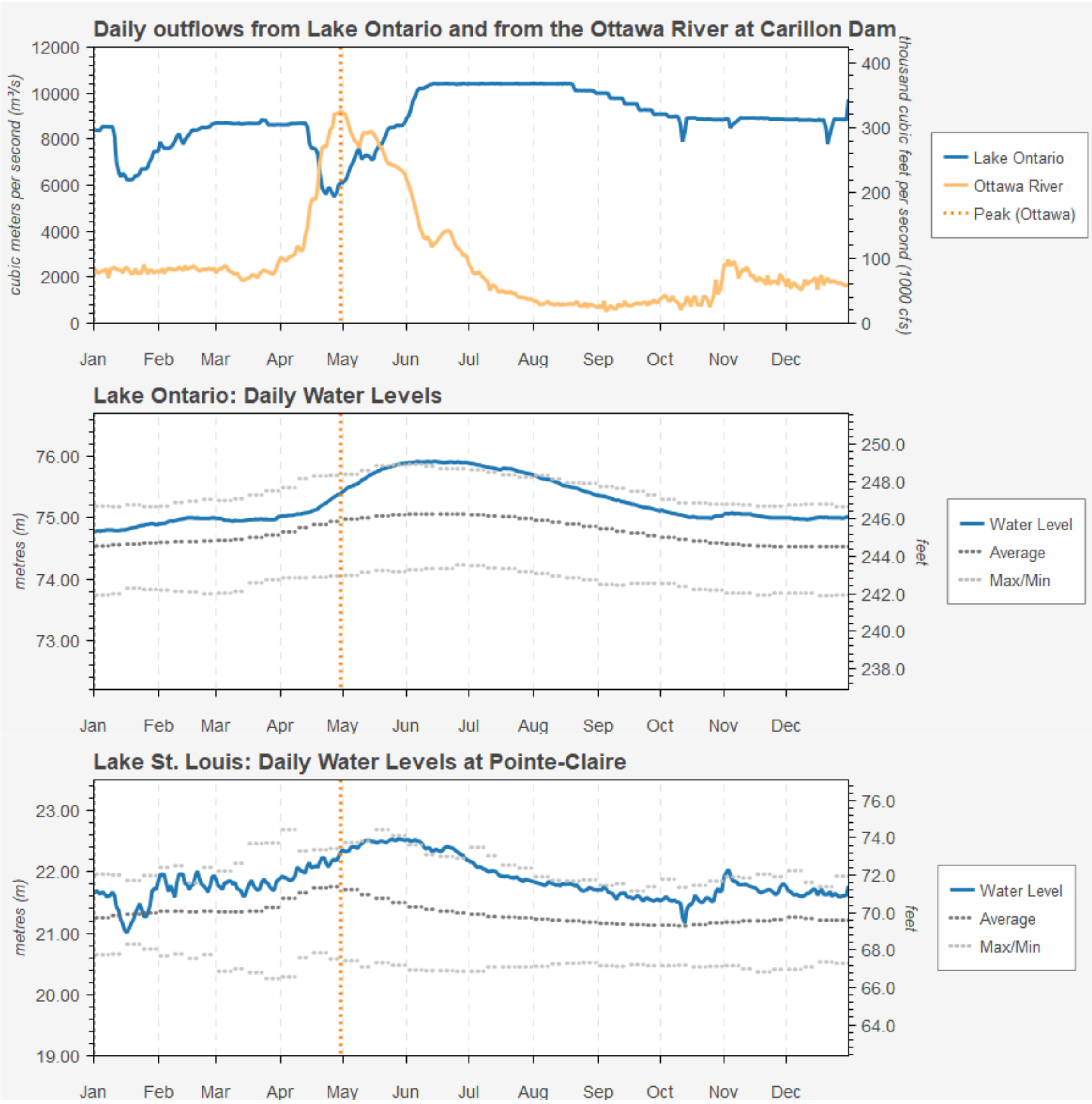

Figure 15: Lake Ontario outflow reductions in spring 2019 compared to timing of peak Ottawa River flows, Lake Ontario levels and Lake St. Louis levels

In summary, the Board managed outflows during the unusual and extreme weather conditions from November 2018 through late-May 2019 according to Plan 2014 rules that were based on Board operations under the previous regulation plan, Plan 1958-D. During this entire period, water supplies coming into Lake Ontario were consistently high, reaching record-breaking levels in May, and neither regulation plan would have been able to take significantly more water off Lake Ontario quickly enough to make a meaningful difference in water levels and prevent the flooding in 2019.

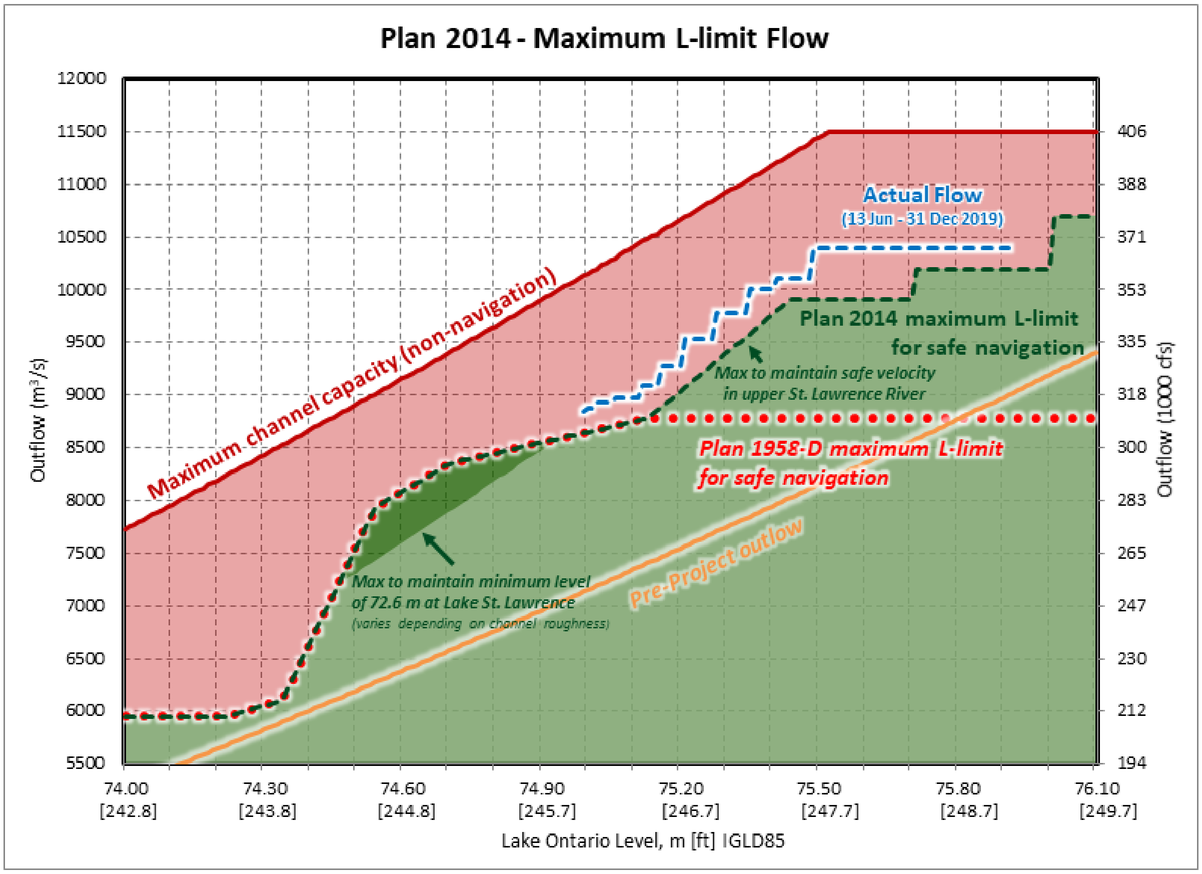

Figure 16: The Plan 2014 L-limit prescribes the maximum outflow that can be released for a given Lake Ontario level, while still permitting safe navigation in the St. Lawrence River. This maximum outflow declines as water levels decline because as they do this reduces the capacity and increases current velocities in the St. Lawrence River. However, the Plan 2014 L-limit prescribes higher outflows than both pre-project conditions and the Plan 1958-D L-limit, and in 2019 outfows above the L-limit were released for an extended period as the Board deviated from Plan 2014 and tried to remove additional water from Lake Ontario.

Question 17. Did Plan 2014 hold water back to intentionally raise the level Lake Ontario?

Answer: No, water levels rose because of high inflows, which are uncontrolled, even while Plan 2014 outflows were well above average and at maximum flow limits throughout much of 2018 and 2019.

Explanation:

The uncontrolled, natural factors that directly influenced Lake Ontario water levels in 2018 and 2019 were also the primary factors in determining – and often constraining – outflows during this time, including:

- wet weather in late-fall and winter;
- ice conditions in the St. Lawrence River in winter;
- high and eventually record-high inflows from Lake Erie;

- deep, dense snowpack and late snowmelt coinciding with major rainfall resulting in record-flows from the Ottawa River basin; and,
- wet spring conditions around Lake Ontario itself.

It was these natural factors that at times limited how much outflow could be released under Plan 2014, not the rules themselves. These natural factors would have had the same impact on the system and similar reductions in outflow would have needed to be considered under any regulation plan, including the previous Plan 1958-D.

In fact, despite these natural constraints, total releases from Lake Ontario under Plan 2014 were well above average during much of 2018 and 2019. During the summer and fall of 2018, a combination of high Plan 2014 outflows and near-average levels of Lake Ontario resulted in very low (and at times record-low) levels of Lake St. Lawrence, limiting further outflow increases during this period. Following that, and notwithstanding the reductions needed to establish a stable ice cover, high outflows continued to be prescribed by Plan 2014 during most of the winter, again resulting in very low levels on Lake St. Lawrence.

Figure 17: St. Lawrence River at Lake St. Louis, Maple Grove, Quebec, 2 June 2019 (source: IJC)

Outflows were temporarily reduced according to Plan 2014 during the record Ottawa River freshet in spring. While these reductions are built into the F-limit rule of Plan 2014, similar actions have been taken in the past under the previous regulation plan, and regulation of outflows under any plan would have to be done in consideration of the exceptional spring conditions and the resulting impacts, both upstream and downstream. Following the spring, outflows were increased to record-setting rates as downstream flooding subsided in early-June. As described in a previous answer, without the project the levels of Lake Ontario would have been even higher in 2019.

Figure 18: Lake Ontario at Greece, New York, 28 May 2019 (source: ILOSLRB)

Question 18. Did operation of dams on the Ottawa River system help to reduce flows to the St. Lawrence River?

Answer: Yes. While the IJC has no authority over the dams in the Ottawa River system, as was the case in 2017, those dams were operated to reduce high flows and flooding all along the Ottawa River, and this helped reduce peak flows into the St. Lawrence River near Montreal as well.

Explanation:

In response to the extreme flooding on the Ottawa River system, every measure was taken to reduce discharges from upstream reservoirs. Further information on operations in the Ottawa River system are available on the Ottawa River Regulation and Planning Board website and a video presentation summarizing the 2019 high water event is also available.

Flood reservoirs in the northern, regulated parts of the Ottawa River basin were lowered during winter to create space to allow much of the spring runoff to accumulate in the reservoirs. The storage space allowed for reduced river flows during the spring to reduce peak flood levels throughout the Ottawa River. These actions also reduced the peak flows entering the St. Lawrence River and this helps mitigate flood impacts in the Montreal area as well. For example, at the peak of the Ottawa River flood on 30 April 2019, the combined flow reduction due to the reservoir storage amounted to approximately 5000 m^3/s (176,600 cfs) in reduced discharge from Carillon Dam, the most downstream dam on the Ottawa River. This equates to more than 50 cm (1.6 ft) at Lake St. Louis on the St. Lawrence River and is in addition to the effects that Lake Ontario regulation had in reducing the peak levels here. During flood events, the safety and security of riparian residents and the integrity of water retention structures take priority over hydropower production.

While flow reductions were significant, there are limitations to using the dams to reduce flows on the Ottawa River, particularly under the extreme conditions experienced in 2019. Storage capacity in the Ottawa River basin is small compared to the total volume of the annual spring freshet (i.e. the surge that occurs in the spring when rains combine with snowmelt). Total runoff from the 2019 spring freshet was nearly four times the total storage volume of the reservoirs in the basin. In addition, approximately 60 percent of the drainage area of the Ottawa River basin is uncontrolled and has no significant reservoir storage capacity. The extreme rainfall received in late-April and early-May 2019 was widespread, including significant totals in the northern part of the Ottawa River basin where there was heavy snow waiting to melt, and also over the uncontrolled southern portion of the basin at the downstream end of the system, closest to the St. Lawrence River. The physical geography of this southern area does not allow further storage of flood waters – in fact, this was clearly illustrated in 2017 and 2019 by the extensive and severe flooding that occurred along the lower Ottawa River during the record-flows in late-April and early-May.

Question 19. Would the Board have had more flexibility to release water if Plan 1958-D had been in place leading up to the record-high levels of 2019?

Answer: Likely not, as outflows from Plan 2014 were already near or at the maximum that could be released from Lake Ontario without causing additional impacts on interests throughout the system.

Explanation:

It is impossible to know exactly how the Board would have responded under Plan 1958-D in the lead-up to the spring flooding. Such decisions are based on uncertain information and with considerable subjectivity.

However, during extremely wet conditions, the constraints imposed by the capacity of the system are the same, and outflows with the new plan are very similar to those that would have occurred operating with the old plan. This is because the Plan 2014 rules that apply during such wet conditions were designed to reflect the Plan 1958-D rules plus what was learned through years of experience with deviations from Plan 1958-D during similarly wet conditions in the past. Under Plan 1958-D, the Board needed to deviate frequently from the outflow rules to address conditions (the plan plus deviations is known as 1958-DD). Deviations from Plan 1958-D rules were often needed to address winter ice conditions, adjust for the effects of high or low Ottawa River flows on the lower St. Lawrence River, and to maximize outflows to moderate Lake Ontario flooding while maintaining safe conditions for navigation. These conditions had to be addressed by deviations from Plan 1958-D, but are now included and considered directly in the outflow rules for Plan 2014.

Natural factors – including record-high inflows from Lake Erie and from the Ottawa River system – would have had the same impact on the system, and similar reductions in outflow would have needed to be considered under any regulation plan, including the previous Plan 1958-D

For example, had the Board been operating under Plan 1958-D prior to the spring flooding in 2019, the Board would have certainly considered the potential increased risk that high inflows from Lake Erie throughout 2018 would have posed to Lake Ontario. However, high Lake Erie flows have historically not proven to be a strong indicator of spring flooding during the following year. Furthermore, Lake Ontario had reached seasonal average levels by the summer, and remained near average through the fall of 2018. Plan 2014 was nonetheless prescribing maximum L-limit outflows throughout this time, largely in response to the continuing high inflows from Lake Erie, resulting in extremely low levels on Lake St. Lawrence, immediately upstream of Moses-Saunders Dam.

Given this, it is possible that the Board may have operated in such a way that it would have caused slightly higher levels on Lake Ontario and the St. Lawrence River in the latter half of 2018 and possibly continuing into 2019. Under Plan 1958-D the Board may have reduced outflows below the maximum safe flow for navigation during the summer of 2018 in order to raise levels of Lake St. Lawrence and thereby providing some relief to those having to cope with the record-low levels there at the time. The Board had done this under similar circumstances in the past while operating under Plan 1958-D.

In January 2019, winter weather conditions would have dictated the same outflow reductions under both plans to ensure safe ice formation and lower the risk of ice jams in the St. Lawrence River. Stable ice conditions allowed high outflows in February and March 2019, but also again caused low water levels upstream of the dam, which increased risk to municipal water intakes (this risk would have been considered under both plans). As ice melted in March, and prior to the Seaway opening later that month, outflows remained very high (just slightly below maximum values). Given that forecasts at the start of March 2019 did not suggest the extreme weather to come, it is unlikely that the Board would have deviated from Plan 1958-D to increase the outflow significantly; had the Board done so, this would have reduced Lake Ontario water levels by at most 5 cm (less than 2 inches). When the Seaway opened in late-March, Plan 2014 again set outflows at maximum safe rates for navigation, as would have been done under Plan 1958-DD. During April and May, the record-breaking Ottawa River flows and severe flooding downstream of the dam would have limited outflows from Lake Ontario under both plans.

In summary, additional deviation authority may have resulted in small differences in outflows prior to the spring of 2019, but this would have made little difference in the water level of Lake Ontario and the St. Lawrence River by spring when record-high inflows began, and the differences may have made flood conditions worse, not better.

Question 20. Why not draw Lake Ontario down each fall so that there is sufficient storage to prevent flooding in the spring?

Answer: The outcome would have immediate consequences on other interests and will not reliably prevent future flooding impacts on Lake Ontario.

Explanation:

Plan 2014 does attempt to draw down Lake Ontario levels when water supplies are high, as they have been in the fall of 2017, 2018 and again in 2019. This helped to successfully prevent flooding in 2018. However, the physical capacity simply does not exist to prevent flooding in years when winter and spring water supplies upstream and downstream are as extreme as those experienced in 2017 and again in 2019.

Previous studies have shown that it is not possible to prevent all flooding on Lake Ontario, even if this was the only objective of the regulation plan (e.g., see final report by the International Lake Ontario – St. Lawrence River Study Board, pg 33). Furthermore, the impacts that can occur during low water years must be considered. For example, if there is a drought in the following spring, drawing down Lake Ontario as much as possible each fall would result in significant impacts to other interests. Extreme fall drawdowns are also known to have detrimental impacts to environmental restoration interests as well.

Potential Future Measures in 2020 and Beyond

Question 21. What further actions can be taken to lower water levels and reduce the risk of flooding in 2020?

Answer: Outflows will remain high in 2020. The IJC has given the Board authority to continue deviating from Plan 2014 even after Lake Ontario falls below the criterion H14 trigger levels, and this will allow the Board to further increase outflows whenever opportunities arise considering the impacts that these flow increases will have on other interests of the system.

Explanation:

The Board has had authority to deviate from Plan 2014 since 7 May 2019, after Lake Ontario rose above the high water trigger levels known as criterion H14. In light of the present extraordinary circumstances, the IJC has given the Board authority to deviate from Plan 2014 even after Lake Ontario falls below the criterion H14 trigger levels.

The outflow released from June through December 2019 was the highest ever recorded for this seven-month period. High outflows are expected to continue to be released in 2020 as the Board continues to consider all possible measures to lower the level of Lake Ontario as rapidly and as much as possible, heading into next spring. The Board has been reviewing data from the past three years to better understand when potential opportunities to deviate from Plan 2014 might be available over the next several months, and what the effects of such deviations might be on water levels and interests throughout the Lake Ontario - St. Lawrence River system.

Forecasts indicate that Plan 2014 outflows will be very high and at or near maximum values for several months. The IJC's decision will allow the Board to further increase outflows when opportunities arise considering the impacts that these flow increases will have on other interests of the system. These opportunities are expected to remove a small amount of additional water from Lake Ontario to reduce the risk of high water in 2020.

However, the Board stresses that while an outflow strategy can influence water levels, the main driver is weather, especially when wet conditions are as extreme as they were in 2017 and 2019. Likewise, the amount of additional lowering that will be achieved through deviations will largely depend on weather and water supply conditions, and whether or not a flood occurs during the spring of 2020 will also depend on weather conditions and water supplies over the winter and spring months, not the regulation plan. While the Board and the Plan are doing all that can be done, no flow management plan can eliminate the risk of future flooding.

Question 22. Are these high water levels of 2017 and 2019 the "new normal"?

Answer: Extreme high water levels are never normal, but they have occurred in the past and they will occur again in the future – when, or how frequently, is uncertain.

Explanation:

The primary cause of high water levels is always the same - wet weather. Record-precipitation caused the record-high water levels in 2017, and persistent, widespread wet weather also led to record-high inflows from Lake Erie and the Ottawa River system in 2019, resulting in new record Lake Ontario levels. Weather and water supply conditions are uncontrolled and highly unpredictable – we know extremes have occurred in the past and we expect they will occur again in the future, so we must be better prepared for the next event, even though it is difficult to know how soon that will be.

Question 23. How can shoreline residents and businesses prepare for potential future high-water events?

Answer: It is imperative that shoreline residents and businesses assess and address risk by considering all available options when living near any body of water that can potentially cause damage or harm.

Explanation:

No regulation plan can eliminate the risk of future flooding. The only reliable means of avoiding high water impacts is through shoreline resilience measures

Shoreline property owners have been impacted by two record-high water events within three years. Multi-year high water events occurring in close succession are not new – for example, Lake Ontario rose above 75.50 m (247.70 ft) and caused shoreline damages in 1973, 1974 and 1976. However, the severity of the events in 2017 and 2019 is alarming.

It is impossible to predict with any certainty the frequency of occurrence of such extreme events, but it is highly probable that extreme high and low water events will occur again at some point in the future. In the short term, it is important for residents and businesses with at-risk properties to consider "resilient" approaches to shoreline management and implement strategies to minimize the potential negative impacts.

Unfortunately, there are no simple or easy solutions, but it is absolutely essential to assess and address risk by considering all available options when living near any body of water that can potentially cause damage or harm.

There is not a "one size fits all" solution to preparing for extremes. Some of the options for consideration may include both engineered and non-engineered approaches, or a combination of actions to find the most optimal response to local conditions. Some examples include:

Engineered Resiliency Responses

- Shoreline Protection - seawalls, revetments, groins, bulkheads, etc.
- Beach nourishment
- Flood proofing/ relocating vulnerable structures and roads
- Floating docks/dock extensions/modular board walks
- Dredging
- Marina facility relocations
- Water intake and sewer modifications
- Coastal wetland construction to mitigate losses
- Soft engineering/green infrastructure (e.g. re-vegetation of shoreline)

Non-Engineered Adaptive Responses

- Integrated shoreline management planning
- Zoning restrictions/ setbacks
- Acquisition of vulnerable properties, non-functional marinas
- Improved flood plain mapping/ technical services
- Alteration of recreational boating season
- Cargo load adjustments
- Abandoning non-functional water intakes

Figure 19: Lake Ontario beach at Cobourg, Ontario, 29 May 2019 (source: Ganaraska Conservation)