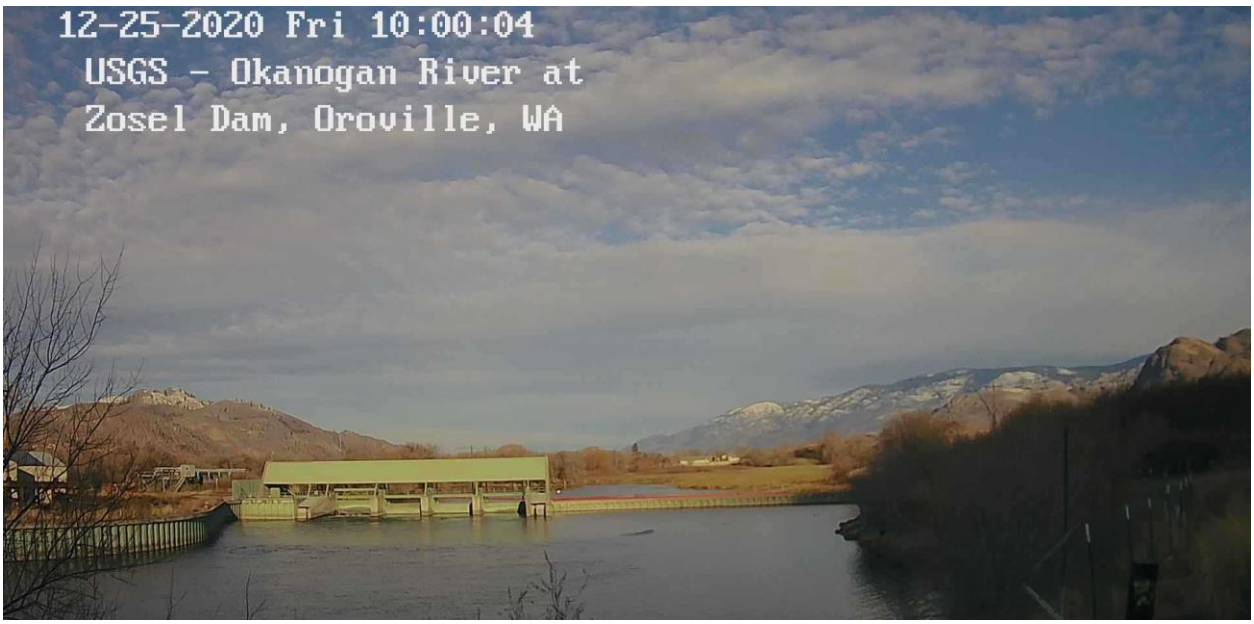
International Osoyoos Lake Board of Control

2020 Annual Report to the International Joint Commission



Cover photo:

Webcam view of Zosel Dam and exposed weir (looking upstream) taken on December 25, 2020, showing low water conditions on the Okanogan River, located downstream of Osoyoos Lake

(*credit:* USGS, https://waterdata.usgs.gov/wa/nwis/uv/?station=12439000).

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EXCECUTIVE SUMMARY

This report documents the activities of the International Osoyoos Lake Board of Control (IOLBC or Board), hydrologic and climatic conditions of the Okanagan/Okanogan and Similkameen basins, and compliance of the Applicant to the International Joint Commission (IJC or Commission) Orders of Approval for Osoyoos Lake during 2020. The Board, comprised of ten members with equal representation from Canada and the U.S., was established on September 12, 1946 by the IJC to carry out the provisions of the Commission's Order of Approval. In 2020, the Board operated under the authority of the Commission's Supplementary Order dated January 29, 2013.

To fulfill its mandate, the Board's efforts are focused on water-level management issues related to the operation of Zosel Dam, located on the Okanagan (Canadian spelling)/Okanogan (U.S. spelling) River about 1.6 mi (2.6 km) downstream from the outlet of Osoyoos Lake, a water body that straddles the international boundary between Canada and the United States. Zosel Dam is owned by Washington State, which is referred to as the Applicant in the IJC Orders and this annual report. The dam is operated by the Oroville-Tonasket Irrigation District under authority of the Washington State Department of Ecology (WADOE).

During 2020, the Board held quarterly teleconferences, hosted virtual annual Board and Public meetings, and briefed IJC Commissioners during the virtual Fall Ottawa semi-annual meeting to fulfill its mandate from the IJC to oversee the IJC Orders for Osoyoos Lake. The spring Washington semi-annual meeting was not held in 2020 due to the COVID-19 pandemic and resulting travel restrictions. The Board also oversaw the development of a hydrologic model of current and future conditions of the Similkameen River Basin to understand and plan for the effects of climate change within the Similkameen River Basin on the IJC Orders for Osoyoos Lake. The Board also developed a proposal to fund the integration of this model with an existing model of the Okanagan/Okanogan Basin to assess and the plan for the effects of projected climatic changes within the Okanagan River Basin on the IJC Orders of Osoyoos Lake. A second proposal was developed by the Board to fund Osoyoos Lake Science Forum in Fall 2021 in Osoyoos, BC.

Above-average precipitation during the 2019-2020 winter resulted in higher-than-normal snowpack within the Similkameen and Okanagan/Okanogan basins. As a result, drought criteria defined by Condition 8 of the IJC Orders were not met for neither the Similkameen River flow volume nor the maximum level of or net inflow volume to Okanagan Lake; therefore, the Board did not make a drought declaration under Condition 8 in 2020. The Applicant remained in compliance of lake levels mandated by the Orders of Approval throughout 2020.

LIST OF ACRONYMS

IJC	International Joint Commission
IOLBC	International Osoyoos Lake Board of Control
OBWB	Okanagan Basin Water Board
USGS	U.S. Geological Survey
ECCC	Environment and Climate Change Canada
USACE	U.S. Army Corps of Engineers
WADOE	Washington State Department of Ecology
BCFLNRORD	BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development
OTID	Oroville-Tonasket Irrigation District

LOCATION OF OSOYOOS LAKE

Osoyoos Lake is a 10-mile (16-km) long by 1-mile (1.6-km) wide lake that spans the international boundary between Canada and the United States in southcentral British Columbia and northcentral Washington state (Figure 1). The Okanagan River flows into Osoyoos Lake north of Osoyoos, BC, and is largely regulated by Okanagan Lake Dam operations. During normal hydrologic conditions, outflow from Osoyoos Lake into the Okanogan River is controlled by the operation of Zosel Dam about 1.6 mi (2.6 km) downstream from the outlet of Osoyoos Lake. During periods of high runoff, the Similkameen River may cause backwater of the Okanogan River at which point the stage of the Similkameen River controls outflow from Osoyoos Lake. The Similkameen River's watershed is mostly within Canada, but two of its headwaters tributaries, the Pasayten and Ashnola rivers, originate in the United States.

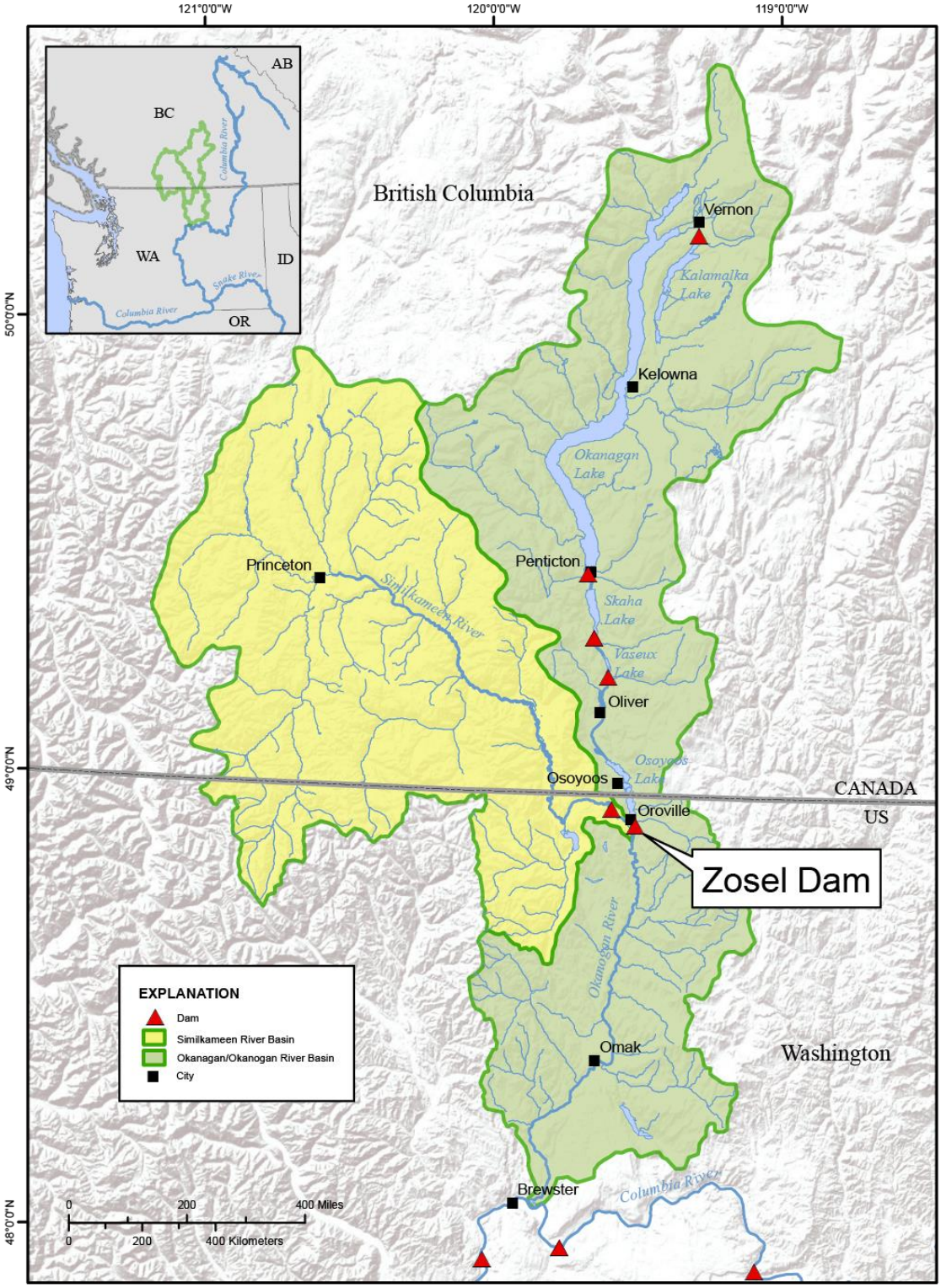


Figure 1 - Location of Zosel Dam, and the Okanagan/Okanogan and Similkameen watersheds.

ORDERS OF APPROVAL

Throughout any given year, Osoyoos Lake levels may fluctuate in accordance with criteria specified in the IJC's Supplementary Order of Approval dated January 29, 2013. These criteria are summarized within the rule curve presented in Figure 2.

The gray area in

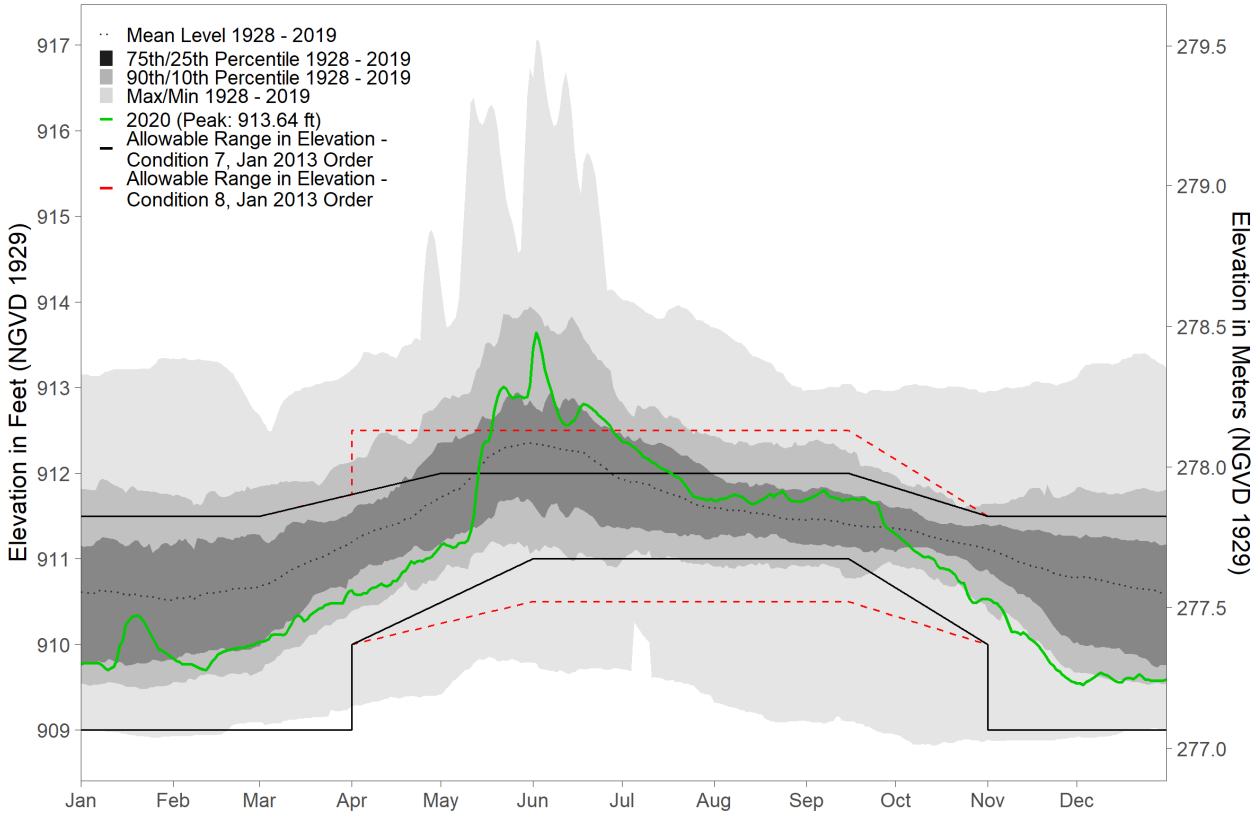


Figure 2 shows the authorized range of normal operating elevations: an upper range of 911.5 ft (277.8 m) on January 1; 911.5 ft (277.8 m) on March 1; 912 ft (278.0 m) on May 1; 912 ft (278.0 m) on September 15; 911.5 ft (277.8 m) on November 1 and 911.5 ft (277.8 m) on December 31; and to the extent possible the elevation of Osoyoos Lake does not fall below the NGVD 1929 elevation of 909.0 ft (277.0 m) on January 1; 909.0 ft (277.0 m) on March 31; 910.0 ft (277.4 m) on April 1; 911 ft (277.7 m) on June 1; 911 ft (277.7 m) on September 15; 910.0 ft (277.4 m) on October 31; 909.0 ft (277.0 m) on November 1 and 909.0 ft (277.0 m) on December 31. Elevation limits are linearly interpolated between dates.

The area between the red dashed lines in Figure 2 shows the lake elevations authorized by the IJC from April 1 to October 31 if drought criterion 8(a) and either 8(b i) or 8(b ii) in table 1 are declared in effect by the Board, or such as in 2019, when a Condition 10 variance is approved. During such conditions, the elevation of Osoyoos Lake may be raised to 912.5 ft (278.1 m) from April 1 to September 15, after which the lake level shall be decreased to reach an elevation of 911.5 ft (277.8 m) by November 1. To the extent possible, during the April 1 to October 31 period, the elevation of Osoyoos Lake should not fall below 910.0 ft (277.4 m) on April 1; 910.5 ft (277.5 m) on June 1; 910.5 ft (277.5 m) on September 15; and 910.0 ft (277.4 m) on October 31. Between dates, elevation limits are linearly interpolated. Condition 9 of the 1982 Order recognizes that backwater from high flow in the Similkameen River and (or) excessive flow in the Okanagan River may cause Osoyoos Lake levels to rise above the authorized range.

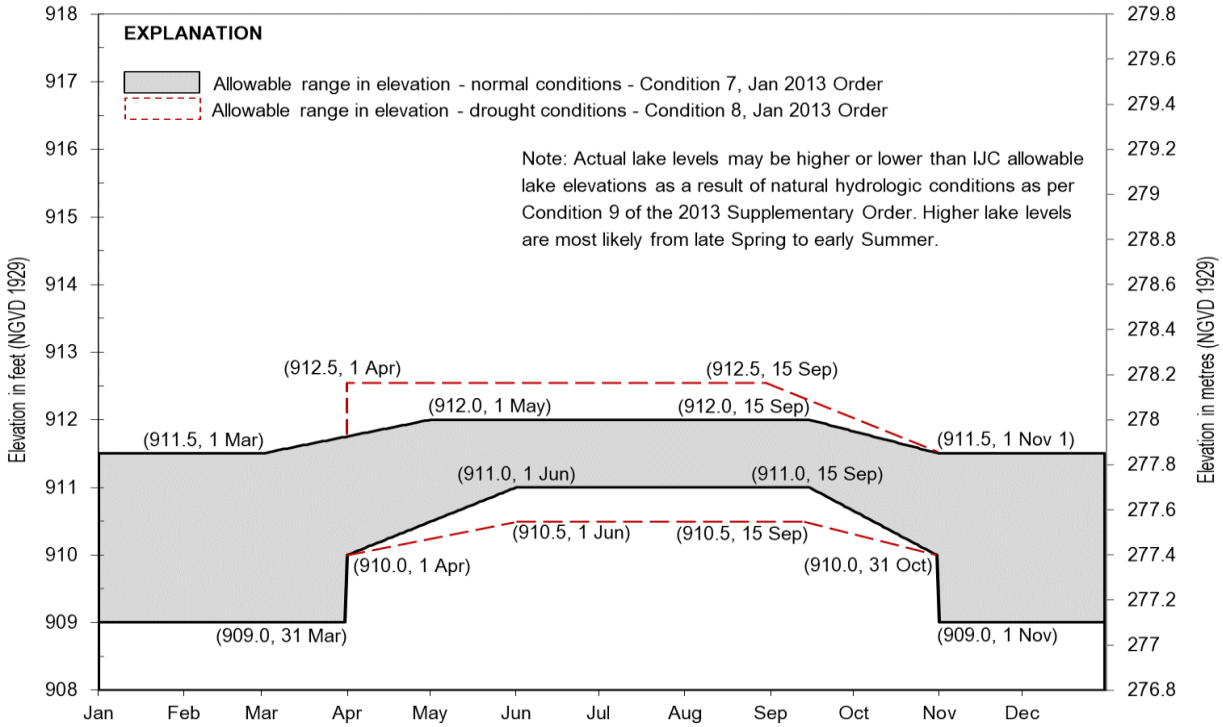


Figure 2 – 2013 Osoyoos Lake Supplementary Order of Approval rule curve.

BOARD MEMBERSHIP

In 2020, the number of Board members remained the same at a total of ten members with equal representation from Canada and the U.S. There was one change in the Board's membership in 2020; U.S. Section Member Col. Mark Geraldi resigned in June, and Col. Alexander Bullock was appointed to take his place.

	Canadian Section		***U.S. Section***
	Dave Hutchinson (Chair) Environment & Climate Change Canada National Hydrological Services		Cindi Barton (Chair) U.S. Geological Survey Washington Water Science Center
	Ted White (Member) B.C. Ministry of Forests, Lands, Natural Resource Operations & Rural Development		Col. Alexander Bullock (Member) U.S. Army Corps of Engineers Seattle District
	Anna Warwick Sears (Member) Okanagan Basin Water Board		John Arterburn (Member) Confederate Tribes of the Colville Reservation
	Sue McKortoff (Member) Mayor of Osoyoos		Kris Kauffman (Member) Water Resource Engineer
	Brian Symonds (Member) B.C. Ministry of Forests, Lands, Natural Resource Operations & Rural Development (retired)		Arnie Marchaud (Member) Private Citizen
	Martin Suchy (Secretary) Environment & Climate Change Canada		Andrew Gendaszek (Secretary) U.S. Geological Survey

	National Hydrological Services		Washington Water Science Center

BOARD ACTIVITIES IN 2020

Board Quarterly Calls

The Board continued holding quarterly conference calls in March, June, September and December (as initiated in 2015). Agenda items included discussion of current hydrologic conditions, tracking work plan and special projects progress, and preparing for upcoming meetings. Summaries of these calls are posted on the Board's public website (https://ijc.org/en/olbc/library/minutes).

Annual Board Meeting

The Annual Board Meeting was to be held in Oroville, Washington this year; however, due to the COVID-19 pandemic, the Board held its annual meeting virtually using Microsoft TEAMS on October 8, 2020 from 12:30 to 3:30 pm PST. The meeting included a presentation on the history of the IJC Orders of Approval for Osoyoos Lake, implementation of the Orders in 2020, dam operations and personnel updates, several special presentations, along with updates on special projects. The development of the 2021 Board Work Plan was deferred to the December quarterly call.

Cindi Barton (U.S. Section Co-Chair) presented an overview of the Board and the IJC Orders of Approval for Osoyoos Lake. Andrew Gendaszek (Secretary, U.S. Section) presented on hydrologic conditions during 2020 for Osoyoos Lake, the Similkameen River and the Okanagan/Okanogan River. Shaun Reimer (BC FLNRORD – Water Resources Engineer, Penticton, BC) presented 2020 Okanagan System operations. 2020 Zosel Dam operations were presented by Al Josephy (Washington State Department of Ecology, Lacey, WA).

Mary Verner (Washington State Department of Ecology) announced that Al Josephy was stepping down from his role as the Applicant's technical and operational representative to the Board and that Trevor Hutton is assuming the position. Joe Witczak remains as the dam safety contact. Mary Verner also announced that she was stepping down as the Applicant's administrative representative to the Board and Sage Park is assuming her duties.

Al Josephy (Washington State Department of Ecology) updated the Board about Washington State Department of Ecology's operation of Zosel Dam in 2020. Ecology's first goal for Zosel Dam operations is to adhere to the IJC Orders of Approval for Osoyoos Lake. While operating within the Orders, Ecology also seeks to protect water rights within the Okanogan River and the Columbia River Basin while working with fisheries organizations to maintain instream flows for fish. Mr. Josephy described 2020 Osoyoos Lake levels in the context of the IJC rule curve, 2020 operational plan, and previous Osoyoos Lake levels. Ongoing maintenance at Zosel Dam included gate cycling, verifying limit switch operations, inspection of mechanical systems, and visual gate and seal inspection. Ecology has developed long-term planning for dam maintenance and will develop a project upgrade inspection and report for 2020.

Shaun Reimer (British Columbia – Forest, Lands, Natural Resource Operations and Rural Development) provided an overview of Okanagan system operations in 2020. In spring 2020, Okanagan Lake was drawn down in anticipation of above-average inflow forecasts to Okanagan Lake resulting from high snowpack. Inflow projections were above-average from February through March but underestimated eventual inflow to Okanagan Lake because of higher-than-normal rain in May and June. A relatively dry summer with slightly lower-than-

normal inflows into Okanagan Lake have allowed Okanagan Lake operations to return Okanagan Lake target levels by September.

Lower snowpack in the southern part of the Okanagan Basin resulted in less runoff to the Okanagan River between Okanagan and Osoyoos Lakes allowing Okanagan Dam operations to pass higher flows through to Osoyoos Lake.

The board had three special external presentations this year. First, Todd Sellers and Scott Jutila of the International Rainy-Lake of the Woods Watershed Board (IRLWWB) presented an overview of the IRLWWB at its transformation into a watershed board. The Rainy-Lake of the Woods watershed covers a 70,000 square-kilometer area of Minnesota, Ontario, and Manitoba. The IRLWWB, which was created in 1925, has a mandate to coordinate management of water levels and flows on the Rainy and Namakan lakes, monitor and report on ecological health and water quality of Lake of the Woods and Rainy Lake boundary waters aquatic ecosystem, and assist the IJC in preventing and resolving disputes regarding the boundary waters of the Rainy-Lake of the Woods watershed.

From 1925 to 1966, the Board's mandate was limited to water levels and flows, but in response to a 1959 reference to the IJC regarding pollution in the watershed, the Rainy River Water Pollution Control Board was created in 1966. An IJC task force was created in 2010 to examine bi-national governance of the Lake of the Woods and Rainy River, which recommended amalgamation of the International Lake of the Woods Board of Control and the Rainy River Water Pollution Control Board, defined a new water-quality mandate, and a bi-national plan of study of transboundary water quality and water-level regulation of Lake of the Woods. A 2013 IJC directive created the International Rainy-Lake of the Woods Watershed Board (IRLWWB) as per the recommendations in 2012.

The watershed board had strong local support on both sides of the border that pushed all levels of government to form the watershed board and key pieces of legislation were introduced within the U.S. and Canada that supported the board including the *Ontario Clean Water Act* in 2006, changes to the Minnesota wetlands conservation legislation in the 1990's and 2000's, and 2010 Federal Private Members Bill in Canada and Minnesota legislative change seeking a reference from the IJC.

Next, Joel Trubilowicz (Northwest Hydraulic Consultants) presented an update on the hydrologic model of the Similkameen Basin that was funded by the IJC International Watersheds Initiative (IWI). The long-term goals of this modeling effort are to integrate Similkameen and Okanagan River models, predict potential changes in Lake Osoyoos water levels, and prepare for possible modifications to operations and management of the system. In the current phase of the project, a hydrologic model of the Similkameen River basin is being constructed and an ensemble of projected changes in climate are being used to assess future peak flows and low flows in the Similkameen basin.

The models were constructed using RAVEN, which is an open source and flexible platform that allows estimation and interpolation of watershed forcings and simulation of hydrologic processes. The Similkameen RAVEN model was constructed for 34 sub-basins and 913 hydrologic response units using 3 soil profiles and 6 landcover/land-use profiles and gridded meteorological data. Hydrologic processes were simulated at a daily timestep. A historic and future water demand model developed by Associated Engineering was used in the Canadian part of the Similkameen Basin, and historic and future water demand within the U.S. was assumed to be equal to fully licensed allocation.

NHC has completed a soft calibration of the Similkameen RAVEN model that incorporates the water-demand model, a snow-pillow assessment of snow-water equivalent, and an annual

water balance. NHC is in the process of using the program OSTRICH to automatically calibrate the model, integrating an ensemble of climate data, and estimating future changes in peak flows and low flows.

The final special presentation was by Chris Curran (U.S. Geological Survey), who presented interim results of an in-progress study of sediment impounded behind Enloe Dam on the Similkameen River. Historic mining within the Similkameen River basin has contributed to concerns that contaminated sediment has accumulated behind Enloe Dam. The construction of Enloe Dam was completed in 1923 and was used to generate hydropower until operation of the powerplant ceased in 1958 by the Okanogan Public Utility District. The USGS has been assessing the chemistry of sediment collected by hand and within sediment cores. In addition to analyses of mercury, copper, arsenic, lead, gold, silver, and platinum, sediment samples were analyzed for grain size, carbon, 15N, 137Cs, and 210Pb. The volume of sediment impounded behind Enloe Dam was estimated through bathymetric surveys and geophysical surveys using ground-penetrating radar to map the sediment/bedrock interface.

Annual Public Meeting

The public meeting of the Board was held Thursday October 8, 2020. Due to the COVID-19 pandemic the meeting was held virtually using the GoToWebinar platform. Cindi Barton (U.S. Co-Chair) presented an overview of the Board and the IJC Orders of Approval for Osoyoos Lake and discussed allowable lake levels under the rule curve established under the 2013 Supplementary Orders of Approval. She described the system of dams regulating the Okanagan Basin, including Zosel Dam, which controls the level of Osoyoos Lake and is operated by the Washington State Department of Ecology. Ted White (Canadian Board member), provided a brief overview of the hydrology of Osoyoos Lake, the Okanagan/Okanogan River, and the Similkameen River during 2020. Finally, it was indicated that the Board monitored the presence of wildfires within the basin.

Andy Gendaszek (Board Secretary, U.S. Secretary) presented several Board projects that have been completed or are in process. A high-water monument was installed near the Memorial Fountain in Osoyoos in March 2019 and a similar monument will be installed in Oroville once COVID-19 travel restrictions are eased. The IOLBC in partnership with the OBWB (Okanagan Basin Water Board) is tentatively planning to host an Osoyoos Lake Water Science Forum in the fall of 2021, as a follow-up to the 2007, 2011 and 2015 events. A steering committee and sub-committees are being formed to develop the program and funding for the forum.

The Board subsequently responded to comments and questions from the public. The first question asked if the Board could provide a detailed study of what flood levels are on Osoyoos Lake based on an analysis that includes the effect of a backwater curve of the Okanagan River through the lake. It was noted that the Design Brief of 1992 indicated a flood level of 280.7 m at Zosel Dam, but this is not the same at Lakehead Campground (the north end of the lake). The board responded that the Okanagan Basin Water Board (OBWB) recently built a hydrologic model of the Okanagan Basin, a hydraulic model of the Okanagan River, and that findings are posted on the OBWB website. A contractor for the IOLBC is currently building a hydrologic model of the Similkameen River Basin that will provide analysis of current and future drought and flood conditions on Osoyoos Lake that affects the IJC Orders. The second question requested that actual flood levels be available for planning purposes, and that RDOS (Regional District Okanagan and Similkameen) is currently updating the Official Community Plan Bylaw for Area "A" and this includes a section on flood protection. The Board responded that the OBWB also has a link on their website to the “Okanagan Flood Story”, which provides useful information pertaining to flood protection.

Board Field Tour

Due to the COVID-19 pandemic, the annual Board and public meetings were held virtually in 2020 and no field trip took place. The Board previously planned to travel along the Similkameen River from its mouth at Oroville to the headwaters in Canada. This field trip will be considered for the next in-person annual Board meeting.

Board Appearances at IJC Semi-Annual Meetings

The Board presented a progress report virtually during the fall semi-annual IJC meeting on October 22 in Ottawa, while the spring appearance in Washington which was to be held in April, was cancelled due to travel restrictions imposed by the COVID-19 pandemic. The fall meeting was attended virtually by the Canadian and U.S. section Co-chairs Dave Hutchinson and Cindi Barton, respectively, along with numerous Board Members from both sections, and supported by both Board Secretaries.

Public Communications

The Board posted five news releases on its website to inform the public and news media about Board activities and hydrologic conditions within the Okanagan/Okanogan and Similkameen Basins that affect Osoyoos Lake levels and the IJC Orders for Osoyoos Lake. The first news release on May 15 updated the public about rising Osoyoos Lake levels above 912 feet due to spring snowmelt conditions, but that the dam operator remained in compliance with the Order of Approval because Zosel Dam gates were fully opened and Zosel Dam no longer controlled the level of Osoyoos Lake. A second news release on May 29 informed the public of further expected lake level increases, explained the terms of the Order, and updated the public on current snowpack conditions. A third news release on June 5 indicated that Osoyoos Lake levels had crested at 913.65 feet and that levels were beginning to drop. The next news release on July 21 informed the public that Osoyoos Lake levels had dropped below 912.0 ft and had returned to levels within the IJC Order of Approval Rule Curve. The final news release in September 2020 informed the public about the virtual Board Public Meeting to be held on October 8.

Special Projects

The Board submitted two IJC-IWI proposals in 2020. The first proposal requested funding for a second phase of a project to assess the impact of projected climate change on the IJC Orders of Approval for Osoyoos Lake. During the first phase of this project, NHC was funded by the IJC-IWI program to develop a hydrologic model of the Similkameen River Basin. The second phase of this project currently under consideration for funding will integrate the hydrologic model of the Similkameen Basin with previously developed hydrologic and hydraulic models of the Okanagan/Okanogan basin funded by the OBWB. This second phase will complete the assessment of the impact of projected climate change on the IJC Orders of Approval for Osoyoos Lake. The IJC-IWI selected the second phase of this project for funding by the U.S. Section of the IJC in spring 2021 following the completion of the Similkameen basin model. The Board Secretaries are working with the IJC to implement the project.

Second, the IJC-IWI selected the Osoyoos Lake Science Forum for funding by the U.S. Section. The Forum will tentatively be held in Osoyoos, BC in Fall 2021. In late 2020, a steering committee and several sub-committees were formed to develop the program and secure additional funding for the Forum.

The previously IJC-IWI funded High-Water Monument was installed in Spring 2019 in Osoyoos, BC and the U.S. monument was to be installed in Spring 2020 in Veterans Memorial Park but was not yet installed because of COVID-related travel restrictions.

Finally, Ascent films developed five five-minute vignettes from "A River Film" about agriculture, native fisheries, fisheries, infrastructure, and the temperature-oxygen squeeze. The Board and the IJC posted these vignettes on their respective websites and the Board Secretaries posted them on the Board website.

Other Activities

The Board monitored the presence of wildfires within the Okanagan Basin in 2020, which included the Palmer Fire (18,000 acres), the Pearl Hill Fire (223,780 acres), and the Cold Springs Fire (190,000 acres). None of these fires directly impacted Osoyoos Lake or the Okanagan River.

2020 HYDROLOGIC CONDITIONS

Drought Criteria

Condition 8 of the Commission's Supplementary Orders of Approval dated January 29, 2013, provides three criteria for declaring a year of drought (Table 1). In a year when the Board has declared a drought, the Osoyoos Lake level may be managed under the drought rule curve specified within Condition 8 that allows a wider range from April through October as compared to non-drought years (Figure 2). In early spring 2020, the forecasted hydrologic conditions satisfying the drought criteria within the IJC Order were not met. Condition 8(a), the volume of flow in the Similkameen River at Nighthawk, WA, for the period April through July was just above the 1,000,000 acre-feet threshold; however, neither of the Okanagan Lake criteria, 8(b i) or 8(b ii), were close to their thresholds. As the spring freshet progressed, the hydrologic conditions confirmed that the criteria for drought declaration would not be achieved, and the Applicant operated the dam under the normal Condition 7 conditions.

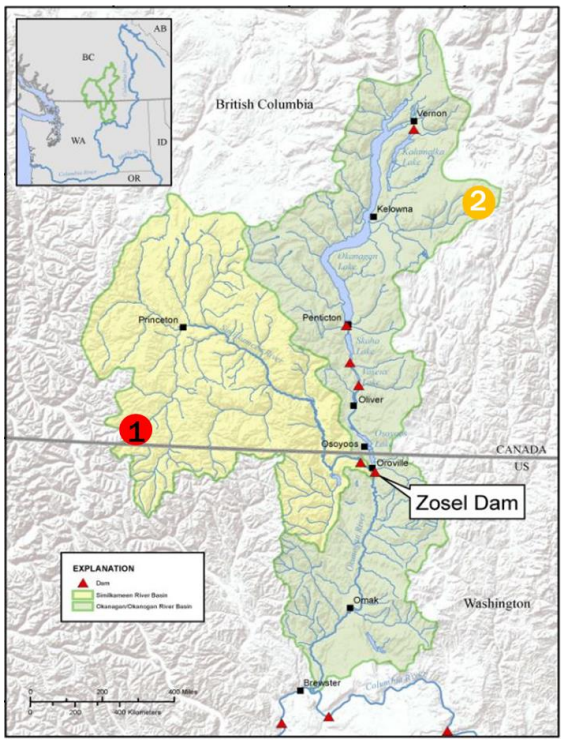
Table 1 – Summary of drought criteria and forecast and actual values in 2020. The Board declares a drought if condition 8(a) and either condition 8(b i) or 8(b ii) are met (ac-ft, acre-feet; ft, feet)

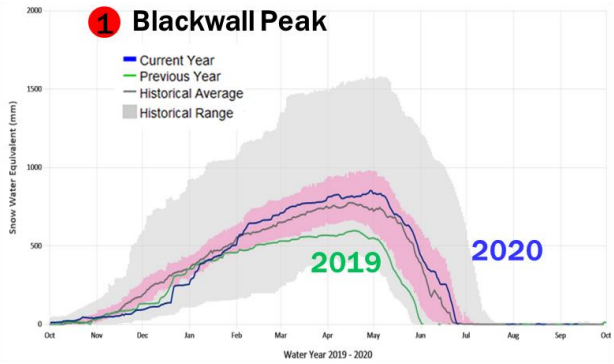
Criteria for declaring a drought	Numerical criteria	2020 Value forecasted in (a) Early April (b) Early May	Drought criterion met?	Actual 2020 value I
Condition 8(a): Volume of flow in the Similkameen River at Nighthawk, WA, for the period April through July as calculated or forecasted by U.S. authorities is less than 1 million ac-ft	< 1,000,000 ac-ft	(a) 1,005,000 ac-ft (b) 1,189,000 act-ft	(a) No (b) No	1,733,411 ac-ft

Condition 8(b i): Net inflow to Okanagan Lake for the period April through July as calculated or forecasted by Canadian authorities is less than 195,000 ac-ft	< 195,000 ac-ft	(a) 503,000 ac-ft (b) 489,000 ac-ft	(a) No (b) No	704,000 ac-ft
Condition 8(b ii): Level of Okanagan Lake in June or July is less than or is forecasted by Canadian authorities to be less than 1,122.6 ft (Canadian Geodetic Survey Datum)	< 1,122.6 ft	(a) 1,123.3 ft (b) 1,123.3 ft	(a) No (b) No	1,124.54 ft. (June 25)

Snowpack and Precipitation

Snowpack measured during the first part of the 2019-2020 Water Year was at or below normal in both the Similkameen and Okanagan basins, as measured at the Blackwall Peak and Mission Creek snow pillows (Figure 3), respectively. This was especially visible in the Similkameen watershed, where the January 1 2020 Basin Snow Water Index was at 75% of normal (Figure 4). However, increased precipitation as snowfall in the Similkameen and Okanagan basins was well above normal for January and February (Figure 5), which contributed to a quickly building snowpack, as seen in Figures 3 and 4. By mid-February, snowpacks at the Blackwall Peak and Mission Creek snow pillow stations were near the 60th and 85th percentiles of the historical snowpack for that date.





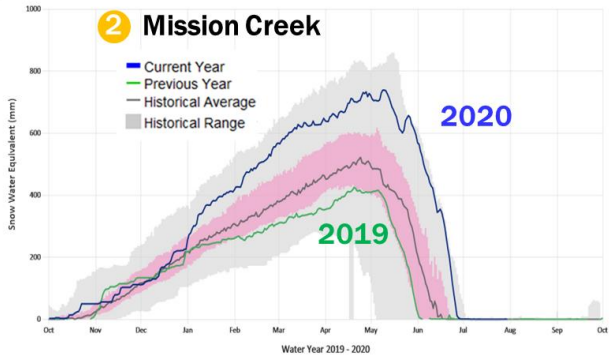


Figure 3 – Mountain snowpack conditions for water year 2019-2020. Historical Maximum, 75th/25th Percentile, Daily Mean, Minimum, and 2019/2020 data. 1) Blackwell Peak (1967-2020) Similkameen River Basin, 2) Mission Creek (1969-2020) Okanagan/Okanogan River Basins. (BC River Forecast Center, 2020).

Precipitation during March and April was below normal for the region (Figure 5), which temporarily stalled further snowpack growth; however, Snow Water Indices for both the Similkameen and Okanagan Basins exceeded 100% of normal for the remainder of the season (Figure 4). Precipitation in May and June was also above normal, which resulted in both further snowpack accumulation and rain on snowmelt, particularly in the Okanagan basin. Overall, snowpack in 2020 at the north and east of the Okanagan Basin was above average and greater (as measured at Mission Creek snow pillow) than snowpack in the south and west of the Okanagan Basins measured at Brenda Mines snow pillow. The snowpack at Blackwall Peak (Similkameen) reached zero snow by late-June, in line with the historical mean, while the snowpack at Mission Creek in the Okanagan, which historically reaches zero a bit earlier, remained until the beginning of July, close to the historic maximum (Figure 3). July and August were both drier than normal, while precipitation in September was near normal.

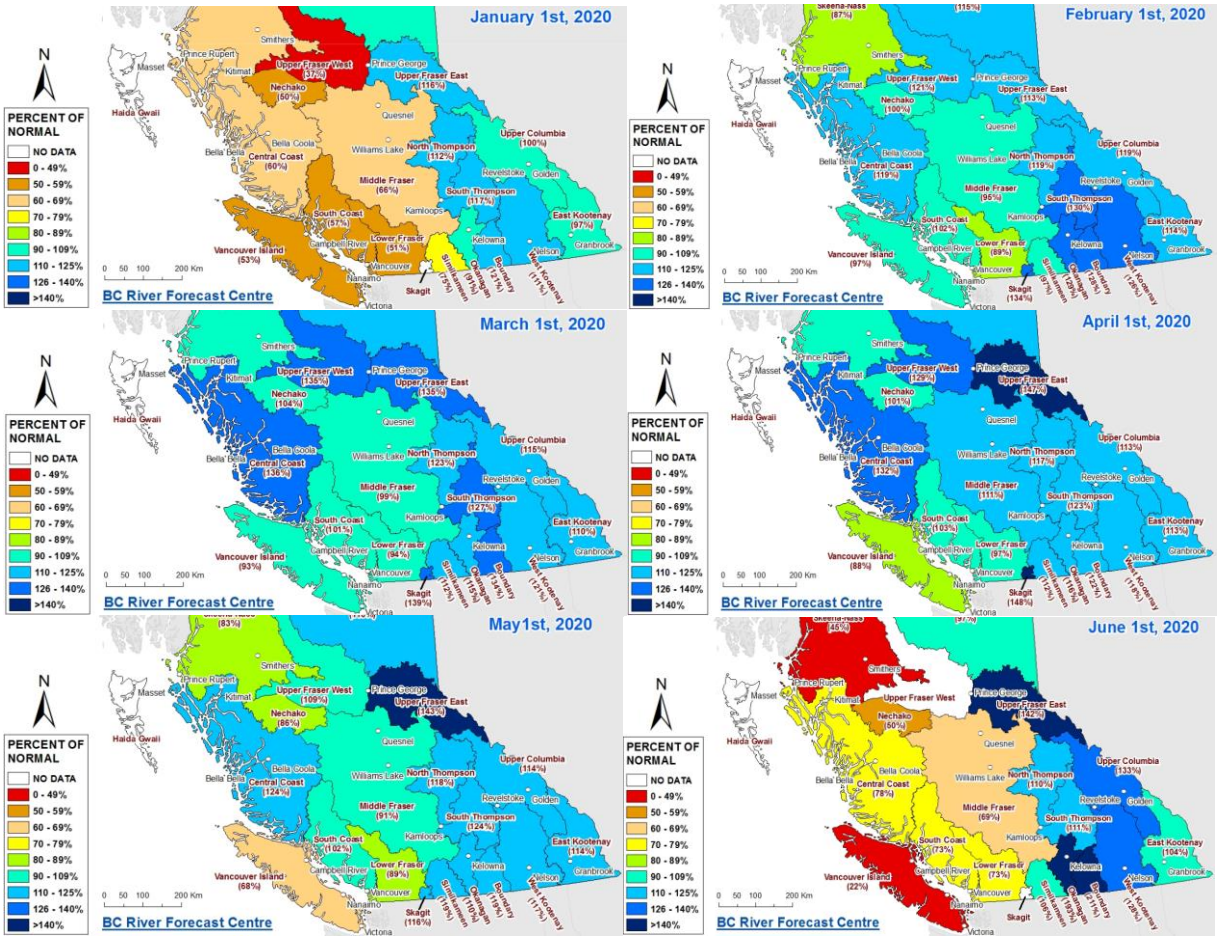


Figure 4 – Monthly Basin Snow Water Index, indicate conditions as a percent of normal. For the period January to June 2020 (Province of British Columbia, River Forecast Centre, 2020).

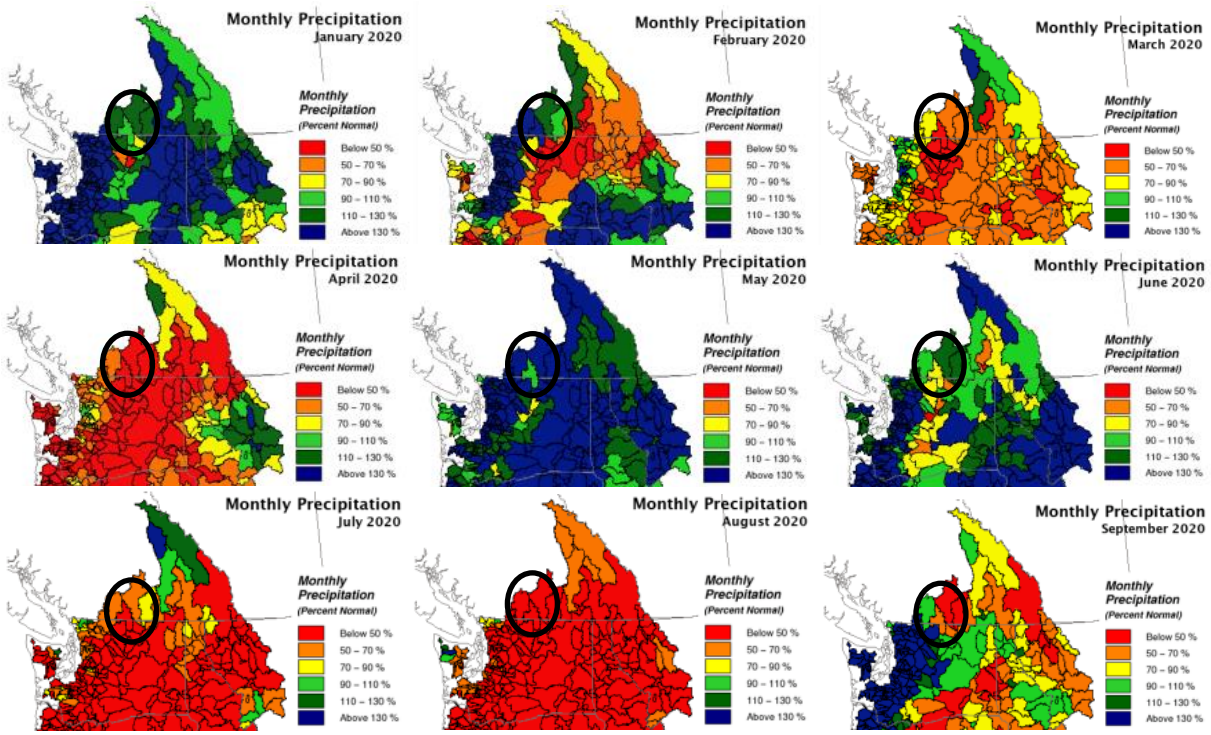


Figure 5 – Monthly Precipitation in the Columbia River Basin. The black oval represents the Okanagan/Okanogan and Similkameen River Basins. January to September 2020.
NOAA, https://www.nwrfc.noaa.gov/water_supply/wy_summary/wy_summary.php?date=10/01/2019&tab=1

<u>Okanagan Lake Inflow, Okanagan Lake Level, and Okanagan River Discharge</u>

Cumulative net inflow to Okanagan Lake from April through July and peak Okanagan Lake level in June and July were forecasted to exceed Condition 8 drought criteria in early April and early May in contrast to 2019 when below-normal snowpack accumulated within the Okanagan Basin. Actual Okanagan Lake net inflow, which was greatest in May, and peak level of Okanagan Lake exceeded earlier forecasts and reached 704,000 acre-feet (868 million m^3) and 1,124.54 feet, respectively (Figures 6 and 7). The 2020 peak Okanagan Lake level exceeded the operational target of 1123.6 feet (342.48 m). In anticipation of increased runoff during the spring freshet, Okanagan Lake was drawn down through increased outflow during the spring resulting in elevated discharge of the Okanagan River at Penticton and Oliver beginning in late winter and continuing through the summer (Figures 8 and 9).

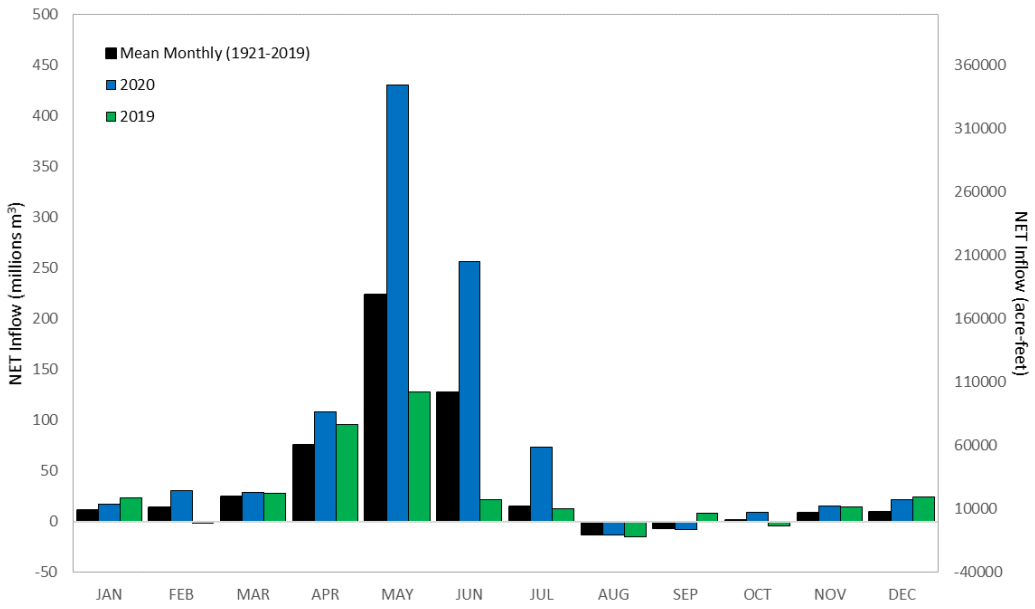


Figure 6 – Historical monthly mean (1921-2019), 2020 and 2019 monthly net inflow to Okanagan Lake.

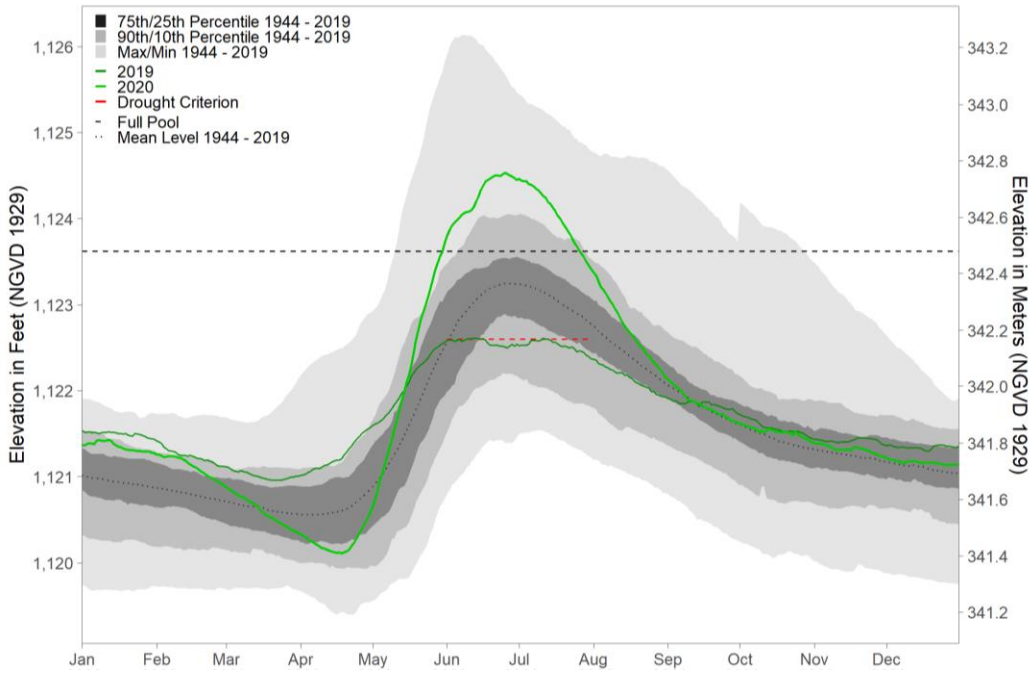


Figure 7 – Okanagan Lake at Kelowna (WSC station 08NM083), BC. Historical (1944-2019): Maximum, 90th/10th and 75th/25th Percentiles, Daily Mean, Minimum, 2020 water-surface elevation (Environment and Climate Change Canada, 2021), and Condition 8bii Drought Criteria – 1,122.6 ft (IJC Order of Aproval).

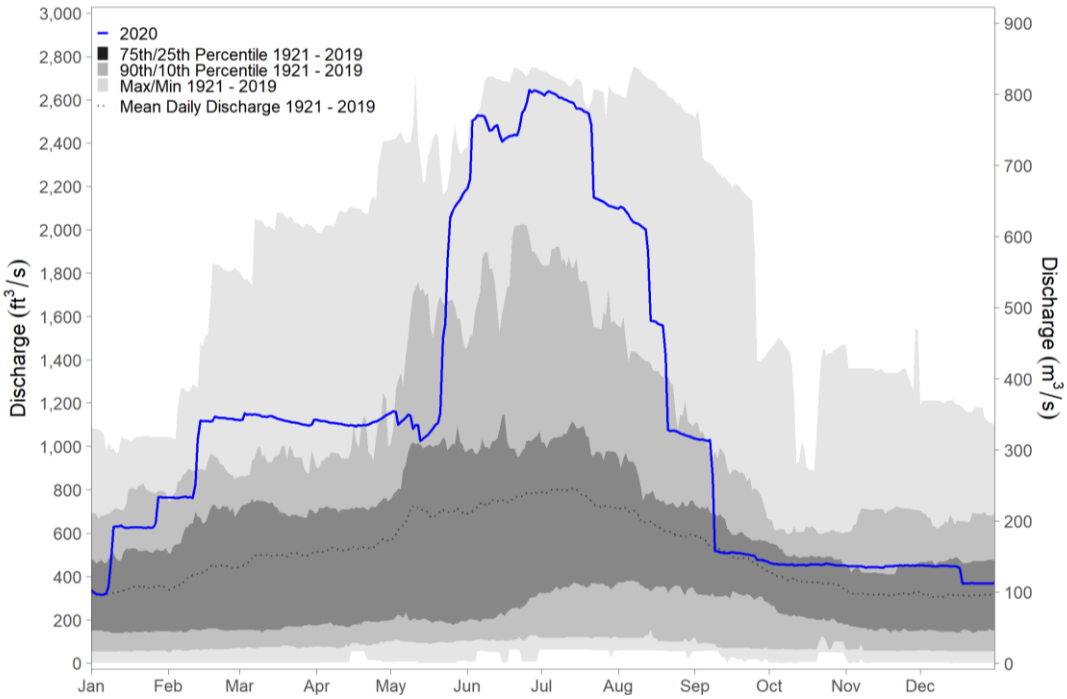


Figure 8 - Okanagan River at Penticton (WSC station 08NM050), British Columbia. Historical (1921-2019): Maximum, 90th/10th and 75th/25th Percentiles, Daily Mean, Minimum, and 2020 streamflow discharge (Environment and Climate Change Canada, 2021).

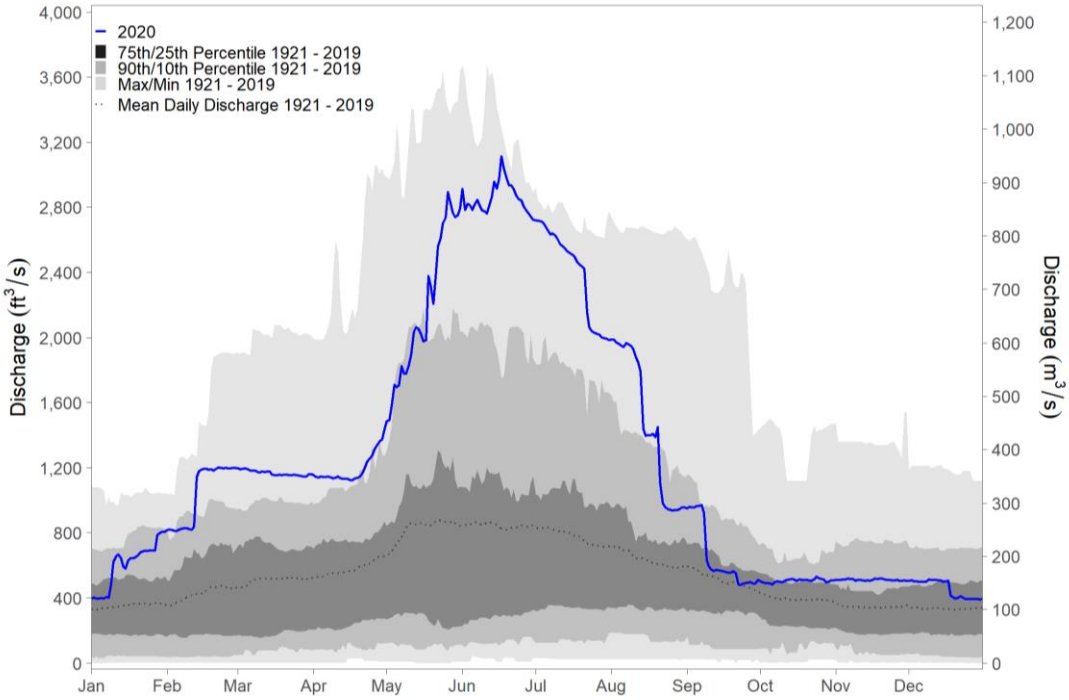


Figure 9 - Okanagan River near Oliver (WSC station 08NM085), British Columbia. Historical (1944-2019): Maximum, 90th/10th and 75th/25th Percentiles, Daily Mean, Minimum, and 2020 streamflow discharge (Environment and Climate Change Canada, 2021).

Okanogan River Discharge and Similkameen River Discharge

As a result of the above normal spring snowpack, the Similkameen River reached a peak instantaneous discharge of 20,700 cfs (586.2 cms) on June 1 during the spring freshet (Figure 10) compared to 10,500 cfs (297.3 cms) on May 18, 2019.

Drought criteria within the Similkameen River and Okanagan Lake outlined in the Orders of Approval for Osoyoos Lake were not met in 2020. Cumulative April - July flow volume for the Similkameen River was 1,733,411 acre-feet as measured at the USGS streamflow gaging station at Nighthawk, which was greater than the early April and early May forecasts (Table 1).

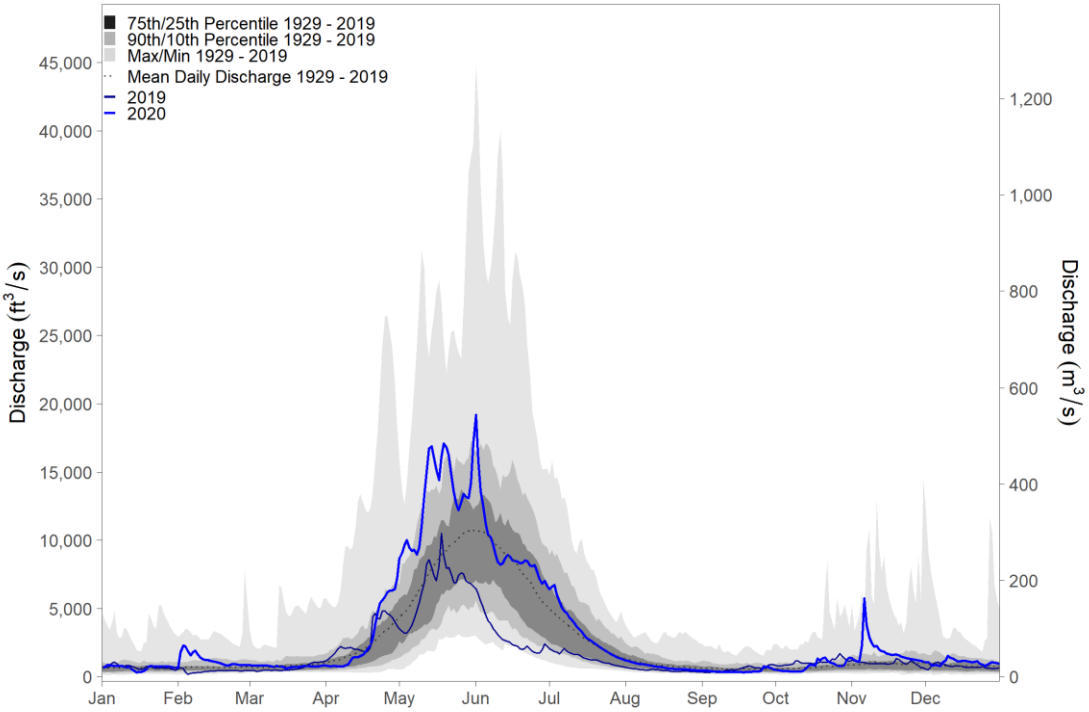


Figure 10 – Similkameen River at Nighthawk (USGS 1244250), Washington. Historical (1929-1919): Maximum, 90th/10th and 75th/25th Percentiles, Daily Mean, Minimum, and 2020 mean daily discharge (US Geological Survey, 2021).

Mean daily discharge of the Okanogan at Oroville (downstream from Zosel Dam) ranged from a minimum of 138 cfs (3.9 cms) on January 14 to 3,190 cfs (90.3 cms) on June 4 (Figure 11). The minimum discharge recorded on January 14 resulted from the development of an ice jam (discussed further below), created by the accumulation of ice flows at the southern end of the lake during a period of sub-freezing temperatures and strong northerly winds. The ice jam reduced conveyance capacity of the Okanogan River and also caused a concomitant increase in the level of Osoyoos Lake. A similar ice jam, which also reduced discharge of the Okanogan River, occurred during the previous year in February 2019. Maximum mean daily discharge during 2020 was 3,190 cfs (90.3 cms), which occurred during the spring freshet on June 4 and 5. During these days, the corresponding Osoyoos Lake elevation was 913.4 and 913.21 ft (278.40 and 278.35 m). The maximum instantaneous discharge of the Okanogan River at Oroville during 2020 also occurred during the spring freshet on June 4 at 07:30 PDT.

Mean daily discharge of the Similkameen River near Nighthawk ranged from a minimum of 316 cfs (8.9 cms) on January 15 to 19,200 cfs (543.7 cms) on June 1 (Figure 10). The maximum instantaneous discharge of the Similkameen River (20,700 cfs; 586.2 cms) also occurred on June 1 between 03:00 and 05:15 PDT during the spring freshet. During this period of elevated discharge, the Similkameen River created a backwater effect that controlled discharge of the Okanogan River at Oroville and therefore Zosel Dam operations did not control outflow from Osoyoos Lake. The annual mean discharge of the Similkameen River was 3,095 cfs (87.6 cms) in 2020, which was 134 percent of the 91-year (1929-2019) average of 2,309 cfs (65.4 cms). From 1929 through 2019, there were 24 years when the annual mean flow was less than 2,309 cfs (65.4 cms). The lowest annual mean discharge of record, 1,030 cfs (29.2 cms), occurred in 2001.

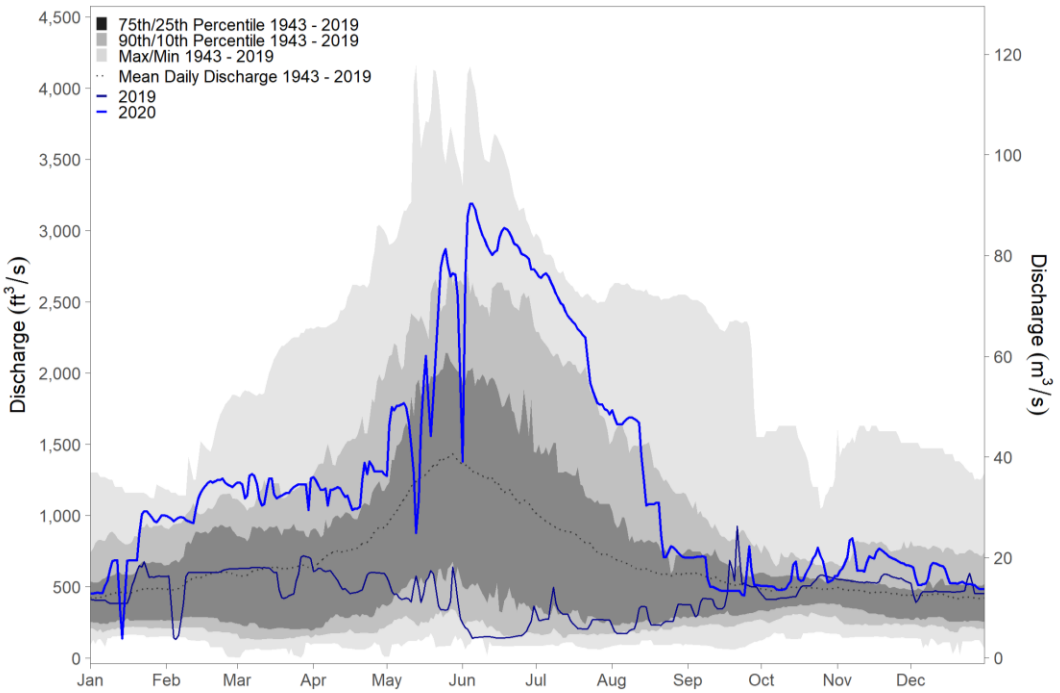


Figure 11 – Okanogan River at Oroville (USGS station 12439500), Washington. Historical (1943-2019): Maximum, 90th/10th and 75th/25th Percentiles, Daily Mean, Minimum, and 2020 mean daily discharge (US Geological Survey, 2021).

2020 OSOYOOS LAKE LEVEL AND ORDER COMPLIANCE

Throughout any given year, Osoyoos Lake levels may fluctuate in accordance with criteria specified in the IJC's Supplementary Order of Approval dated January 29, 2013. Lake levels are influenced naturally by discharge in the Okanagan/Okanogan and Similkameen Rivers and by the operation of Zosel Dam. Mean daily lake levels measured at the USGS Station no. 12439000 (Osoyoos Lake at Oroville) are plotted in green for 2020 (Figure 12).

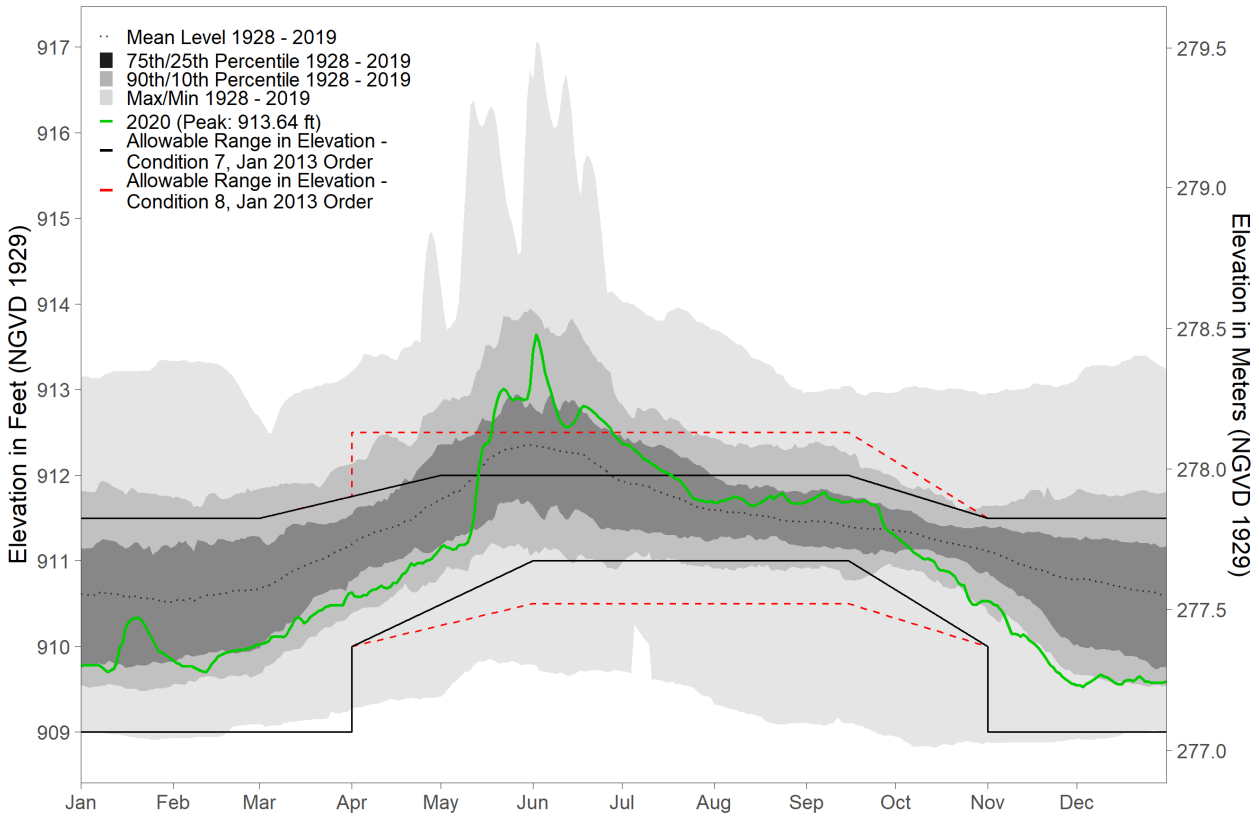


Figure 12 – Allowable Osoyoos Lake elevations per IJC Supplemental Order of Approval dated January 29, 2013, Historical (1928-1919): Maximum, 75th/25th and 90th/10th Percentiles, Daily Mean, Minimum, and 2020 daily mean lake elevations recorded at USGS station 12439000.

Osoyoos Lake levels were largely within the allowable range of the standard (Condition 7) rule curve in 2020 except for the period between May 14 and July 17 when lake levels exceeded the upper bound of the rule curve (912.0 feet). While the water level exceeded the standard rule curve by a maximum of 1.65 feet (0.50 m) in June, this exceedance was allowable under the Orders because all Zosel Dam gates were fully opened on May 11 and Zosel Dam no longer controlled outflow from the Lake; instead, outflow was controlled by the stage of the Similkameen River during this period of the spring freshet.

The maximum instantaneous Osoyoos Lake elevation was 913.65 ft. (278.48 m), which occurred at 07:00 PDT on June 2. The maximum daily mean elevation also occurred on June 2

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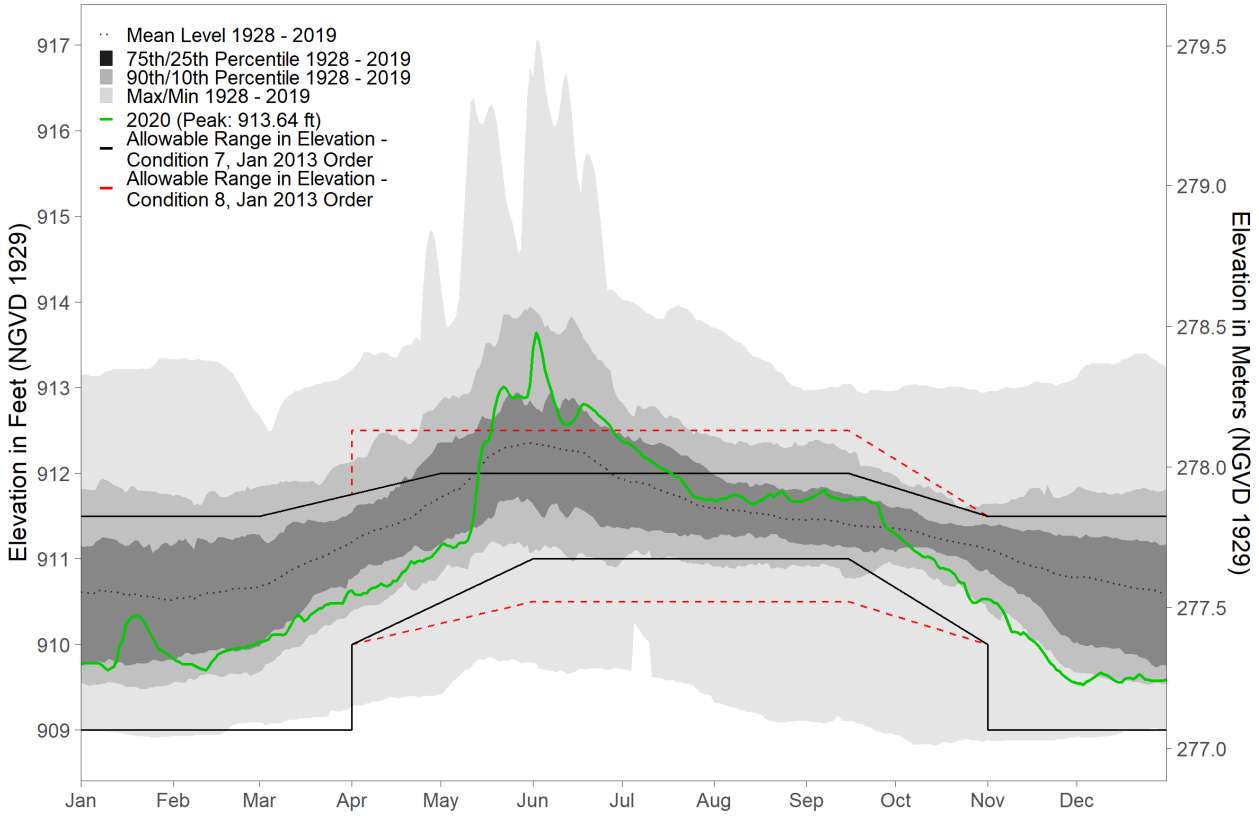

Figure 12) and was 913.64 ft (278.48 m). After Osoyoos Lake stage decreased below 912.0 feet on July 18, Zosel Dam resumed control of outflow from Osoyoos Lake for the rest of the year. In 2020, there were no other deviations from the rule curve that was in effect and thus the Applicant was in compliance with the IJC's 2013 Supplementary Order of Approval.

Another increase in lake stage, which occurred entirely within the rule curve, occurred as a result of decreased capacity at the outlet of Osoyoos Lake due to an ice jam that formed during a period of cold weather in January (Figure 13). The Board monitored the development of ice jam and Osoyoos Lake stage during the ice-jam event until the jam thawed in late January and lake levels lowered.

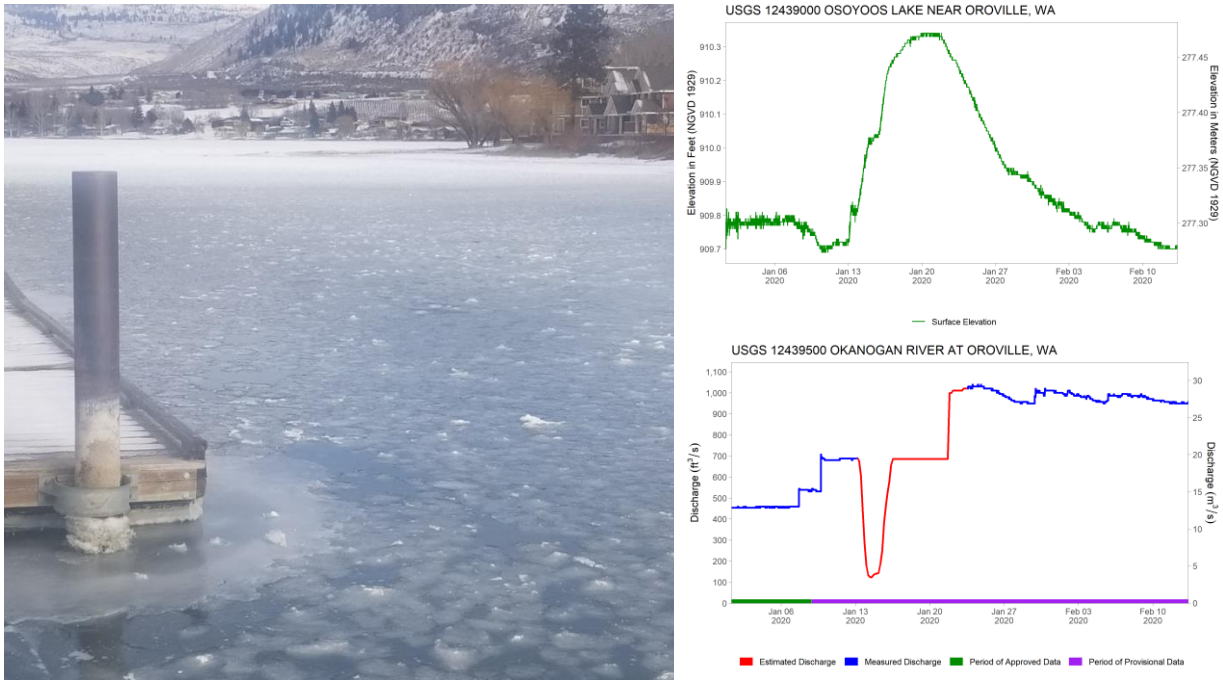

Figure 13 – Ice jam formation reduced channel outflow from Osoyoos Lake, and increased lake levels. a) Photograph at the outlet of Osoyoos Lake at Veterans Memorial Park (Oroville, Washington) in January 2020. b) Osoyoos Lake near Oroville lake elevation (USGC 1243900) in Jan-Feb, 2020. c) Okanogan River near Oroville discharge (USGS 12439500) in Jan-Feb, 2020.

The minimum instantaneous elevation was 909.52 ft (277.22 m), which occurred at 07:30 PST on December 3. The minimum daily mean elevation was 909.53 ft (277.23 m), which also occurred on December 3.

<u>Backwater Conditions</u>

Inflows into Osoyoos Lake from the Okanagan River, combined with high flows in the Similkameen River (at the confluence with Okanogan River) during freshet may result in a stop or reversal of flow across Zosel Dam due to a hydraulic dam, limiting the discharge of Osoyoos Lake water under certain conditions. In 2020, elevated discharge of the Similkameen River (above 10,000 cfs, Figure 14 – dark blue line) contributed to reduced discharge of the Okanogan River at the outlet of Osoyoos Lake on several occasions during the spring freshet in May (Figure 14 – light blue line). The Okanogan River at Oroville (between Zosel Dam and Similkameen/Okanogan River confluence) discharge began to decrease, while Osoyoos lake inflows continued, resulting in Osoyoos Lake levels to rise quickly (Figure 14 – red line). The blue rectangles (Figure 14) illustrate the periods of this effect on three occasions in May 2020.

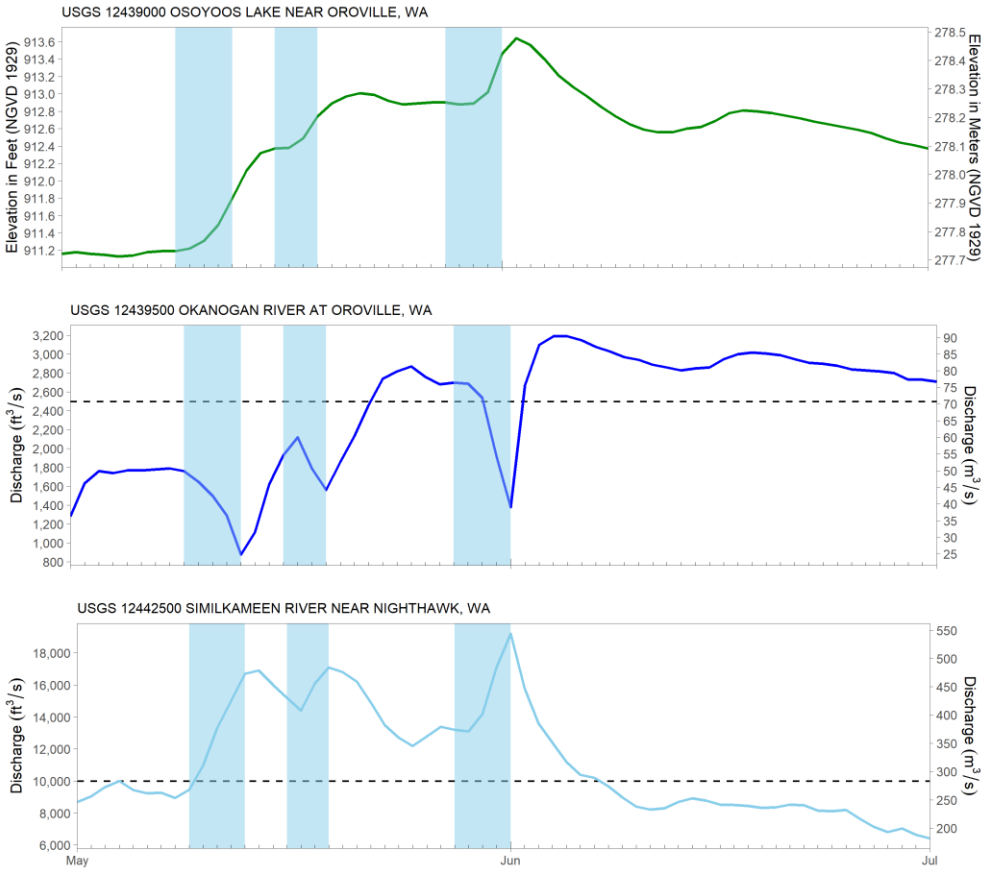

Figure 14 – Similkameen River 2020 backwater conditions. As Similkameen discharge increases (particularly when above 10,000 cfs), Okanogan River at Oroville (between Zosel Dam and Similkameen/Okanogan River confluence) discharge begins to decrease. If Osoyoos lake inflows continue, Osoyoos Lake levels rise quickly. The blue rectangles show prominent periods of Similkameen backwater effect on Osoyoos Lake.

Okanogan River Flow Capacity

Conditions 3 and 4 of the IJC Order of 1982 specify that the flow capacity of the Okanogan River channel between the outlet of Osoyoos Lake up to and including Zosel Dam be at least 2,500 cfs (70.8 cms) when the elevation of Osoyoos Lake is 913.0 ft (278.3 m) and there is no appreciable backwater effect from the Similkameen River. Discharge of the Okanogan River as measured at the USGS gage at Oroville downstream of Zosel Dam (USGS station no. 12439500) surpassed 2,500 cfs (70.8 cms) twice in the period May to July 2020. The maximum daily mean discharge measured at this location was 3,087.9 cfs (87.4cms) on June 17, 2020. Discharge was above 2,500 cfs and Osoyoos Lake was above 913 feet elevation between June 2 and June 6 as shown on Figure 15, as illustrated by the light green rectangle. As a result, the flow capacity of the Okanogan River was confirmed in 2020.

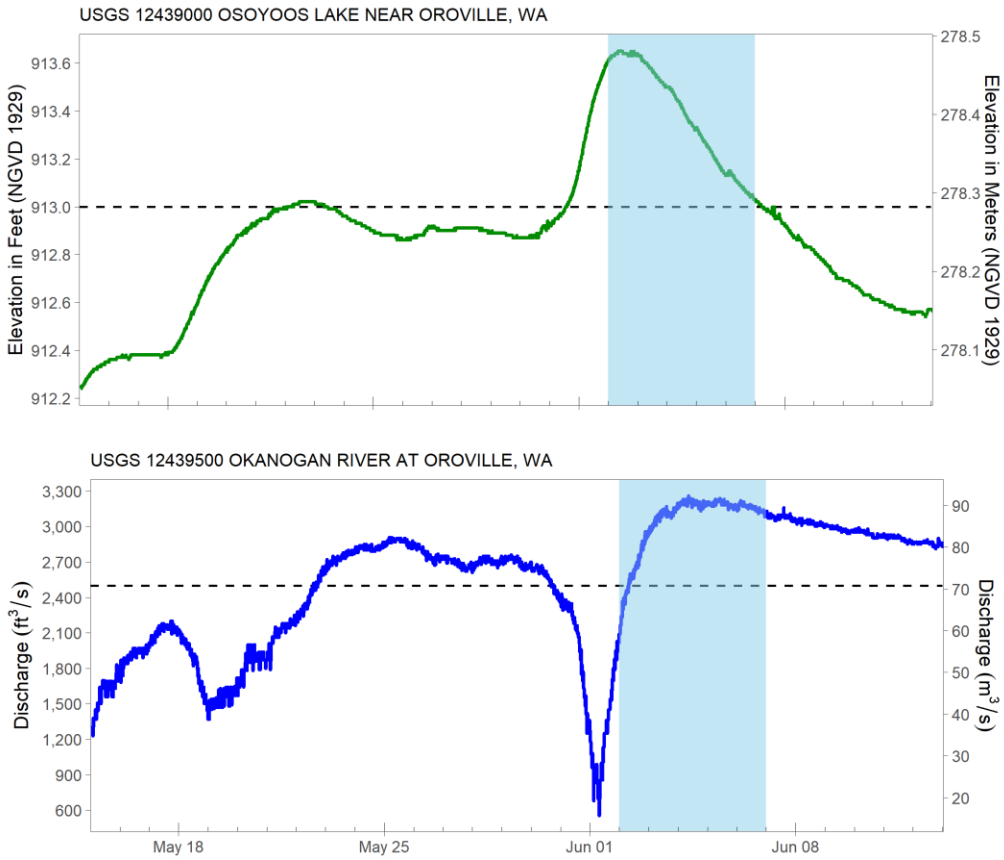

Figure 15 – Okanogan River flow capacity demonstration for the period May 15 to June 12, 2020. Top, mean daily Osoyoos Lake elevations recorded at USGS station 12439000, along with 913 ft. threshold. Bottom, mean daily discharge recorded at Okanogan River at Oroville (USGS station 12439500) and 2,500 cfs threshold.

APPENDIX: OSOYOOS LAKE LEVELS, INFLOWS, AND OUTFLOWS IN 2020

A. International gaging stations in operation throughout the year:

(1) For Stage Records
Osoyoos Lake near Oroville, Washington
Okanogan River at Oroville, Washington (auxiliary gage)

(2) For Discharge Records
Okanagan River near Oliver, British Columbia
Okanogan River at Oroville, Washington (base gage)
Similkameen River near Nighthawk, Washington

B. Compliance with the lake levels specified in the Orders of Approval is measured at the station "Osoyoos Lake near Oroville," where elevations are expressed in terms of the U.S. National Geodetic Vertical Datum of 1929 (NGVD 1929).

C. Osoyoos Lake (USGS station no. 12439000)

Maximum instantaneous elevation	913.65 ft. (278.48 m) – Jun 2 07:00 – Jun 2 10:30
Minimum instantaneous elevation	909.52 ft. (277.22 m) – Dec 3 07:30
Maximum daily mean elevation	913.64 ft. (278.48 m) – Jun 2
Minimum daily mean elevation	909.53 ft. (277.23 m) – Dec 3
Lake elevation at time of maximum daily mean discharge for Okanogan River at Oroville	913.4 ft. (278.40 m) and 913.21 ft. (278.35) – Jun 4 and Jun 5

D. Okanogan River at Oroville (USGS station no. 12439500)

Maximum instantaneous discharge	3,260 cfs (92.3 cms) – Jun 4 07:30
Minimum instantaneous discharge	122 cfs (3.0 cms) – Jan 14 04:30
Maximum daily mean discharge	3,190 cfs (90.3 cms) – Jun 4 and Jun 5
Minimum daily mean discharge	138 cfs (3.9 cms) – Jan 14
Annual mean discharge	1,260 cfs (35.7 cms)

The annual mean discharge was 183 percent of the 77-year (1943-2019) average of 688.0 cfs (19.5 cms).

E. Similkameen River near Nighthawk (USGS station no. 12442500)

Maximum instantaneous discharge	20,700 cfs (586.2 cms) – Jun 1 03:00 – 05:15
Minimum instantaneous discharge	269 cfs (7.6 cms) – Jan 15 12:30
Maximum daily mean discharge	19,200 cfs (543.7 cms) – Jun 1
Minimum daily mean discharge	316 cfs (8.9 cms) – Jan 15
Annual mean discharge	3,095 cfs (87.6 cms)

The annual mean discharge was 134 percent of the 91-year (1929-2019) average of 2,309 cfs (65.4 cms).

F. Okanagan River at Oliver (ECCC station no. 08NM085)

Maximum instantaneous discharge	3168 cfs (89.7 cms) – Jun 16-17 23:50 – 00:15
Minimum instantaneous discharge	380.1 cfs (10.5 cms) – Jan 5 18 05:50 to 19:50
Maximum daily mean discharge	3,167 cfs (89.7 cms) – Jun 17
Minimum daily mean discharge	388 cfs (11.0 cms) – Jan 5
Annual mean discharge	1,254 cfs (35.5 cms)