Annual Report of The Columbia River Treaty, Canada and United States Entities

01 August 2018 through
30 September 2019

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2019 ANNUAL REPORT

OF THE

COLUMBIA RIVER TREATY

CANADA AND UNITED STATES ENTITIES

FOR THE PERIOD

01 AUGUST 2018 – 30 SEPTEMBER 2019

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Project Naming Conventions

Hugh Keenleyside Dam

The official name of the project is Hugh Keenleyside Dam, but it will be referred to as Keenleyside in the report. The official name of the associated reservoir is Arrow Lakes Reservoir, but it will be referred to as Arrow in the report, i.e. "Arrow" will always refer to the reservoir and "Keenleyside" will always refer to the dam/project/facility. Note that when the Treaty was signed, the dam was referred to as Arrow; the re-naming to Hugh Keenleyside Dam was completed later.

Mica Dam and Powerhouse

The official name of the project/facility is Mica Dam and Powerhouse, but it will be referred to as Mica in the report. The official name of the associated reservoir is Kinbasket Lake Reservoir, but it will be referred to in the report as Kinbasket.

Libby Dam

The official name of the project is Libby Dam, but it will be referred to as Libby in the report. The official name of the associated reservoir is Lake Koocanusa.

Duncan Dam

The official name of the project is Duncan Dam, but it will be referred to as Duncan in the report. The official name of the associated reservoir is Duncan Reservoir, but it will be referred to in the report as Duncan.

Reporting Periods:

Water Year (WY) and Operating Year (OY) Description

This 2019 Annual Columbia River Treaty Entity Report is for the Water Year (WY) 01 October 2018 through 30 September 2019, with additional information on the operation of Mica, Keenleyside, Duncan, and Libby dams, as needed to cover the reservoir system planning and operating period. The WY is defined as 1 October to 30 September in North America due to the timing of the natural progression of hydrologic processes. It begins with the start of soil moisture recharge in the fall, continues through a period of groundwater recharge and maximum runoff and concludes with a period of maximum evapotranspiration during the summer when deciduous trees and other plants are in bloom.

The Pacific Northwest reservoir system planning and operating period is referred to as the Operating Year (OY), defined as the period from 1 August through 31 July. This is the period used for establishing reservoir operating criteria under the Pacific Northwest Coordination Agreement as well as the Treaty. The timeframe corresponds to the traditional cycle for power operations when reservoirs begin drafting to meet firm load (August) and completes at the end of the runoff season when reservoirs refill at the end of July.

Additional operations carry on past July into August and September, such as the runoff period used in Flood Risk Management (FRM) operations (April – August) and Libby Reservoir operational targets at the end of September. This Annual Report of the Columbia River Treaty from the Canada and United States Entities describes hydrologic data from WY and OY 2019, therefore, to fully describe the yearly operations of the Columbia River in this annual report, a fourteen (14) month period encompassing the OY and the WY, from 1 August 2018 to 30 September 2019, is described. When August and September are referred to in the text the year is stated to clarify which month is being described.

EXECUTIVE SUMMARY

General

This annual Columbia River Treaty Entity Report is for the Water Year (WY) 2019, 01 October 2018 through 30 September 2019, with additional information on the operation of Mica, Keenleyside, Duncan, and Libby dams, as needed to cover the reservoir system planning and operating period (Operating Year) 01 August 2018 through 31 July 2019.

Water Year (WY) 2019 streamflow and snowpack conditions were generally below average with an April-August runoff volume, measured at The Dalles, of 99.9 cubic kilometers (km^3) (81.0 Million acre-feet, Maf), or 93 percent of the 30-year average (1981 – 2010). April-August runoff volumes in the Upper Columbia, Kootenai, and Pend Oreille basins were below the 30-year average at 90, 76, and 90 percent, respectively. April-August runoff was above average in the Snake Basin 117 percent).

Seasonal runoff volumes for the April-August 2019 period, adjusted to exclude the effects of regulation of upstream storage, are listed below for eight locations in the Columbia River Basin:

Location	Volume in km^3	Volume in MAF	Percentage of 1981-2010 Average
Libby Reservoir Inflow	5.5	4.5	76%
Duncan Reservoir Inflow	2.2	1.8	89%
Mica Reservoir Inflow	12.8	10.4	94%
Arrow Reservoir Inflow	24.3	19.7	90%
Columbia River at Birchbank	40.5	32.8	84%
Grand Coulee Reservoir Inflow	59.3	48.1	85%
Snake River at Lower Granite	30.3	24.6	117%
Columbia River at The Dalles	99.9	81.0	93%

(Source: NWRFC Runoff Processor)

A weak El Niño was present throughout the 2019 Water Year over the tropical Pacific. As is typical with El Niño conditions, water supply in the Columbia Basin was slightly lower than long-term averages with above average temperatures and below average precipitation as a whole. There were two key breaks from this overall trend with one of the coldest Februaries on record and a very wet first half of April which improved water supply conditions heading into the

spring/summer runoff period. For more information on weather and streamflows, go to Section IV.

For the Columbia River Treaty 01 August 2018 through 30 September 2019 reporting period, the Canadian Storage projects were operated according to the 2018-19 and the 2019-20 Detailed Operating Plans (DOPs), the 2003 Columbia River Treaty Flood Control Operating Plan (FCOP), and supplemental operating agreements as described below. The Libby project was operated consistently with the Libby Coordination Agreement (LCA), including the Libby Operating Plan (LOP), United States (U.S.) requirements for power, 2019 NOAA Fisheries Columbia River System Biological Opinion (2019 BiOp), the 2000 U.S. Fish and Wildlife Service Federal Columbia River Power System (FCRPS) BiOp, as supplemented in 2006 for Libby Dam (collectively referred to as the 2000/2006 BiOp)

Entity Agreements

During the period covered by this report, the following joint U.S.-Canadian agreements were approved by the Entities:

Date Signed by Entities	Description of Agreement
06 February 2019	Extension of the Columbia River Treaty Short-term Entity Agreement on Coordination of Libby Project Operations
08 July 2019	Columbia River Treaty Entity Agreement on the Detailed Operating Plan for Canadian Storage 01 August 2019 through 31 July 2020

Columbia River Treaty Operating Committee Agreements

The Columbia River Treaty Operating Committee (CRTOC) completed the following supplemental operating agreements during the reporting period:

Date Signed	Description	Authority
13 December 2018	Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 29 December 2018 through 31 July 2019	Detailed Operating Plan 01 August 2018 through 31 July 2019

System Storage

The 2018-19 Operating Year began on 01 August 2018 with the Canadian Storage at 18.3 km^3 (14.8 Maf), or 95 percent full. Canadian Storage drafted to a minimum of 3.9 km^3 (3.2 Maf), or 20 percent full on 29 March 2019, and refilled to 16.3 km^3 (13.2 Maf), or 85 percent full, on 31 July 2019. Canadian Storage operated in proportional draft mode during August 2018 through December 2018, in February 2019, and again during July 2019 through the end of this reporting period to meet Treaty firm loads. Throughout the Operating Year, the composite Canadian Storage targeted the Treaty Storage Regulation (TSR) study composite storage, plus any operations implemented under mutually-agreed-upon Supplemental Operating Agreements, including the Short Term Libby Agreement (STLA) and the Nonpower Uses Agreement (NPU). Exceptions occurred in all periods due to inadvertent draft or storage, which occurs routinely due to updated inflow forecasts or differences between forecast and actual inflows, as well as after-the-fact changes in proportional draft points.

As in past years, the CRTOC negotiated an NPU agreement to manage Keenleyside outflows and to improve conditions for fish in both countries. Under provisions of that agreement, the U.S. Entity stored 1.2 km^3 (504 thousand second-foot-days (ksfd), 1 Maf) of flow augmentation water by 01 February 2019 to be released to support flow objectives in the U.S. for salmon Operation under the agreement also helped to manage flows downstream of

Keenleyside for Canadian whitefish during the January through June period. Operation under the agreement helped to manage flows downstream of Keenleyside for Canadian whitefish during the January through June period. All of the water stored for Flow Augmentation under the NPU was released, for Columbia River salmon migration, from late June through late July 2019.

The actual January through July runoff for the Columbia River above The Dalles was 111.3 km^3 (90.2 Maf), or 89 percent of the 1981-2010 average. The actual April through August 2019 runoff for the Columbia River above The Dalles was 99.9 km^3 (81.0 Maf), or 93 percent of the 1981-2010 average. Below is the water supply forecast evolution for January - July at The Dalles.

January – July Water Supply Forecast for the Columbia River above The Dalles:

As Projected in	Volume km^3	Volume Maf	Percent of 1981 – 2010 Average
January	102.7	83.3	95
February	92.9	75.3	86
March	94.5	76.6	88
April	93.3	75.6	86
May	101.6	82.4	94
June	101.9	82.6	94
Jan – Jul Actual	111.3	90.2	89
Apr – Aug Actual	99.9	81.0	93

Operations of the three Canadian projects (Mica, Keenleyside, and Duncan) and Libby in the United States for the 14-month period from 01 August 2018 to 30 September 2019 are illustrated in Section VIII as Charts 5 through 8. The hydrographs show actual reservoir levels, discharges, inflows, and the Flood Risk Management (FRM) Rule Curve. The FRM Rule Curve specifies maximum month-end reservoir levels which permit timely evacuation of the reservoir to mitigate potentially high inflows from precipitation and snowmelt events.

Treaty Project Operations

Mica Dam (Kinbasket Reservoir)

Kinbasket reached a maximum elevation in 2018 of 747.25 m (2,451.6 ft), 7.13 m (23.4 ft) below normal full pool, on 17 August 2018. Low refill levels in 2018 were due to a compressed freshet leading to very dry summer conditions. Kinbasket reservoir was drafted as typically observed across the fall and winter. Winter of 2018-19 started relatively mild but quickly became unprecedentedly cold and dry; these conditions lasted through February and early March. Significantly more draft occurred as a result in February 2019 to meet high winter electricity demand. In 2019, the minimum level reached was 714.82 m (2,345.2 ft) on 14 April 2019, about 4.42 m (14.5 ft) lower than the 2018 minimum level.

From February to August 2019, reservoir inflows were about 93% of average. Low inflows combined with deep draft in the spring caused the reservoir to refill to below average levels: maximum was 748.10 m (2,454.4 ft) on 27 September 2019, 6.28 m (20.6 ft) below normal full pool.

Hugh Keenleyside Dam (Arrow Lakes Reservoir)

In Operating Year 2017-18 Arrow reached a maximum level of 439.73 m (1,442.7 ft), or 0.40 m (1.3 ft) below full pool, on 13 July 2018. Arrow releases are regulated under the Columbia River Treaty (CRT) and its supplemental operating agreements. Under dry conditions, storage must be drafted as far as necessary to meet Treaty firm loads consistent with the principles of proportional draft under the CRT. When conditions become wetter, Treaty storage comes out of proportional draft. As the draft began from a near-full storage, Arrow Lakes Reservoir summer levels were within recreation range through 04 September 2018 (Labour Day). Arrow followed a typical draft across the winter to reach a minimum level of 429.25 m (1,408.3 ft) on 02 February 2019. By comparison, in 2018, Arrow Lakes Reservoir reached a minimum level of 429.16 m (1,408.0 ft) on 28 March 2018.

Arrow Lakes Reservoir refilled in April/May/June to a maximum level of 438.91 m (1,440.0 ft) on 21 June 2019. This is about 1.22 m (4.0 ft) below full pool and 0.82 m (2.7 ft) below the

2018 maximum level. As in past years, Arrow Lakes Reservoir drafted during the summer months, with levels reaching 434.46 m (1,425.4 feet) on Labour Day.

Duncan Dam (Duncan Reservoir)

Duncan began the operating year near-full pool, at 576.59 m (1,891.7 ft), 0.09 m (0.3 ft) below full pool on 01 August 2018. By comparison in the previous year, the reservoir reached a similar maximum level of 576.50 m (1,891.4 ft), 0.18 m (0.6 ft) below full pool on 13 August 2017. From September 2018 through April 2019, Duncan was operated to supplement flows into Kootenay Lake, to provide spawning and incubation flows for fish downstream in the Duncan River and to meet Treaty FRM requirements. As in most years, the reservoir was drafted to near empty in late April. Duncan reached its minimum level, 547.42 m (1,796.0 ft) on 18 April 2019. By comparison, the reservoir reached a similar minimum level of 547.09 m (1,794.9 ft) on 19 April 2018.

The reservoir discharge was reduced to its minimum of 3 m^3/s (0.1 kcfs) in May to initiate reservoir refill and reduce flood risk downstream at Meadow Creek and around Kootenay Lake. Releases from Duncan were held at minimum until the end of July, when discharges were gradually increased to manage the rate of reservoir refill. In 2019, Duncan refilled to a maximum of 576.47 m (1,891.3 ft), 0.21 m (0.7 ft) below full pool on 02 August 2019. Duncan discharges were increased during August 2019 to facilitate drafting the reservoir to reach the summer recreation target of 575.46 m (1,888.0 ft) between 10 August 2019 and Labour Day 2019 as per the Duncan Water Use Plan Order.

Libby Dam (Lake Koocanusa)

Lake Koocanusa ended July 2018 at elevation 746.12 m (2,447.9 ft). The project was drafted to elevation 744.87 m (2,443.8 ft) at the end of August 2018. From September 2018 through April 2019, the project was operated to meet minimum bull trout flows, FRM requirements, and emergency hatchery operations. For ten days in early March, releases from Libby were increased to clear ice from the water intake for the Burbot and Kootenai Sturgeon fish hatchery. On 26 March 2019, Libby Dam reached its minimum elevation for the year of 733.26 m (2405.7 ft) then operated to its minimum flow until the onset of refill 22 April 2019, when operations went to the

Variable Flow (VarQ) FRM rules until the start of the sturgeon pulse. On 29 May 2019, Libby began to release the sturgeon volume of 1.0 km^3 (0.8 Maf) set by the May water supply forecast of 6.1 km^3 (5.0 Maf), which is 85 percent of average. The 2019 sturgeon volume was released in a single pulse operation with the goal of matching timing with high elevation runoff. The pulse began on 29 May 2019 with project outflows ramping up to 566 m^3/s (20.0 kcfs) for 20 days. The outflows were then stepped down to the minimum bull trout flow of 198 m^3/s (7.0 kcfs) over six days using ramping rates. The sturgeon volume was expended on 26 June 2019. Lake Koocanusa ended the month of June at elevation 740.48 m (2,429.4 ft).

The operation for the rest of the summer, July through August 2019, was to try to refill Libby as much possible and meet the 746.46 m (2,449.0 ft) target by the end of September 2019, as required in the 2019 BiOp and coordinated through the Technical Management Team (TMT). Libby reached its peak elevation for the summer on 22 August 2019, at 744.47 m (2,442.5 ft) 22 August 2019, at 744.47 m (2,442.5 ft), which was 5.03 m (16.5 ft) below full pool. Due to low inflows and pool, Libby releases were kept at the minimum bull trout flow of 198 m^3/s (7.0 kcfs) from July through August 2019 then ramped down to 170 m^3/s (6.0 kcfs), the minimum bull trout flow for September 2019. Libby elevation was 744.35 m (2,442.1 ft) at the end of August 2019 and this elevation was maintained through the end of September 2019. The Kootenai Tribe of Idaho had requested low flows for in-stream habitat work in previous summers, but this request was not made in 2019. Libby held 170 m^3/s (6.0 kcfs) through the end of September 2019.

Treaty Benefits

Flood Risk Management Operations

Columbia River Basin projects were operated for FRM objectives according to the May 2003 FCOP. Overall, the 2019 runoff volumes were below normal across the Columbia River Basin. The regulated peak outflow during the freshet from The Dalles Dam was 9,447 m^3/s (333.6 kcfs) on 19 May 2019, and the unregulated peak flow was at 13,133 m^3/s (463.8 kcfs) on 04 June 2019. The peak stage observed during the freshet at Vancouver, Washington, was 3.23 m (10.6 ft) on 04 June 2019, and the estimated peak unregulated stage was 4.94 m (16.2 ft) on 20 May 2019, while the flood stage is 4.88 m (16.0 ft). For the spring season, observed regulated peak stage at

Vancouver, Washington, was 4.75 m (15.6 ft) with an unregulated peak of 5.58 m (18.3ft), which occurred on 12 April 2019 and was due, in part, to high discharges from the Willamette River.

Flood Risk Management Benefits

Water Year 2019 resulted in a relatively quiet FRM season due to below average seasonal volumes. Below normal 01 April 2019 snow pack, early runoff, and below average late season precipitation across the basin resulted in no significant local flood risk issues. Reservoirs throughout the Columbia River basin, including the Treaty projects, were carefully managed to meet system needs and to achieve local FRM objectives as detailed below. The actual unregulated runoff for the overall Columbia River Basin (U.S. and Canada combined) measured at The Dalles for January through July 2019 was 111.3 km^3 (90.2 Maf), 89 percent of the 1981-2010 average. The peak regulated (and estimated unregulated) flows and river stages are shown in the following tables:

Columbia River Streamflow at The Dalles Dam, Oregon

Date	Peak Unregulated Flow	Date	Peak Regulated Flow
04 June 2019	13,133 m^3/s (463.8 kcfs)	19 May 2019	9,447 m^3/s (333.6 kcfs)

Columbia River Stage at Vancouver, Washington
Flood Stage is 4.88 m (16.0 ft)

Date	Peak Unregulated Stage	Date	Peak Regulated Stage
20 May 2019	4.94 m (16.2 ft)	19 May 2019	3.23 m (10.6 ft)

Hydroregulation by the Duncan and Libby projects limited the peak level of Kootenay Lake at Queen's Bay to 532.27 m (1,746.3 ft) on 05 June 2019. Without regulation from those Treaty dams, the peak level would have been approximately 533.52 m (1,750.4 ft). As documented in

the 2003 FCOP, flood damages commence at Nelson when the Kootenay Lake elevation reaches 534.9 m (1,755.0 ft). Duncan, Keenleyside, Mica and Libby projects limited the peak flow of the Columbia River at Trail, just upstream of Birchbank, British Columbia, to 2,662 m^3/s (94.0 kcfs) on 11 June 2019. Absent the dams, but with natural lake effects at Kootenay Lake, the flow would have been approximately 5,182 m^3/s (183.0 kcfs). For reference as per the DOP16, the bankfull flow at Birchbank is estimated to be 5,097.0 m^3/s (180.0 kcfs).

Power Benefits

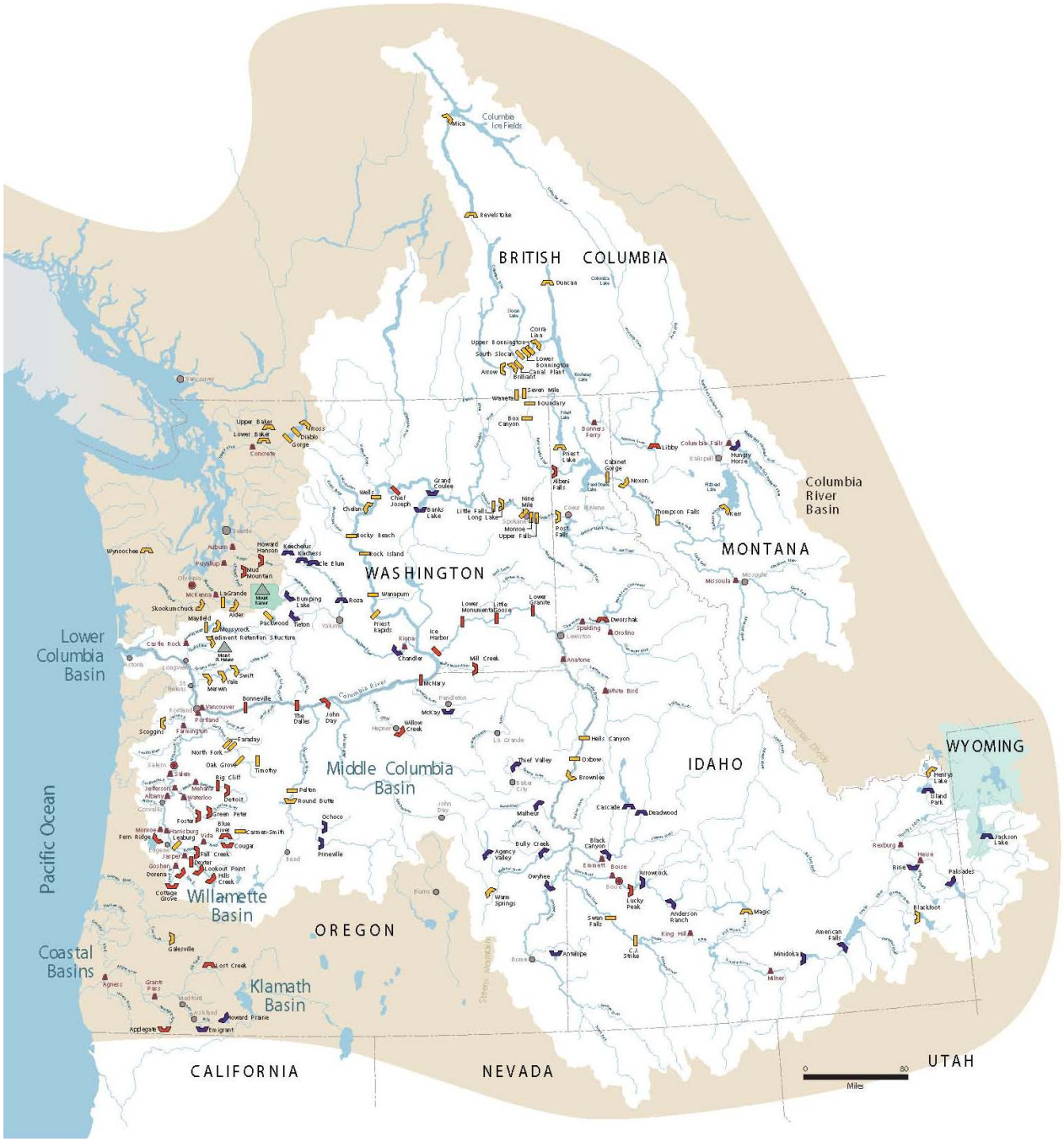
A Determination of Downstream Power Benefits (DDPB) is computed in conjunction with the Assured Operating Plan (AOP). This computation represents the optimized generation from downstream U.S. projects that could have been produced by an optimized Canadian/U.S. system. The DDPB is prepared in accordance with the Treaty and Protocol, and other Entity Agreements. The Canadian Entitlement (CE) represents one-half of the DDPB. For the period 01 August 2018 through 31 July 2019, the CE amount, before deducting transmission losses, was 472.5 average Megawatts (aMW) of energy, scheduled at rates up to 1,284 Megawatts (MW). From 01 August 2019 through 30 September 2019, the amount, before deducting transmission losses, was 454.3 aMW of energy, scheduled at rates up to 1,141.5 MW.

During the course of the 2018-19 Operating Year, there were no CE delivery curtailment events.

Actual U.S. power benefits from the operation of Canadian Storage can only be roughly estimated. Canadian Storage has such a large impact on the operation of the U.S. system that its absence would significantly affect operating procedures, nonpower requirements, loads and resources, and market conditions, thus making any benefit analysis highly speculative. A rough estimate of the impact on U.S. hydroelectric power generation during the 2018-19 Operating Year, with and without the regulation of Canadian Storage, based on the Pacific Northwest Coordination Agreement (PNCA) Actual Energy Regulation (AER), that includes minimum flow and spill requirements for U.S. fishery objectives, is 343 aMW. The increase in hydroelectric power generation occurred primarily in the fall and winter months, October through March. No quantification of the financial benefit is provided in this report.

Treaty operating plans are designed to adapt to streamflow and water supply conditions that arise and evolve over the Operating Year. Operating Plans are implemented through the TSR model study which incorporates streamflows, water supply forecasts and other parameters. In the study, Canadian Storage targets are updated twice a month; once a period has passed, target contents for that period are finalized in the first TSR of the subsequent period. This report discusses conditions as realized for the 2018-19 Operating Year and describes the response of Canadian Storage to the observed inflows and water supply conditions which occurred over the year. The risk mitigation benefits associated with the Treaty's flexibility to adapt to the broad array of water conditions that were possible going into the water year are not addressed or quantified in this report.

Columbia Basin Map



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Acronyms and Abbreviations

AER.....Actual Energy Regulation

aMW…….. .....Average Megawatts

AOP…….....Assured Operating Plan

BC Hydro .....British Columbia Hydro and Power Authority

BiOp .....Biological Opinion

BPA.....Bonneville Power Administration

CE……...Canadian Entitlement

CEEA .....Canadian Entitlement Exchange Agreement

cfs .....Cubic feet per second

CRC.....Critical Rule Curve

CRT .....Columbia River Treaty

CRTHC .....Columbia River Treaty Hydrometeorological Committee

CRTOC .....Columbia River Treaty Operating Committee

DDPB .....Determination of Downstream Power Benefits

DOP.....Detailed Operating Plan

DRL.....Duncan River below the Lardeau R. confluence

ESP…….Ensemble Streamflow Procedure

FCOP.....Flood Control Operating Plan

FCRPS.....Federal Columbia River Power System

FRM .....Flood Risk Management

ft .....feet

hm^3 .....Cubic hectometers

ICF .....Initial Controlled Flow

IJC .....International Joint Commission

kaf .....Thousand acre-feet

kcfs.....Thousand cubic feet per second

KLBC .....Kootenay Lake Board of Control

km^3 .....Cubic kilometer (one billion cubic meters)

ksfd.....Thousand second-foot-days (= kcfs x days)

LCA.....Libby Coordination Agreement

LOP .....Libby Operating Plan

m .....Meter

m^3/s .....Cubic meters per second

Maf.....Million acre-feet

MG ….....Major General

MW .....Megawatt

MWh .....Megawatt hour

NOAA Fisheries.....National Oceanic and Atmospheric Administration's National Marine Fisheries Service, formerly NMFS

NPU.....Nonpower Uses Agreement

NTSA .....Non-Treaty Storage Agreement

NWRFC .....Northwest River Forecast Center

ORC .....Operating Rule Curve

OY……..Operating Year (Aug-Jul)

PEB .....Permanent Engineering Board

PEBCOM .....PEB Engineering Committee

PNCA.....Pacific Northwest Coordination Agreement

POP .....Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans for Canadian Storage

SSARR .....Streamflow Synthesis and Reservoir Regulation (computer simulation)

STLA…….....Columbia River Treaty Short-Term Entity Agreement on Coordination of Libby Project Operations

TMT……Technical Management Team

TSR…… Treaty Storage Regulation

U.S. .....United States

USACE .....U.S. Army Corps of Engineers

VarQ.....Variable flow flood risk management

VRC .....Variable refill curves

WSF……Water Supply Forecast

WUP.....Water Use Plan

WY .....Water Year (Oct-Sep)

Unit Conversions

Distance

1 km = 3280.839895 ft

1 m = 3.280839895 ft

Volume

1 m^3 = 35.314666721 ft^3

1 km^3 = 35314666721 ft^3

1 km^3 = 0.81070828 Maf

1 hm^3 = 0.000810708 Maf

1 hm^3 = 0.81070828 kaf

1 hm^3 = 0.40873 ksfd

1 ksfd = 1.98347 kaf

Flow

1 m^3/s = 35.31466672 cfs

Measurement Conventions

Flows are daily averages

Elevations are measured at end-of-day

I – INTRODUCTION

This annual Columbia River Treaty Entity Report is for the Water Year (WY) 2019, 01 October 2018 through 30 September 2019, with additional information on the operation of Mica, Keenleyside, Duncan, and Libby dams, as needed, to also cover the reservoir system Operating Year, 01 August 2018 through 31 July 2019. Also described are the power and flood risk management (FRM) effects downstream in Canada and the United States (U.S.). This report is the 53rd of a series of annual reports covering the period since the ratification of the Columbia River Treaty (Treaty, CRT) in September 1964.

Duncan, Keenleyside, and Mica in Canada were constructed as required under the CRT, and Libby in the U.S. was constructed as provided for by the CRT. Treaty storage in Canada (Canadian Storage) is operated for the primary purposes of FRM and increasing hydroelectric power generation in Canada and the U.S. In 1964, the Canadian and U.S. governments each designated at least one Entity to formulate and carry out the operating arrangements necessary to implement the CRT. The Canadian Entity for these purposes is British Columbia Hydro and Power Authority (BC Hydro). The Canadian Entity for the limited purpose of making arrangements for disposal of all or portions of the Canadian Entitlement (CE) within the U.S. is the government of the Province of British Columbia. The U.S. Entity is the Administrator & Chief Executive Officer of Bonneville Power Administration (BPA) and the Division Commander of the Northwestern Division, U.S. Army Corps of Engineers (USACE). These Treaty Entities (USACE, BPA, and BC Hydro) have arranged for a series of Treaty-related agreements to provide benefits beyond those for FRM and power, related to values such as fisheries, recreation, and others.

The following is a summary of key features of the CRT and related documents:

1. Canada was to provide 19.1 cubic kilometers (km^3) (15.5 Million acre-feet (Maf)) of usable storage. This has been accomplished with 8.6 km^3 (7.0 Maf) in Kinbasket, 8.8 km^3 (7.1 Maf) in Arrow, and 1.7 km^3 (1.4 Maf) in Duncan.
2. For the purpose of computing downstream power benefits, the U.S. base system hydroelectric facilities will be operated in a manner that makes the most effective use of the improved streamflow resulting from operation of the Canadian Storage.

3. The U.S. and Canada are to share equally the downstream power benefits pre-determined to be generated in the U.S. resulting from operation of the Canadian Storage.
4. The U.S. paid Canada a lump sum of $64.4 million (U.S.) for one-half of the present worth of expected future FRM benefits in the U.S. to September 2024, resulting from operation of the Canadian Storage.
5. Under certain specified conditions, the U.S. has the option of requesting the evacuation of additional FRM space above that specified in the CRT, for a payment of $1.875 million (U.S.) plus power losses for each of the first four requests for this "on-call" storage. No requests under this provision have been made to date.
6. The U.S. had the option (which it exercised) to construct Libby Dam with a reservoir that extends 67.6 kilometers (42 miles) into Canada and for which Canada agreed to make the land available.
7. Both Canada and the U.S. have the right to make diversions of water for consumptive uses. In addition, since September 1984, Canada has had the option of making, for power purposes, specific diversions of the Kootenay River into the headwaters of the Columbia River. This has not been exercised.
8. Differences arising under the Treaty that cannot be resolved by Canada and the U.S. may be referred to either the International Joint Commission (IJC) or to arbitration by an appropriate tribunal.
9. The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964, after which either Government has the option to terminate most sections of the Treaty if a minimum of 10 years advance notice has been given. No termination notices have been made to date.
10. In the Canadian Entitlement Purchase Agreement of 13 August 1964, Canada sold its entitlement to downstream power benefits (Canadian Entitlement) to the Columbia Storage Power Exchange (a consortium of U.S. utilities) for 30 years beginning at Duncan on 01 April 1968, Keenleyside on 01 April 1969, and Mica on 01 April 1973. That sale has now expired and all CE has reverted to British

Columbia provincial ownership and is delivered to the Canadian-U.S. border under the terms of the ‘Aspects Agreement’.

11. Canada and the U.S. each appointed Entities to implement Treaty provisions, as well as two members each to a joint Permanent Engineering Board (PEB), to review and report on operations under the CRT.

II - TREATY ORGANIZATION

Entities

There was one meeting of the CRT Entities (including the Canadian and U.S. Entities and Entity Coordinators) during the year on 06 February 2019 in Vancouver, BC.

The members of the two Entities at the end of the report period were:

UNITED STATES ENTITY

Mr. Elliot Mainzer, Chairman
Administrator &
Chief Executive Officer
Bonneville Power Administration
Department of Energy
Portland, Oregon

BG D Peter Helmlinger, Member
Division Engineer
Northwestern Division
U.S. Army Corps of Engineers
Portland, Oregon

CANADIAN ENTITY

Mr. Chris O'Riley, Chair
President & Chief Operating Officer
British Columbia
Hydro and Power Authority
Vancouver, British Columbia

The Entities have designated alternates to act on behalf of the primaries in their absence, appointed in the U.S. by a Memorandum of Agreement between BPA and USACE, and in Canada by the BC Hydro Board of Directors. The BPA Administrator's alternate is the BPA Deputy Administrator and the Northwestern Division Engineer alternate is the Deputy Division Engineer. The alternate for Mr. O'Riley is the BC Hydro Executive Vice President of Operations.

The Entities have appointed Coordinators, Secretaries, and two joint standing committees to assist in CRT implementation activities that are described in subsequent paragraphs. The primary duties and responsibilities of the Entities as specified in the CRT and related documents are to:

1. Plan and exchange information relating to facilities used to obtain the benefits contemplated by the CRT;

2. Calculate and arrange for delivery of hydroelectric power to which Canada is entitled;
3. Operate a hydrometeorological system;
4. Assist and cooperate with the PEB in the discharge of its functions;
5. Prepare and implement Flood Control Operating Plans (FCOPs) for the use of Canadian Storage;
6. Prepare Assured Operating Plans (AOPs) for Canadian Storage and determine the resulting downstream power benefits that Canada is entitled to receive; and
7. Prepare and implement Detailed Operating Plans (DOPs) that may produce results more advantageous to both countries than those that would arise from operation under AOPs.

Additionally, the CRT provides that the two governments, by exchange of diplomatic notes, may empower or charge the Entities with any other matter coming within the scope of the CRT, or appoint additional Entities for specific purposes. The Province of British Columbia is a Canadian Entity for the limited purpose of implementing the Agreement on Disposals of the Canadian Entitlement within the United States for 01 April 1998 through 15 September 2024 between the BPA and the Province of British Columbia (Disposal Agreement).

Entity Coordinators & Secretaries

The Entities have appointed Coordinators from members of their respective staffs to help manage and coordinate CRT-related work and Secretaries to serve as information focal points on all CRT matters within their organizations.

Following are the appointed Coordinators and Secretaries:

UNITED STATES ENTITY COORDINATORS

Kieran Connolly
Vice President,
Generation and Asset Management
Bonneville Power Administration
Portland, Oregon

CANADIAN ENTITY COORDINATOR

Heather Matthews
Director,
Generation System Operations
BC Hydro
Burnaby, British Columbia

Beth Coffey*
Acting Director, Civil Works & Management
Northwestern Division
U.S. Army Corps of Engineers
Portland, Oregon

* Beth Coffey was appointed as interim Corps of Engineers Coordinator replacing David Ponganis as of 01 April 2019

UNITED STATES ENTITY SECRETARY

Jason Ward
Regional Coordination
Power and Operations Planning
Bonneville Power Administration
Portland, Oregon

CANADIAN ENTITY SECRETARY

Chris Revell
Planning and Licensing
Generation System Operations
BC Hydro
Burnaby, British Columbia

Columbia River Treaty Operating Committee

The Columbia River Treaty Operating Committee (CRTOC) was established in September 1968 by the Entities and is responsible for preparing and implementing operating plans as required by the CRT, making studies and otherwise assisting the Entities, as needed. The CRTOC consists of the following eight members:

UNITED STATES SECTION

Pamela Kingsbury, BPA, Alt. Chair
Steven Barton, USACE, Alt. Chair
Julie Ammann, USACE
Trevor Downen, BPA

CANADIAN SECTION

Darren Sherbot, BC Hydro, Chair
Gillian Kong, BC Hydro
Herbert Louie, BC Hydro
Doug D. Robinson, BC Hydro

The CRTOC met during the reporting period to exchange information, approve work plans, discuss issues, agree on operating plans, and brief the PEB and Permanent Engineering Board Engineering Committee (PEBCOM). There were six regular meetings alternating between locations in Canada and the U.S., plus one meeting with the PEBCOM. During the period covered by this report, the CRTOC:

1. Coordinated the operation of the CRT storage in accordance with the then-current hydroelectric operating plans and FCOP;
2. Coordinated changes to procedures and reviewed scheduled delivery of the CE according to the CRT and related agreements;
3. Completed the 01 August 2019 through 31 July 2020 DOP;
4. Completed one supplemental operating agreement for Canadian Storage;
5. Implemented the Libby Coordination Agreement (LCA) including the delivery of one average megawatt (aMW) of power to the U.S. and the July 2018 update to the Libby Operating Plan (LOP);
6. Implemented the Short-term Libby Agreement (STLA) including scheduling Arrow provisional water transactions and associated financial payments;
7. Completed the LOP for 2019-20, 26 June 2019;
8. Briefed both PEBCOM and PEB on Entity activities, and completed the 2018 Entity Annual Report.

These aspects of the CRTOC's work are described in the following sections of this report, which have been prepared by the CRTOC with the assistance of others.

Figure 1. CRT Operating Committee at the PEBCOM Meeting on October 23, 2019. Pictured are (L to R), Herbert Louie (member), Trevor Downen (member), Doug Robinson (member), Pam Kingsbury (U.S. Alternate Chair), Rob Petty, Gillian Kong (member), Chris Revell (Canada Secretary), Darren Sherbot (Canada Chair), Jason Ward (U.S. Secretary), Julie Ammann (member), Maler Annamalai. Not pictured is Steve Barton (U.S. Alternate Chair) due to illness.

Columbia River Treaty Hydrometeorological Committee

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities and is responsible for coordinating hydrometeorological data collection, data exchange and water supply forecasting for the CRT projects in accordance with the Treaty and otherwise assisting the Entities, as needed. The Committee consists of the following four members:

UNITED STATES SECTION	**CANADIAN SECTION**
Ann McManamon, BPA Co-Chair	Stephanie Smith, BC Hydro, Chair
William Proctor, USACE Co-Chair	Georg Jost, BC Hydro, Member

The CRTHC conducted bi-monthly conference calls and met in person twice during the1 October 2018 – 30 September 2019 period:

Meeting 82: 06 June 2019, BC Hydro

Meeting 83: 26 September 2019, USACE

The 2018 CRTHC Annual Report was completed in December 2018 and distributed prior to the end of the year.

Forecasting

The CRTHC updated Appendix 8 of the Principles and Procedures document to specify that early-season volume forecasts will not be used in developing monthly flows for the Actual Energy Regulation (AER)/Treaty Storage Regulation (TSR) but will be used for all other treaty calculations that require seasonal volumes. There was also a change adopted on the use of alternate methods for the forecast of monthly streamflows late in the season when the use of distribution factors for shape is no longer applicable.

In early April of 2019, an atmospheric river impacted the Snake River drainage of the Columbia Basin generating significant precipitation and melting much of the low-lying snowpack in the basin. During that time, natural Snake River flows at Lower Granite peaked at an estimated 6,513 m^3/s (230.0 kcfs), added an additional 12.3 km^3 (10.0 Maf) to the forecasted seasonal volume (roughly a 40 percent increase). This additional volume was not captured in the official April water supply forecasts which were issued on 03 April 2019 in the U.S. and 04 April 2019 in Canada. However, in April precipitation north of the border tracked near normal since the beginning of the month and BC Hydro's internal model runs agreed with that assessment. The Canadian portion of the basin did not experience a similar increase from the official April Treaty forecast. This dramatic increase in seasonal water supply volume caused some issues in the streamflow coordination of some of the projects for the second TSR

in April. Because streamflow forecasts for later months in the TSR are derived from the water supply forecasts, this resulted in unreasonable flow forecasts at some projects for June and July. Preliminary calculations discovered that using the official April (January-July) forecasts left some of the projects on the Snake River with percents of median which were unrealistically low. From a planning perspective the use of those values increased the risk that Treaty planning for June and July would reflect unrealistic inflows and affect decisions regarding release of flow augmentation water for U.S. fisheries objectives. The CRTHC proposed that projects impacted by the storm would use the 15 April forecast generated by the Northwest River Forecast Center (NWRFC) which reflected the additional volume from the atmospheric river event. The Canadian projects and Libby (which were not impacted by the storm) would continue to use their official April forecasts.

Similar conditions occurred again in late May. There was another storm which occurred in the southern portion of the basin increasing the overall forecasted water supply seasonal volume and causing the percentages of some of the coordinated streamflows to be unrealistic. The same approach was taken during May, with the mid-month water supply forecast being used for all but the Treaty projects which remained largely unaffected by these late season storms.

For the past few years, the NWRFC has produced three Ensemble Streamflow Procedure (ESP) forecasts on a nearly daily basis for various forecast points, each differentiated by the number of days of deterministic weather forecasts used to initialize the forecast. The three initializations currently used are 10, 5, and 0 days of weather forecast. The CRTHC recommended that the ESP forecast with 5 days of a short-term forecast included be adopted for Treaty purposes and for operational decisions on the Columbia River system for 2019. In order to make water supply and flood risk management information available to the region and for use in Treaty coordination earlier in each month, the committee also recommended using the ESP forecast prepared on the third working day of each month. At the 11 September 2018 CRTOC meeting, the CRTHC presented these recommendations for the upcoming year, and the recommendations were approved.

Stations

The CRTHC routinely reviews the basin gauging network for adequacy. At this time, the CRTHC believes that the station network is adequate for Treaty purposes. The CRTHC added clarification on how it came to this determination in the 2015 CRTHC Annual Report.

The Akamina Pass snow pillow site in Alberta which is used in the Libby water supply equation was damaged by a forest fire in 2018. The USACE proposed a procedure to estimate those data which was reviewed by the CRTHC for use during the 2019 forecasting season. That station has since been reestablished and the USACE will be reviewing the estimated procedure and the current observations to determine how to move forward for the 2020 water supply forecasting season

Several stations in Canada were decommissioned due to poor gauging, dangerous sampling conditions and damage caused by a forest fire; several other stations were added. All of these stations are listed as "Support Stations" on the committee's tracking process and are not used in specific computations for treaty purposes.

Data Exchange

The committee continues to work toward better data exchange processes. Recently, this has resulted in improvements to official notifications of data reporting changes, and the creation of Entity-specific point-of-contact directories for critical data exchange and validation issues.

Permanent Engineering Board

Provisions for the establishment of the Permanent Engineering Board (PEB) and its duties and responsibilities are included in the CRT and related documents. The members of the PEB at present are:

UNITED STATES SECTION	**CANADIAN SECTION**
James C. Dalton, Chair Washington, D.C.	Mr. Marco Presutti, Chair* Ottawa, Ontario
Edward Sienkiewicz, Member Newberg, Oregon	Tim Newton, Member** Vancouver, British Columbia
Dr. Larry McCallister, Alternate Washington, D.C.	Renata Kurschner, Alternate Delta, British Columbia
Steve Oliver, Alternate*** Portland, Oregon	Les MacLaren, Alternate Victoria, British Columbia

* Marco Presutti was appointed to replace Dr. Niall O'Dea as of 05 February 2019.

** Tim Newton retired from his position on the PEB on 31 March 2019. A replacement has not been formally announced.

*** Steve Oliver resigned from his position on the PEB on 03 April 2019. A replacement has not been formally announced.

The following serve as Secretaries to the Board:

Sean Smith, Secretary Washington, D.C.	Darcy Blais, Secretary Ottawa, Ontario

Under the CRT, the PEB is to assemble records of flows of the Columbia River and the Kootenay River at the international boundary. The PEB is also to report to both governments if there is substantial deviation from the hydroelectric operating plans or the FCOP, and, if appropriate, include recommendations for remedial action. Additionally, the PEB is to:

1. Assist in reconciling differences that may arise between the Entities;
2. Make periodic inspections and obtain reports, as needed, from the Entities to assure that CRT objectives are being met;
3. Prepare an annual report to both governments and special reports when appropriate;
4. Consult with the Entities in the establishment and operation of a hydrometeorological system; and

5. Investigate and report on any other CRT-related matters at the request of either government.

The Entities continued their cooperation with the PEB during the past year by providing copies of Entity agreements, operating plans, CRTOC agreements, updates to hydrometeorological documents, personnel appointments, pertinent correspondence, and the annual Entity report to the PEB for their information and review. The annual joint meeting of the PEB and the Entities was held on 05-06 February 2019 in Vancouver, British Columbia. The Entities and the PEB met to discuss the current status of the CRT Review, the preparation and implementation of operating plans, the Libby Variable Flow (VarQ), FRM issues and other topics requested by the PEB. The STLA was extended for another year allowing additional time to complete and review studies.

PEB Engineering Committee

The PEB has established the PEBCOM to assist in carrying out its duties. The PEBCOM met with the Operating Committee on 24 October 2018 in Portland, OR. The members of PEBCOM at the end of this reporting period were:

UNITED STATES SECTION	**CANADIAN SECTION**
Sean Smith, Chair Washington, D.C.	Darcy Blais, Chair Ottawa, Ontario
Steve Yexley, Member Lakewood, CO	Tracey Kutney, Member Ottawa, Ontario
Daniel Rabon, Member Washington, DC	Dr. K.T. Shum, Member* Victoria, British Columbia
John Roache, Member Boise, Idaho	Dr. Amy Sopinka, Member Victoria, British Columbia

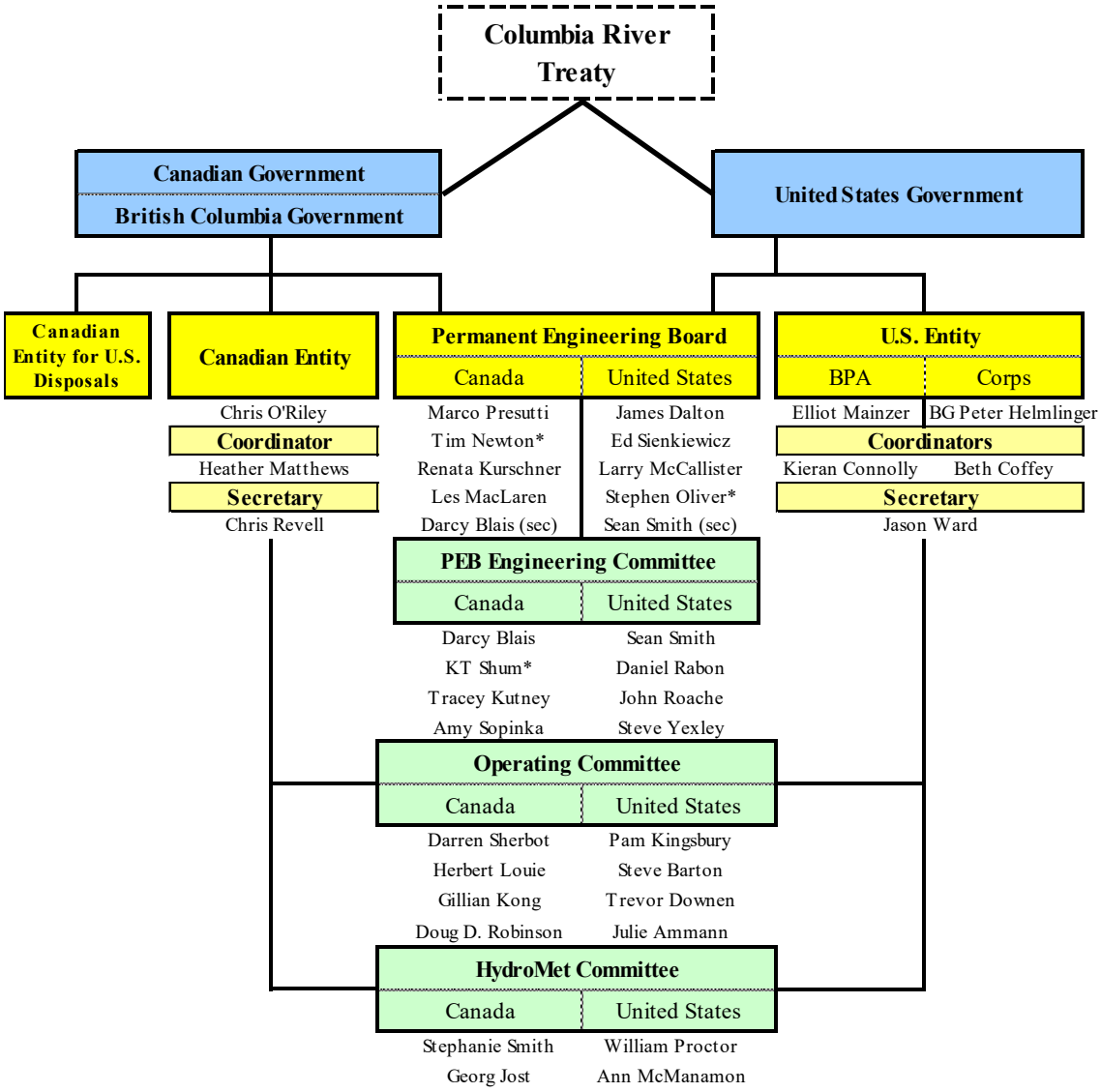
* Dr. K.T. Shum has retired and no replacement has yet been named

International Joint Commission

The IJC was created under the Boundary Waters Treaty of 1909 between Great Britain (on behalf of Canada) and the U.S. Its principal functions are rendering decisions on the use of boundary waters, investigating important problems arising along the common frontier not necessarily connected with waterways, and making recommendations on any question referred to it by either government. If the Entities or the PEB cannot resolve a dispute concerning the CRT, that dispute may be referred to the IJC for resolution. The current IJC membership includes U.S. Section Chair Jane Corwin, Canadian Section Chair Pierre Beland, U.S. members Robert Sisson and Lance Yohe, and the other Canadian members are Henry Lickers and Merrell-Ann Phare. The IJC writes Orders to implement decisions relating to boundary waters and also appoints local Boards of Control to insure compliance with IJC Orders and to keep the IJC informed. There are three IJC Boards of Control west of the Continental Divide: the International Columbia River Board of Control, the International Osoyoos Lake Board of Control, and the International Kootenay Lake Board of Control (KLBC), which oversees the implementation of the 1938 IJC Order on Kootenay Lake.

Columbia River Treaty Organization

Organization Chart for the Columbia River Treaty



Notes:

1. The Entities and the PEB are creations of the Treaty, and all report directly to their respective governments.
2. The Operating Committee and the HydroMet Committee report to the Entities; the PEBCOM reports to the PEB.
3. CRT XIV2(f): The Entities are tasked with "*assisting and cooperating with the PEB*".
4. CRT XV2(c): Similarly, the PEB is directed to *"assist in reconciling differences concerning technical or operational matters that may arise between the entities"*.
5. Names with an "*" have moved on and have not yet had a replacement named as of September 2019.

III - OPERATING ARRANGEMENTS

Power and Flood Control Operating Plans

The CRT requires that the reservoirs constructed in Canada be operated pursuant to FRM and hydroelectric operating plans developed under Annex A of the CRT which:

1. Stipulates that the U.S. Entity will submit Columbia River Treaty Flood Control Operating Plans (FCOP).
2. States that the Canadian Entity will operate in accordance with FRM storage diagrams or any variation which the Entities agree will not reduce the desired aim of the FRM plan; and
3. Provides for the development of assured hydroelectric operating plans for Canadian Storage for the 6th succeeding year of operation (i.e., 5 years in advance).

Article XIV.2.k of the CRT provides that a DOP be developed that may produce results more advantageous to both countries than the AOP. The Protocol to the CRT provides further detail and clarification of the principles and requirements of the CRT.

The Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans for Canadian Storage (POP) signed December 2003 (as amended), together with the FCOP dated May 2003 (as revised), establish and explain the general criteria used to develop the AOP and DOP, and operate CRT storage during the period covered by this report.

The planning and operation of CRT Storage as discussed on the following pages are for the 2018-19 (01 August 2018 through 31 July 2019) and 2019-20 (01 August 2019 through 30 July 2020) periods. The operation of Canadian Storage was guided by the 2018-19 DOP, the 2019-20 DOP and supplemental operating agreements. The DOP required a semi-monthly TSR study to determine end-of-month storage obligations (prior to any adjustments associated with supplemental operating agreements). The TSR included all operating criteria from, and was based on, the Step I Joint Optimum Power Hydroregulation Study from the 2018-19 AOP, with agreed changes. Most of the hydrographs and reservoir charts in this report are for a 14-month period from 01 August 2018 through 30 September 2019.

Assured Operating Plans

Prior to the reporting period, the Entities completed the AOP 2020 and four subsequent AOPs through 2024. The CRTOC conducted a careful review of the 2020-24 AOP load, resource and other data assumptions and completed the AOP for the middle year, AOP 2022. The Entities agreed that the results of the AOP 2022 suite of studies would be used for the two prior years (AOP 2020 and AOP 2021) and for the two subsequent years (AOP 2023 and AOP 2024). Thus, all five AOPs were signed by the Entities in January 2016. The 2019-20 through 2023-24 AOPs and Determination of Downstream Power Benefits (DDPB) are not precedent-setting for future AOP or DDPB studies and are not to be construed as representing a past practice or procedure or constituting a Treaty modification to or revised interpretation of the Treaty.

The Entities have not commenced development of the AOP 2025.

Determination of Downstream Power Benefits

For each Operating Year, the DDPB resulting from Canadian Storage operation is made in conjunction with the AOP according to procedures defined in the CRT, Annexes, and Protocol, and the 2003 POP agreement (except for modifications noted in the AOP or DDPB documents). In conjunction with the 2019-20 through 2023-24 AOP studies, the Entities completed studies for the 2019-20 through 2023-24 DDPBs.

Canadian Entitlement (CE) for the Operating Year

For the period 01 August 2018 through 31 July 2019, the CE amount, before deducting transmission losses, was 472.5 average Megawatts (aMW) of energy, scheduled at rates up to 1,284 MW capacity. From 01 August 2019 through 30 September 2019, the amount, before deducting transmission losses, was 454.3 aMW of energy, scheduled at rates up to 1,141.5 MW capacity. The CE obligation was determined by the 2018-19 and 2019-20 AOP/DDPBs. During the course of the 2018-19 Operating Year, there were no curtailment events.

Detailed Operating Plans

During the period covered by this report, the CRTOC used the DOP (dated June 2018) for 01 August 2018 through 31 July 2019, and the DOP (dated July 2019), for 01 August 2019 through 31 July 2020 period, to guide Canadian Storage operations. These DOPs established criteria for determining the Operating Rule Curves (ORCs), proportional draft points, as well as other operating criteria for use in actual operations. The 2018-19 and 2019-20 DOPs were based respectively on the 2018-19 AOP and 2019-20 AOP loads and resources, rule curves, and other operating criteria with agreed changes for both Canadian and U.S. projects. The 2018-19 and 2019-20 AOPs included an FRM allocation of 4.4 km^3 (3.6 Maf) at Arrow and 5.0 km^3 (4.1 Maf) at Kinbasket. The 2018-19 DOP and 2019-20 DOP operating criteria were used to develop the TSR studies for implementation of Canadian Storage operations. The Mica and Arrow operating criteria came from the 2021-22 AOPs. The changes from the AOP were hydro-independent data, incorporation of updated forecast errors and distribution factors, plant data, Grand Coulee pumping estimates and updated storage/elevation table.

The TSR studies were updated twice monthly throughout the reporting period for current inflow forecasts, FRM curves and variable refill curves (VRCs), and calculated unregulated stream flows for the previous month. The TSR and supplemental operating agreements defined the end-of-period draft rights for Canadian Storage. The VRCs and FRM requirements, subsequent to 01 January 2019, were determined on the basis of seasonal volume runoff forecasts during actual operation. The VRC calculations for Canadian reservoirs and Lake Koocanusa for the 2018-19 Operating Year are shown in Tables 2 through 5. Table 5 shows the calculated VRC for Libby that was used in the TSR study only and was not used in actual operations. The CRTOC directed the regulation of the Canadian Storage on a weekly basis throughout the year, in accordance with the applicable DOPs, the STLA and other supplemental operating agreements.

Libby Coordination Agreement

During the period covered by this report, the LCA[1] was supplemented by the Short-Term Entity Agreement on Coordination of Libby Project Operations (Short-Term Libby Agreement; STLA). The LCA required delivery to the U.S. Entity of one (1) aMW, shaped flat, over the entire 2018-19 Operating Year. The most recent LOP is dated 25 June 2018. The STLA, signed by the Entities in September 2013, was intended to address issues raised by the Canadian entity regarding VarQ operations at Libby until 31 August 2015. The STLA provided the Canadian Entity additional flexibility to draft and store at Arrow. The STLA has been amended five times allowing the agreement to remain in effect until 31 August 2020. During the term that the STLA is in effect, Section 10 and Attachment C of the LCA are suspended. Other portions of the LCA remain in effect.

Entity Agreements

During the period covered by this report, the following joint U.S.-Canadian agreements were approved by the Entities:

Date Signed by Entities	Description of Agreement
06 February 2019	Extension of the Columbia River Treaty Short-term Entity Agreement on Coordination of Libby Project Operations
8 July 2019	Columbia River Treaty Agreement on the Detailed Operating Plan for Canadian Storage 01 August 2019 through 31 July 2020

[1] "Libby Coordination Agreement" (LCA) refers to the "Columbia River Treaty Entity Agreement Coordinating the Operation of the Libby Project With the Operation Of Hydroelectric Plants on the Kootenay River and Elsewhere in Canada," dated 16 February 2000.

Columbia River Treaty Operating Committee Agreements

During the period covered by this report, the CRTOC approved the following joint U.S.-Canadian Storage agreement:

Date Signed	Description	Authority
13 December 2018	Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 29 December 2018 through 31 July 2019	Detailed Operating Plan 01 August 2018 through 31 July 2019

Long-Term Non-Treaty Storage Agreement

The Long-Term Non-Treaty Storage Agreement (NTSA), executed in April 2012, was used by BPA and BC Hydro for power and nonpower purposes through the 2018-19 Operating Year. In accordance with the Entity agreement that approved the 2012 NTSA contract between BPA and BC Hydro, the CRTOC monitored the storage and release operations under the Agreement throughout the Operating Year to ensure they did not adversely affect the operation of CRT storage required by the DOPs.

IV - WEATHER AND STREAMFLOW

Continuing a trend which began during the summer of 2018, a weak El Niño was present throughout the 2019 Water Year over the tropical Pacific (Figure 2). As is typical with this ocean condition, water supplies ended up lower than the long-term average, with above average temperatures and below average precipitation as a whole. There were two key breaks from this overall trend, though: one of the coldest Februaries on record which challenged hydropower operations, and a very wet first half of April which saved the system from what could have become a severe, system-wide drought heading into the spring and summer.

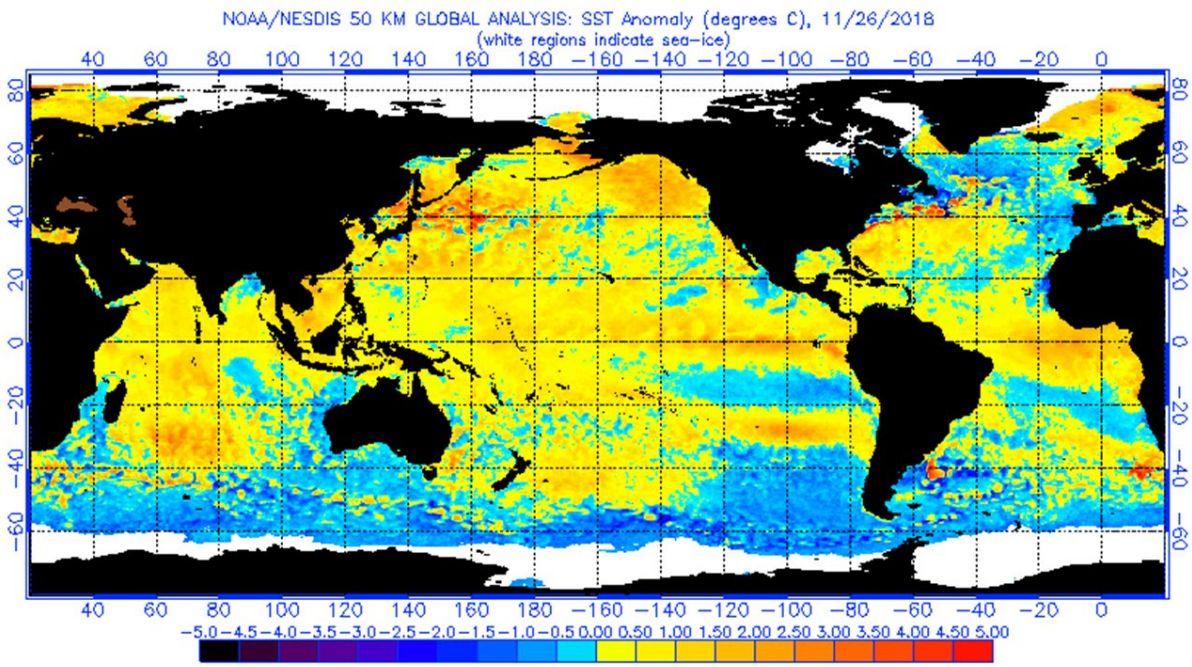


Figure 2: Sea surface temperature anomalies over the Pacific Ocean, November 2018.

For much of the fall and winter, precipitation trended below average, with the overall downward trend in resulting water supplies punctuated by wet and stormy periods in late-October and mid-December 2018. By mid-January, water supply forecasts were hovering near the dry-year trigger for NTSA spring releases and other triggers for drought-related system operations.

The concerns were then alleviated when a blocking upper level ridge set up over the Gulf of Alaska in the closing days of January 2019 (Figure 3). This new jet stream pattern, which

persisted through the first week of March, brought the most impactful weather of the year to the region, and the coldest February in over twenty years as the northern branch of the jet stream aimed from the Yukon Territory into the heart of the Columbia Basin. Major winter storms struck the southern two-thirds of the basin on 03-04 February, 08-09 February, 21-22 February and the southern third of the basin on 24-25 February. These combined storms increased basin-wide snowpacks from 89% of normal to 104% of normal between 01 February and 05 March, with Snake Basin snowpacks making the biggest jump from 83% of normal to 117% of normal.

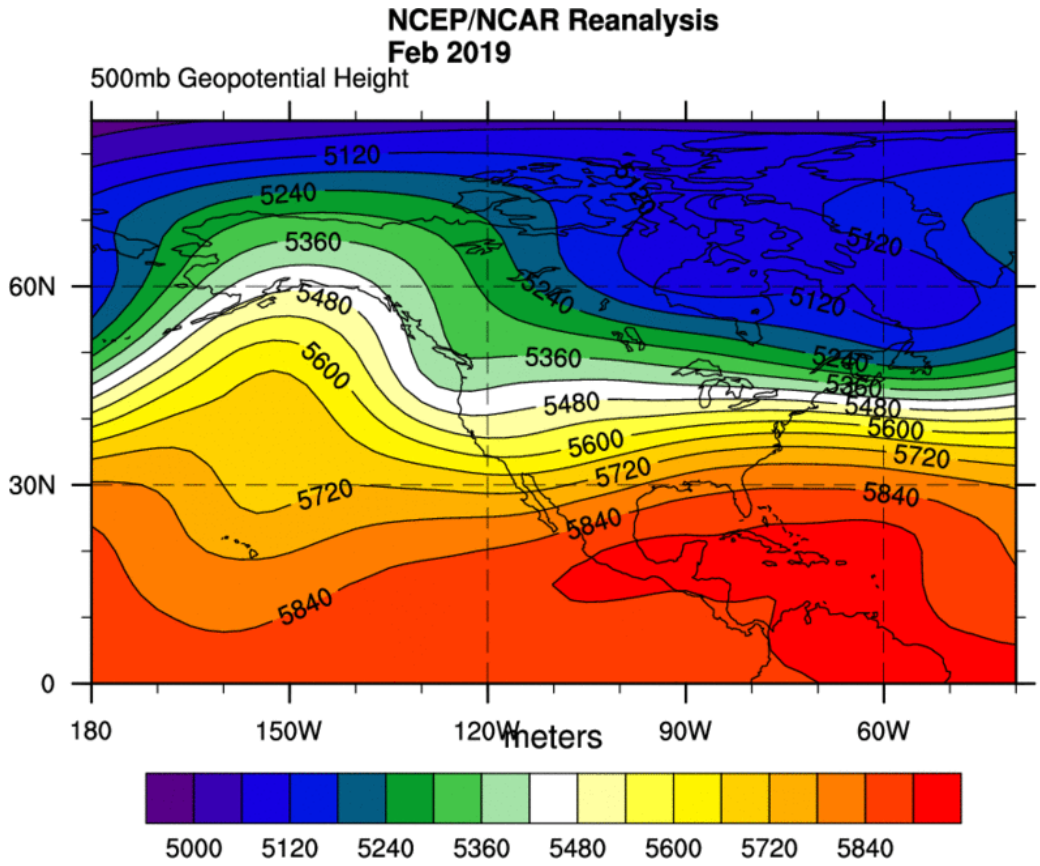


Figure 3: NCEP/NCAR Reanalysis of month average 500mb geopotential heights (m), February, 2019. Note the blocking ridge over the Gulf of Alaska, downstream trough along the BC and US west coasts, and northerly flow from the Yukon Territory into the Columbia Basin.

February temperatures were 4.5°C (8.1°F) below the 1981-2010 average, which made it the coldest February in at least twenty years. Interestingly enough, at no time during the six week period did three-day moving average temperatures fall into 1-in-2 year cold snap levels. However, the sustained cold, coming on top of rather dry soils and most precipitation falling as

snow, caused already low natural flows to fall even farther, with near record low natural flows at both The Dalles and Grand Coulee from mid-February through early March. In most years, the lowest natural flows in the Columbia Basin occur in September. However, during the 2019 Water Year, the lowest natural flows came during this very cold, high energy demand period.

While low elevation snows eased the overall drought picture in February, a warm and dry period across March caused water supply forecasts to again deteriorate toward dry-year triggers, with snowmelt flows commencing unusually early in the US portions of the Columbia Basin. Concerns began to increase that both a drought and early runoff could be taking shape heading into the spring. By 01 April 2019 snowpacks, thanks to the wet February, were healthy in the southern half of the Columbia Basin but were already beginning to melt, while the snowpack above Grand Coulee was at only 83% of normal, and Washington Cascade snowpacks even farther below normal (Figure 4).

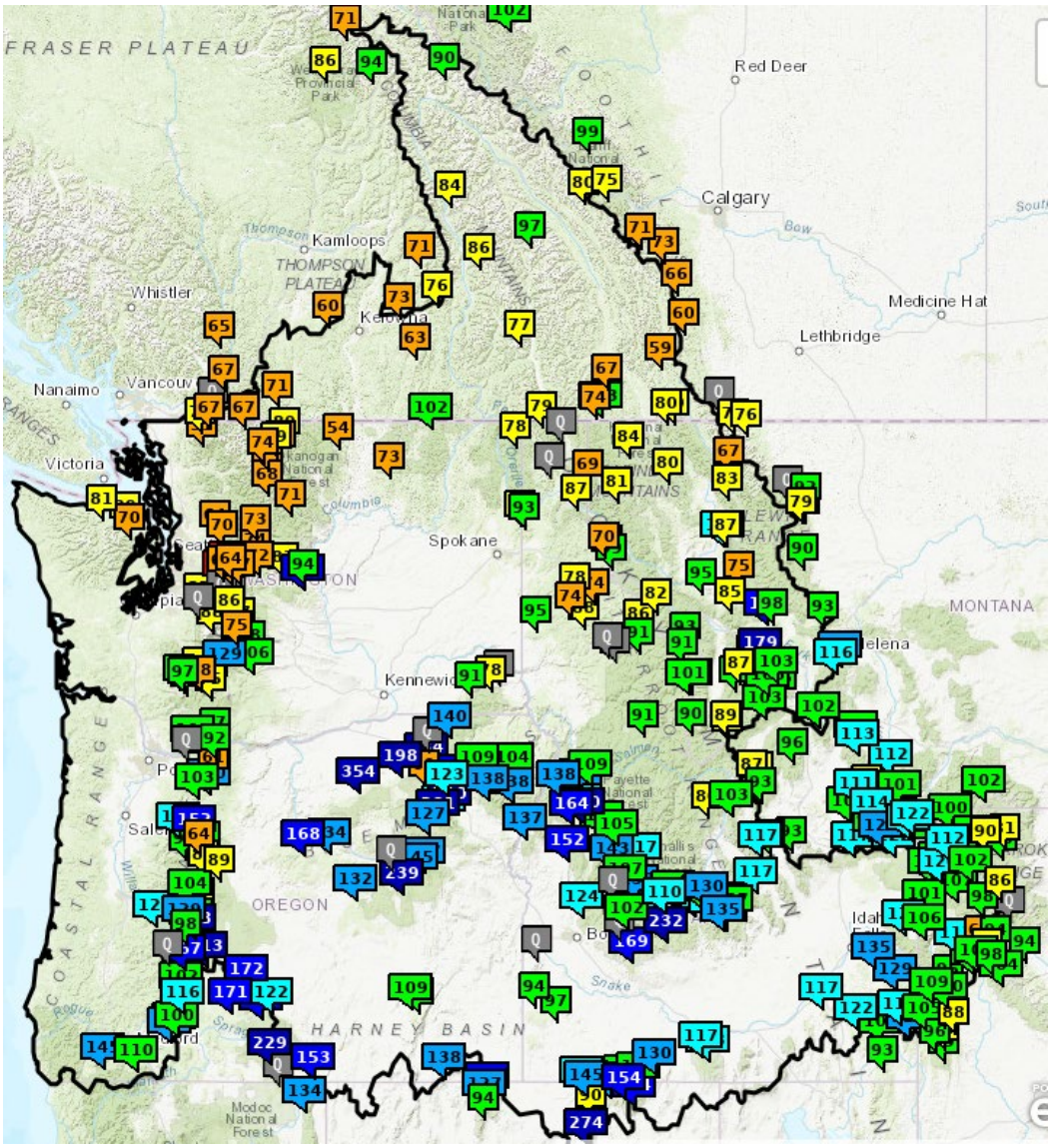


Figure 4: Snowpack percent of average, 01 April 2019 (NWRFC).

The drought concerns eased again in April as for a second year in a row, the region experienced a particularly wet start to the month. Atmospheric river systems, which are unusual so late in the spring in the Columbia Basin, aimed at all but the most northern parts of the basin from 05 to 12 April. The widespread heavy rains rapidly melted a sizeable part of the snowpack in the Snake Basin, with the peak of the spring runoff (and record flows for early April) occurring at Lower Granite Dam on 10 April. While the systems were warm with relatively high snow levels, the higher mountains of B.C. and Western Montana picked up very welcome, late season heavy snow which helped support higher flows than what were initially

anticipated. The combination of these atmospheric river systems and a warm May across the basin led to an early snowmelt cycle, with peak flows at both Grand Coulee and The Dalles occurring about three weeks earlier than usual, almost identical in timing to what was observed in 2018. Also, the wet first half of April, just like what happened in the first half of April 2018, resulted in a much higher water supply than what was expected heading into the FRM season (Figure 5).

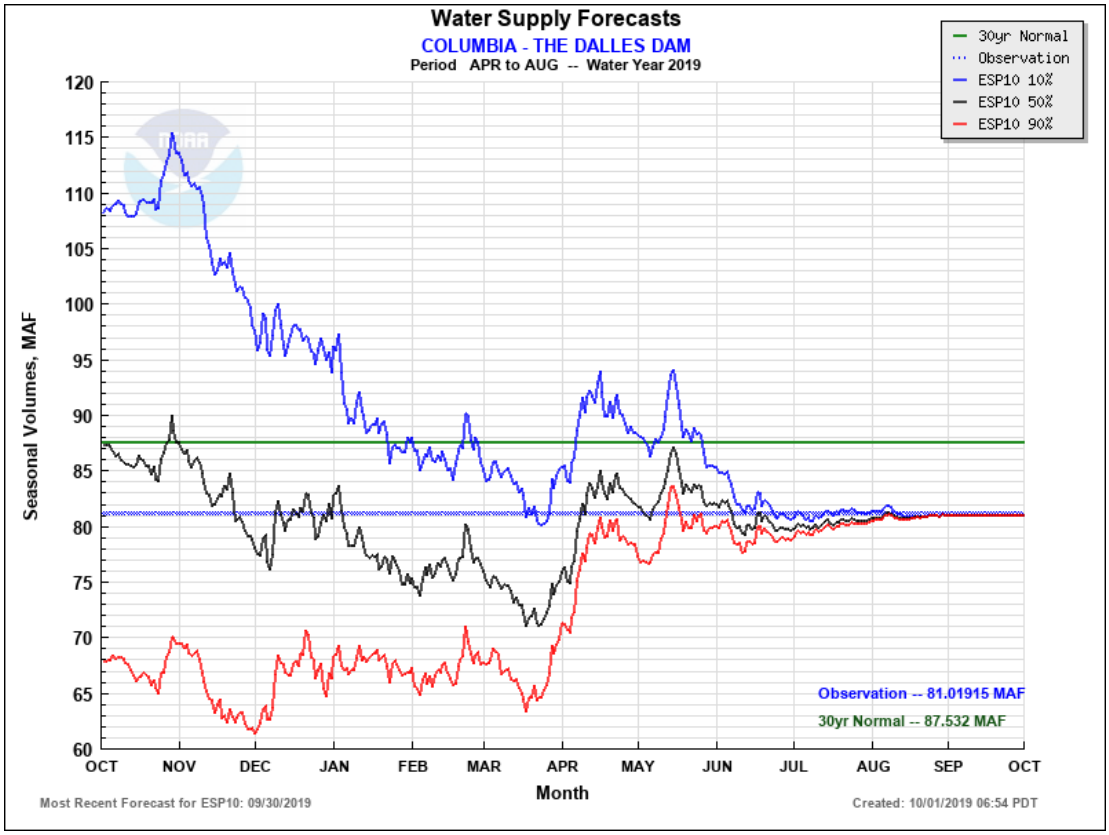


Figure 5: Daily ESP April-August water supply forecasts issued by NWRFC at The Dalles, 2019.

Although flows rapidly diminished unusually early in June, with the exception of a few days in early June, temperatures were only slightly above average for the month, and near or even a bit below average across a large part of the basin in July. The jet stream extended from the central Pacific into British Columbia for much of the second half of June 2019 into early August 2019. With the jet stream still energized by the weakening El Niño, above average rainfall continued across British Columbia and extreme northwest Washington, while the rest of the region dried out. By September 2019, the same rather moist jet stream migrated south

unusually early in the fall season, which led to well above average precipitation, and an unusually early, major winter storm to close out the 2019 Water Year across much of the basin.

Average annual temperatures were near the long-term mean across the Columbia Basin in 2019, due in large part to the very cold February and early March. That broke a six year streak of above average basin annual temperatures. However, this marked the fourth year in the last five when the peak of the spring runoff in the Snake River occurred a month or more earlier than the peak at Grand Coulee. Both trends continue to support several recent several recent studies that the Columbia Basin's climate continues to warm (e.g. RMJOC-II, Part 1 Report, 2018).

Columbia Basin Weather

	Temperature	**Precipitation**	**Precipitation**	**Precipitation**
Location	**Columbia Basin above The Dalles** **Departure from the 1981-2010 average (ºC / ºF)**	**Columbia River above Grand Coulee** **Percent of the 1981-2010 average (%)**	**Snake River above Ice Harbor** **Percent of the 1981-2010 average (%)**	**Columbia River above The Dalles** **Percent of the 1981-2010 average (%)**
August 2018	+1.1 / +1.9	42%	52%	41%
September 2018	-0.5 / -0.9	86%	7%	51%
October 2018	-0.3 / -0.6	91%	108%	98%
November 2018	+0.2 / +0.4	85%	78%	76%
December 2018	+1.3 / +2.2	88%	66%	78%
January 2019	+1.5 / +2.7	62%	64%	64%
February 2019	-4.5 / -8.1	84%	201%	143%
March 2019	-2.1 / -3.9	23%	41%	31%
April 2019	+0.2 / +0.3	96%	120%	109%
May 2019	+1.3 / +2.2	54%	105%	83%
June 2019	+0.8 / +1.5	49%	33%	41%
July 2019	+0.2 / +0.4	99%	26%	64%
August 2019	+1.3 / +2.4	73%	53%	64%
September 2019	-0.6 / -1.1	147%	154%	157%
Water Year 2019	**0.0 / 0.0**	**76%**	**88%**	**81%**

Basin average temperature departures and precipitation percent-of-normal from NOAA/National Weather Service Northwest River Forecast Center.

Streamflow

The observed inflow and outflow hydrographs for the Canadian reservoirs for the period 01 August 2018 through 30 September 2019 are shown in Section VIII on Charts 5 through 7. Libby and Kootenay Lake hydrographs are shown in Chart 8 and 9 respectively. Observed flows and unregulated flows (computed using the USACE Hydrologic Engineering Center's Reservoir System Simulation (HEC-ResSim or ResSim) model with SSARR[2] routing for Kootenay Lake), for the Columbia River at Birchbank, at Grand Coulee, and at The Dalles are shown on Charts 10 through 12, respectively. A plot of the flows that would occur at The Dalles if regulated only by the four Treaty reservoirs is provided in Chart 13 along with the observed and unregulated flows at The Dalles for comparison.

The peak-unregulated discharge for the Columbia River at The Dalles was 13,133 m^3/s (463.8 kcfs) on 04 June 2019, based on the USACE ResSim model run. The average monthly unregulated values shown in the table in the following section are from the NWRFC. The values from NWRFC do not reflect the effects of natural lakes, whereas the USACE ResSim model does. Natural lake effects cause attenuation and dampening of flows; thus, the ResSim model simulations provide lower flows than the NWRFC tabulations. As per the table below, the average unregulated August 2018 - July 2019 streamflow at The Dalles was below average at 4,460 m^3/s (157.5 kcfs), with a corresponding runoff volume of 140.6 km^3 (114.0 Maf) (87 percent of 1981-2010 average) for the same period.

[2] SSARR stands for Streamflow Synthesis and Reservoir Regulation and is a computer simulation model.

Columbia River Unregulated Streamflow

Time Period	Columbia River at Grand Coulee			Columbia River at The Dalles		
	Unregulated Flow		Percent of Average	Unregulated Flow		Percent of Average
	kcfs	m^3/s		kcfs	m^3/s	
Aug-18	72.5	2,052	78	97.8	2,770	78
Sep-18	46.7	1,323	83	71.1	2,013	82
Oct-18	34.6	980	76	63.7	1,805	77
Nov-18	48.2	1,366	99	87.1	2,465	92
Dec-18	35.6	1,008	89	72.0	2,039	79
Jan-19	35.9	1,016	90	72.8	2,061	74
Feb-19	27.7	784	63	73.5	2,081	64
Mar-19	38.0	1,075	63	117.6	3,330	79
Apr-19	127.5	3,610	106	320.2	9,066	138
May-19	235.9	6,681	94	412.2	11,672	100
Jun-19	210.1	5,948	72	326.3	9,240	74
Jul-19	137.7	3,898	77	173.0	4,899	73
Aug-19	81.8	2,315	87	106.8	3,024	86
Sep-19	75.4	2,134	134	102.3	2,896	118
Aug-Jul Average	**87.8**	**2,486**	**83**	**157.5**	**4,459**	**87**

(Source of unregulated flow: NWRFC Runoff Processor)

Seasonal Runoff Forecasts and Volumes

Seasonal runoff volumes for the April-August 2019 period, adjusted to exclude the effects of regulation of upstream storage, are listed below for eight locations in the Columbia River Basin:

Location	Volume in km^3	Volume in MAF	Percentage of 1981-2010 Average
Libby Reservoir Inflow	5.5	4.5	76%
Duncan Reservoir Inflow	2.2	1.8	89%
Mica Reservoir Inflow	12.8	10.4	94%
Arrow Reservoir Inflow	24.3	19.7	90%
Columbia River at Birchbank	40.5	32.8	84%
Grand Coulee Reservoir Inflow	59.3	48.1	85%
Snake River at Lower Granite	30.3	24.6	117%
Columbia River at The Dalles	99.9	81.0	93%

(Source: NWRFC Runoff Processor)

Forecasts of seasonal runoff volume, based on precipitation and snowpack data, were prepared in 2019 for a large number of locations in the Columbia River Basin and updated at the beginning of each month from December to June as the season advanced. Table 1M and Table 1 (see page 51) list the April-through-August 2019 inflow volume forecasts for Mica, Keenleyside, Duncan, and Libby projects as well as The Dalles. The actual runoff volume for these five locations is also given in Tables 1M and 1. The forecasts for Mica, Keenleyside, and Duncan inflow were prepared by BC Hydro. The forecasts for the lower Columbia River inflows were prepared by the NWRFC. The Libby inflow forecast was prepared by USACE. The April 2019 forecast of January through July runoff for the Columbia River above The Dalles was 103.9 km^3 (84.2 Maf) and the actual observed runoff was 111.3 km^3 (90.2 Maf).

The following tabulations summarize the monthly forecasts since 1985 of the January-July runoff for the Columbia River above The Dalles compared with the actual runoff. The average January-July runoff volume for the period of 1981-2010 is 125.0 km^3 (101.3 Maf).

Historic Seasonal Runoff Forecasts and Volumes (km^3)

The Dalles, OR Volume Runoff Forecasts in km^3 (Jan-Jul)

Year	Jan	Feb	Mar	Apr	May	Jun	Actual
1985	161.6	134.4	129.5	121.6	121.6	123.3	108.2
1986	119.4	115.1	127.0	130.7	133.2	133.2	133.6
1987	109.7	101.0	96.2	98.7	94.6	93.5	94.4
1988	97.7	92.3	89.7	91.3	93.9	92.5	90.9
1989	124.6	125.8	116.2	122.7	121.6	119.5	111.8
1990	106.7	124.6	128.3	118.4	118.4	122.7	123.0
1991	143.1	135.7	132.0	130.7	130.7	128.3	132.1
1992	114.2	109.9	103.0	87.8	87.8	83.6	86.8
1993	114.2	106.7	95.3	94.5	88.7	106.2	108.5
1994	98.3	94.1	96.3	90.3	93.1	94.2	92.5
1995	124.7	122.9	116.3	122.9	122.9	120.8	128.3
1996	143.1	150.5	160.4	155.4	165.3	173.9	171.8
1997	170.2	178.9	175.2	183.8	188.7	196.1	196.1
1998	106.6	117.4	113.1	112.0	109.9	124.6	128.3
1999	143.1	148.0	160.4	157.9	153.0	151.7	153.1
2000	129.5	130.7	129.5	129.5	129.5	125.8	120.9
2001	99.2	81.9	72.3	69.2	69.7	68.5	71.8
2002	123.3	125.8	120.0	118.9	121.1	123.3	128.0
2003	99.3	93.3	92.4	105.2	111.3	110.1	108.2
2004	127.0	123.3	114.6	103.9	98.1	105.0	102.4
2005	105.6	101.6	87.2	91.0	92.1	98.4	100.3
2006	124.6	136.9	132.0	132.0	135.7	136.9	141.5
2007	129.5	124.6	123.3	123.3	122.2	118.9	118.0
2008	125.8	127.0	127.0	124.6	120.0	121.1	122.4
2009	116.8	114.6	106.3	113.5	112.4	113.5	111.3
2010	109.2	97.7	88.6	86.0	87.5	91.3	104.5
2011	128.3	135.7	134.4	144.3	157.9	173.9	169.0
2012	106.1	112.6	121.9	139.2	148.1	145.3	159.7
2013	126.4	113.5	110.7	112.4	114.0	115.8	120.5
2014	118.5	98.7	126.0	129.4	135.1	132.8	133.3
2015	126.6	128.0	113.1	118.3	106.7	106.1	103.2
2016	116.1	117.4	126.9	129.1	137.9	123.4	120.4
2017	119.1	115.2	134.2	161.3	168.9	175.0	169.1
2018	122.6	135.3	138.3	148.7	151.1	149.1	146.4
2019	115.3	104.9	104.2	103.8	112.8	113.6	111.3
Minimum	97.7	81.9	72.3	69.2	69.7	68.5	71.8
Median	119.4	117.4	120.0	121.6	121.1	121.1	120.5
Maximum	170.2	178.9	175.2	183.8	188.7	196.1	196.1

Historic Seasonal Runoff Forecasts and Volumes (Maf)

The Dalles, OR Volume Runoff Forecasts in Maf (Jan-Jul)

Year	Jan	Feb	Mar	Apr	May	Jun	Actual
1985	131.0	109.0	105.0	98.6	98.6	100.0	87.7
1986	96.8	93.3	103.0	106.0	108.0	108.0	108.3
1987	88.9	81.9	78.0	80.0	76.7	75.8	76.5
1988	79.2	74.8	72.7	74.0	76.1	75.0	73.7
1989	101.0	102.0	94.2	99.5	98.6	96.9	90.6
1990	86.5	101.0	104.0	96.0	96.0	99.5	99.7
1991	116.0	110.0	107.0	106.0	106.0	104.0	107.1
1992	92.6	89.1	83.5	71.2	71.2	67.8	70.4
1993	92.6	86.5	77.3	76.6	71.9	86.1	88.0
1994	79.7	76.3	78.1	73.2	75.5	76.4	75.0
1995	101.1	99.6	94.3	99.6	99.6	97.9	104.0
1996	116.0	122.0	130.0	126.0	134.0	141.0	139.3
1997	138.0	145.0	142.0	149.0	153.0	159.0	159.0
1998	86.4	95.2	91.7	90.8	89.1	101.0	104.0
1999	116.0	120.0	130.0	128.0	124.0	123.0	124.1
2000	105.0	106.0	105.0	105.0	105.0	102.0	98.0
2001	80.4	66.4	58.6	56.1	56.5	55.5	58.2
2002	100.0	102.0	97.3	96.4	98.2	100.0	103.8
2003	80.5	75.6	74.9	85.3	90.2	89.3	87.7
2004	103.0	100.0	92.9	84.2	79.5	85.1	83.0
2005	85.6	82.4	70.7	73.8	74.7	79.8	81.3
2006	101.0	111.0	107.0	107.0	110.0	111.0	114.7
2007	105.0	101.0	100.0	100.0	99.1	96.4	95.7
2008	102.0	103.0	103.0	101.0	97.3	98.2	99.2
2009	94.7	92.9	86.2	92.0	91.1	92.0	90.2
2010	88.5	79.2	71.8	69.7	70.9	74.0	84.7
2011	104.0	110.0	109.0	117.0	128.0	141.0	137.0
2012	86.0	91.2	98.8	112.9	120.0	117.8	129.4
2013	102.5	92.0	89.7	91.1	92.4	93.9	97.7
2014	96.1	80.0	102.1	104.9	109.6	107.7	108.1
2015	102.6	103.8	91.7	95.9	86.5	86.0	83.7
2016	94.1	95.2	102.9	104.6	111.8	100.0	97.6
2017	96.6	93.4	108.8	130.8	136.9	141.9	137.1
2018	99.4	109.7	112.1	120.5	122.5	120.8	118.7
2019	93.5	85.0	84.5	84.1	91.4	92.1	90.2
Minimum	79.2	66.4	58.6	56.1	56.5	55.5	58.2
Median	96.8	95.2	97.3	98.6	98.2	98.2	97.7
Maximum	138.0	145.0	142.0	149.0	153.0	159.0	159.0

V - RESERVOIR OPERATION

General

During the 2018-19 Operating Year, the Canadian Storage was operated in a manner consistent with DOP19 as modified by Entity or Supplemental Operating Agreements listed in Section III. Libby was operated consistent with the LCA, including the LOP, U.S. requirements for power, and 2019 NOAA Fisheries Columbia River System Biological Opinion (2019 BiOp), the 2000 U.S. Fish and Wildlife Service Federal Columbia River Power System (FCRPS) BiOp, as supplemented in 2006 for Libby Dam (collectively referred to as the 2000/2006 BiOp).

The water supply during the 2018-19 Operating Year was below average, referenced against the 1981-2010 period of record. The actual runoff for the overall Columbia Basin (U.S. and Canada combined) measured at The Dalles, Oregon, for January through July 2019 was 89 percent of normal.

For the period 01 August 2018 through 30 September 2019, the CRTOC executed one operating agreement: the Nonpower Uses Agreement (NPU), effective for the period 29 December 2018 through 31 July 2019 that affected Mica and Keenleyside operations.

Canadian Storage Operation

At the beginning of the 2018-19 Operating Year (01 August 2018), actual Canadian Storage provided under Article II of the CRT (Canadian Storage) was at 18.3 km^3 (14.8 Maf) or 95 percent full. Canadian Storage drafted to a minimum of 3.9 km^3 (3.2 Maf), or 20 percent full in 29 March 2019. The composite Canadian Storage refilled to 16.3 km^3 (13.2 Maf), or 85 percent full, at the end of the Operating Year, 31 July 2019.

The composite Canadian Storage operation was consistent with the DOP TSR for the 2018-19 Operating Year, as modified by Entity or Supplemental Operating Agreements such as the STLA and NPU. During August 2018 through December 2018, during February 2019, and again

during July 2019 through the end of this reporting period, the TSR reflected the coordinated system being in proportional draft.

As specified in the DOP, the release of Canadian Storage is made effective at the Canada-U.S. border. Accordingly, releases from individual Canadian projects can vary from the release required by the DOP TSR plus Supplemental Operating Agreements, as long as this variance continues to meet the required flood risk management draft for CRT reservoirs or limit the ability of the Canadian system to deliver the sum of CRT-specified outflows. Variances from the TSR project target storage operation are accumulated in respective Flex accounts.

An overrun in a Flex account occurs when actual project releases are greater than those specified by the TSR. Conversely, an underrun occurs when actual project releases are less than those specified by the TSR. Flex accounts for Mica, Revelstoke, Keenleyside, and Duncan are balanced at all times (i.e., sum to zero) to ensure that neither underruns nor overruns affect the total CRT release required at the Canadian-U.S. border. The terms "underrun" and "overrun" are used in the description of Mica operations below.

Mica Dam

Operation of Mica during the 2018-19 Operating Year (refer to Chart 5) is governed by BC Hydro system requirements and satisfied all Treaty requirements. Kinbasket reached a maximum elevation in 2018 of 747.25 m (2,451.6 ft), 7.13 m (23.4 ft) below normal full pool, on 17 August 2018. During the fall and winter months, Kinbasket reservoir was drafted as is normal to meet loads.

Winter of 2018-19 started relatively mild but quickly became unprecedentedly cold and dry: these conditions lasted through February and early March. Kinbasket reservoir was drafted nearly 12.2 m (40.0 ft) in February 2019 to meet high winter electricity demand. In 2019, the minimum level reached was 714.82 m (2,345.2 ft) on 14 April 2019, about 4.42 m (14.5 ft) lower than the 2018 minimum level.

Reservoir inflows for the period February to August 2019 were about 93% of average. Low inflows combined with deep draft in the spring caused the reservoir to refill to below average levels; maximum elevation was 748.10 m (2,454.4 ft) on 27 September 2019, 6.28 m (20.6 ft) below normal full pool (approximately 89 percent full, or in terms of content, 22.2 km^3 (18.0 Maf)).

Inflow into Kinbasket was 81 percent of average over the period August 2018 to December 2018. Over this same period, the Mica outflow varied from a monthly average high of about 759 m^3/s (26.8 kcfs) in August 2018 to a monthly average low of about 425 m^3/s (15.0 kcfs) in November 2018. Inflows into Kinbasket were about 93 percent of normal over the period January to July 2019. The Mica discharge over this same period varied from a monthly average high of 1,362 m^3/s (48.1 kcfs) in February to a monthly average low of 34 m^3/s (1.2 kcfs) in June.

Mica had a Treaty overrun of 0.1 km^3 (34.0 ksfd) on 31 July 2018. The maximum underrun for the operating period was 1.4 km^3 (575.0 ksfd) on 20 September 2019, and the maximum overrun was 1.7 km^3 (711.0 ksfd) on 07 June 2019.

For the reporting period, NTSA water was released and stored by both parties into their respective accounts. On 01 March 2019, there was an agreement to open the Recallable accounts for additional draft flexibility. The drafted volume was returned in September 2019, fulfilling the parties' refill obligation under this agreement.

Releases from the non-Treaty accounts were exercised in August 2018, followed by primarily storage primarily storage in September 2018 through October 2018, then releases again in December 2018, February 2019 and March 2019. By the end of March 2019, both BC Hydro and BPA's non-Treaty accounts were drafted to about 0 and 33 percent full, respectively. From mid-May through early June, a total of 1.0 km^3 (421.0 ksfd) of storage was exercised. This storage was subsequently returned across July and August 2019. By the end of August 2019, both BC Hydro and BPA's non-Treaty accounts were drafted to 0 and 33 percent full respectively. Both parties continued to refill their non-treaty accounts through September 2019 increasing the account balances to 30 and 63 percent full for BC Hydro and BPA respectively by the end of the reporting period.

Revelstoke Dam

Revelstoke Reservoir levels fluctuate throughout the day in response to a number of factors, including system electricity demand. Revelstoke Reservoir is normally operated between 571.50 m (1,875.0 ft) and 573.02 m (1,880.0 ft), but may be operated lower for brief periods during unusual conditions. During the spring freshet and winter peak load periods, it is common to have frequent daily fluctuations of the reservoir within about 1.52 m (5.0 ft) of full pool in response to weather patterns and inflow levels. During the 2018-19 Operating Year, Revelstoke Reservoir remained within its normal operating range.

Keenleyside Dam

In Operating Year 2017-18 Arrow reached a maximum level of 439.73 m (1,442.7 ft), or 0.40 m (1.3 ft) below full pool, on 13 July 2018. Arrow releases are regulated under the Columbia River Treaty (CRT) and its supplemental operating agreements. Under dry conditions, storage must be drafted as far as necessary to meet Treaty firm loads consistent with the principles of proportional draft under the CRT. When conditions become wetter, treaty storage comes out of proportional draft.

Due to dry summer conditions in the overall Columbia basin, the coordinated system operated in proportional draft as early as July 2018 and as such higher than normal discharges from Keenleyside were observed primarily in August 2018. However, as the draft began from a near-full storage, Arrow Lakes Reservoir summer levels were within recreation range through 04 September 2018 (Labour Day).

As the overall runoff conditions in the Columbia basin improved in the subsequent periods, the coordinated system came off proportional draft by January 2019. Arrow reached its minimum level of 429.25 m (1,408.3 ft) on 02 February 2019. By comparison, in the previous year, Arrow reached a minimum level of 429.16 m (1,408.0 ft) on 28 March 2018.

After reaching its minimum level in February 2019, the reservoir refilled up to its maximum permissible level for FRM for much of the Operating Year. This was primarily due

to higher discharges from the upstream Columbia generating stations in February and March 2019 contributing to overall higher Arrow reservoir levels in 2019.

Arrow refilled to a maximum level of 438.91 m (1,440.0 ft) or 1.22 m (4.0 ft) below full pool on 21 June 2019. This is about 0.82 m (2.7 ft) above the 2018 maximum level. After that Arrow drafted across the summer to reach about 434.46 m (1,425.4 ft) on Labour Day.

Local inflow into Arrow was 86 percent of average over the period August - December 2018. The Keenleyside discharge varied from a monthly average high of 1,869 m^3/s (66.0 kcfs) in August 2018 to a monthly average low of 883 m^3/s (31.2 kcfs) in October 2018. Local inflow into Arrow was 80 percent of normal over the period January - July 2019. Outflow over this same period varied from a monthly average low of 385 m^3/s (13.6 kcfs) in April to a monthly average high of 1,552 m^3/s (54.8 kcfs) in July 2019.

The CRTOC negotiated a Nonpower Uses Agreement for 2018-19 to manage Canadian and U.S. fisheries' needs. From 29 December 2018 to 01 February 2019, Arrow Treaty flows were reduced to enable 1.2 km^3 (504.0 ksfd, 1.0 Maf) of Flow Augmentation storage as specified under the NPU. Under the provisions of the Water Use Plan (WUP) monitoring requirements, there were no provisions for rainbow trout protection flows downstream of Keenleyside Dam in 2019. All of the water stored for Flow Augmentation under the NPU was released, for Columbia River salmon migration, from late June through late July 2019.

Under terms of the STLA, BC Hydro exercised storage and release from this account during the reporting period. STLA releases were exercised in August 2018 followed by storage in September and October of 2018. Releases were exercised again in November 2018, December 2018, February 2019 and March 2019. By the end of March 2019, the account balance was a draft of 1.34 km^3 (543.0 ksfd). There was no activity until September 2019 when BC Hydro began STLA storage resulting in a drafted account balance of 1.04 km^3 (420.0 ksfd) by the end of September 2019.

Duncan Dam

Operation of Duncan during the 2018-19 Operating Year (refer to Chart 7) followed all Treaty requirements and implemented the operational constraints agreed upon in the Duncan WUP and ordered in the Water License Order (issued on 21 December 2007) except when variances were requested and granted.

Duncan Reservoir began the operating year at near-full-pool at 576.59 m (1,891.7 ft), 0.09 m (0.3 ft) below full pool on 01 August 2018. By comparison, the reservoir reached a similar maximum level of 576.50 m (1,891.4 ft), 0.18 m (0.6 ft) below full pool on 13 August 2017.

Starting 04 September 2018, Duncan discharges were increased to maintain flows in the Duncan River below the Lardeau River confluence (DRL) gauging station at 249 m^3/s (8.8 kcfs) maximum, to facilitate drafting of the reservoir prior to the start of the kokanee spawning downstream of Duncan. Discharges were reduced on 25 September 2018 to target kokanee spawning flows of 74 m^3/s (2.6 kcfs) minimum at DRL through 21 December 2018. After the kokanee spawning flow period, Duncan Dam increased discharge to target 249 m^3/s (8.8 kcfs) maximum from 22 December 2018 through January 2019 to facilitate drafting of the reservoir to meet the end-of-month Treaty FRM targets. As in most years, the reservoir was drafted to near empty in late April. Duncan reached its minimum level, 547.42 m (1,796.0 ft) on 18 April 2019. By comparison, the reservoir reached a similar minimum level of 547.09 m (1,794.9 ft) on 19 April 2018.

The reservoir discharge was reduced to its minimum of 3 m^3/s (0.1 kcfs) in May 2019 to initiate reservoir refill and reduce flood risk downstream at Meadow Creek and around Kootenay Lake. Releases from Duncan were held at minimum until the end of July 2019, when discharges were gradually increased to manage the rate of reservoir refill. In 2019, Duncan refilled to a maximum of 576.47 m (1,891.3 ft), 0.21 m (0.7 ft) below full pool on 02 August 2019. Duncan discharges were increased during August 2019 to facilitate drafting the reservoir to reach the summer recreation target of 575.46 m (1,888.0 ft) between 10 August 2019 and Labour Day 2019 as per the Duncan Water Use Plan Order.

Libby Dam

The operation of Libby Dam and Lake Koocanusa is shown in Chart 8 for the period 01 August 2018 through 30 September 2019. Lake Koocanusa ended July 2018 at elevation 746.12 m (2447.9 ft), 3.38 m (11.1 ft) below full pool. The project was drafted to elevation 744.87 m (2443.8 ft) at the end of August 2018, with outflows held constant for the month at 255 m^3/s (9.0 kcfs), the 2018 bull trout minimum. The Kootenai Tribe of Idaho (KTOI) requested low flows in the fall of 2018 to assist with the continuing habitat restoration work in the Kootenai River, as in previous years. For the month of September 2018, releases were 170 m^3/s (6.0 kcfs) and the project ended September 2018 at elevation 744.20 m (2,441.6 ft). The final April-August 2018 inflow volume to the project was 7.6 km^3 (6.2 Maf), or 105 percent of the 30-year normal (1981-2010).

In October 2018, releases were reduced and held to 113 m^3/s (4.0 kcfs), the project minimum outflow and the project ended October at elevation 744.26 m (2,441.8 ft). Outflow was increased in November to target end-of-year FRM requirements. The December 2018 water supply forecast (WSF) for the April-August 2019 runoff period was estimated at 7.2 km^3 (5.8 Maf), or 98 percent of the 30-year normal (1981-2010), setting the 31 December FRM elevation to 736.31 m (2,415.7 ft). Releases were load shaped through December reaching the end of December FRM target of 736.24 m (2,415.5 ft). Outflow for November-December 2018 averaged 360 m^3/s (12.7 kcfs).

Releases were lowered to minimum flows in January because the end-of-January 2019 FRM elevation of 738.80 m (2,423.9 ft) was higher than the current pool elevation. The April-August 2019 water supply forecast for the month of January 2019 was 7.0 km^3 (5.7 Maf). This was later adjusted to 7 km^3 (5.64 Maf) after the final monthly volume forecasts for Libby were updated.

Libby's April-August 2019 water supply forecast for the month of February 2019 was 6.56 km^3 (5.3 Maf), or 90 percent of average. Releases continued to be set at minimums of 113 m^3/s (4.0 kcfs) in February resulting in an end-of-month elevation of 734.75 m (2,410.6 ft), 7.86 m (25.8 ft) below the FRM target.

The March WSF for April-August 2019 increased slightly to 6.8 km^3 (5.5 Maf, 93 percent of average) with a corresponding end-of-month FRM target of 744.14 m (2,441.4 ft), 9.36 m (30.7 ft) lower than the March first-of-month elevation for Lake Koocanusa. Releases continued to be at minimum flows 113 m^3/s (4.0 kcfs) through March, aside from a brief operation to assist the Burbot and Kootenai Sturgeon fish hatchery operations. February average monthly temperatures were 6.9°C (12.5°F) below normal; February had the lowest inflows on record, which carried over to early March. These unusually cold temperatures and record low inflows caused the intake to the downstream fish hatchery to freeze, so a brief increase in releases from Libby was required for hatchery fish survival. In early March, releases were increased to 283 m^3/s (10.0 kcfs) for six days and then outflows returned to minimum flows of 113 m^3/s (4.0 kcfs) over four days.

The water supply forecast decreased in April 2019 due to below average precipitation in March, 18% of normal. The April WSF was 5.9 km^3 (4.8 Maf), or 81 percent of average, with an end-of-month FRM target of 747.67 m (2,453.0 ft). Due to continued low inflow and pool elevation, Libby's outflows were at minimum flows of 113 m^3/s (4.0 kcfs). Libby reached a minimum elevation of 733.26 m (2405.7 ft) on 26 March 2019. Inflows began to rise at the end of April due to increasing temperatures. The start of refill was retroactively declared for 12 April 2019, and the April VarQ flow was calculated as 396 m^3/s (14.0 kcfs). Beginning 22 April, Libby's outflows were slowly increased to match inflows due to inflows remaining below the VarQ flow. Outflow from Libby was as 255 m^3/s (9.0 kcfs) at the end of April.

The May 2019 WSF was 6.2 km^3 (5.0 Maf), or 85 percent of average. The VarQ flow for May increased to 510 m^3/s (18.0 kcfs). However at the beginning of May inflows remained below the VarQ flow, therefore releases matched inflows until inflows were greater than 510 m^3/s (18.0 kcfs). On 14 May 2019, inflows had increased enough that releases were set at the VarQ flow. On 29 May 2019, Libby began to release the sturgeon volume, 1.0 km^3 (0.8 Maf) set by the May WSF, with releases set at to 566 m^3/s (20.0 kcfs) for 20 days. The outflows were then stepped down to the minimum bull trout flow of 198 m^3/s (7.0 kcfs) over six days using ramping rates. The sturgeon volume was expended on 26 June. Lake Koocanusa ended the month of June at elevation 740.48 m (2,429.4 ft).

The operation for the rest of the summer, July through August 2019, was to try to refill Libby as much as possible and meet the 746.46 m (2,449.0 ft) target by the end of September 2019, as required in the 2019 BiOp and coordinated through the Technical Management Team (TMT). The target elevation of ten feet below full pool, or, 746.46 m (2,449.0 ft), is based on The Dalles water supply forecast being above the 20th percentile runoff volume (below 20th percentile the requirement would be to draft to 743.41 m, or 2,439.0 ft). Libby reached its peak elevation for the summer on 22 August 2019, 744.47 m (2,442.5 ft) 22 August 2019, 744.47 m (2,442.5 ft), 5.03 m (16.5 ft) below full pool. Because the winter snowpack and precipitation were consistently below normal, peak pool elevation in Lake Koocanusa was expected to be low. However summer precipitation was higher than expected, especially in July with Kootenai River Basin precipitation at 113 percent of normal for the month. Although Lake Koocanusa did not reach full pool, it was higher than initially forecast. Due to low inflows and pool, Libby kept releases at the minimum bull trout flow of 198 m^3/s (7.0 kcfs) from July through August 2019 then ramped down to 170 m^3/s (6.0 kcfs), the minimum bull trout flow for September 2019. Libby elevation was 744.35 m (2,442.1 ft) at the end of August 2019 and remained there through September 2019. Although the Kootenai Tribe of Idaho requested low flows in-stream habitat work in previous summers, this request was not made in 2019. Libby held the 170 m^3/s (6.0 kcfs) minimum release through the end of September 2019.

Kootenay Lake

Kootenay Lake is operated (refer to Chart 9) to meet numerous interests, including the provision of meeting maximum levels under the IJC and minimum flow targets in the Kootenay River at Brilliant Dam. Operations target a minimum Brilliant Dam flow of 453 m^3/s (16.0 kcfs) during October through November and 510 m^3/s (18.0 kcfs) during the period December through September.

On 13 July 2018, Kootenay Lake (at Nelson) was drafted to 531.36 m (1,743.3 ft), at which point the IJC compliance gauge switched from Queens Bay to Nelson, and the lake was maintained near 531.27 m (1,743.0 ft) through the end of August 2018. Beginning in September 2018, Kootenay Lake was drafted to target 530.96 m (1,742.0 ft) from mid-

September to mid-October to support the kokanee shoal spawning operation on the lake. During this time, the operation was to pass inflows and to provide fish flows downstream. Periodically, Brilliant discharges fell below the minimum target flow of 453 m^3/s (16.0 kcfs) to as low as 181 m^3/s (6.4 kcfs) in October due to low inflows. Kootenay Lake was not able to refill until the late November when Libby began increasing discharges and as such augmented inflows into Kootenay Lake.

Beginning in late December 2018, the lake was drafted to meet loads and to accommodate a Brilliant Expansion plant outage in February 2019. Further, as is normal, the IJC maximum level began to lower linearly towards 531.57 m (1,744.0 ft) by 01 February 2019 and 531.08 m (1,742.4 ft) by 01 March 2019. Kootenay Lake reached a minimum level of 529.89 m (1,738.5 ft) on 05 April 2019.

The International Kootenay Lake Board of Control, after consultation with Fortis BC, declared the Commencement of Spring Rise for Kootenay Lake on 24 April 2019. Following this declaration, the Corra Linn and Kootenay Canal projects continued to pass maximum discharge (free flow), limited only by the natural flow restriction of Grohman Narrows until 12 June 2019. This was earlier than normal due to well below normal snowpack and inflows into Kootenay Lake. Kootenay Lake reached a maximum level of 532.27 m (1,746.3 ft) on 04 June 2019, well below 534.01 m (1,752.0 ft), the onset of minor flood concerns. By comparison, in 2018, the peak level was 534.07 m (1,752.2 ft) on 26 May 2018. Discharge from Kootenay Lake peaked at 1,453 m^3/s (51.3 kcfs) on 4 June 2019 while the Kootenay River discharge at Brilliant peaked at 1,804 m^3/s (63.7 kcfs) on the same day. On 04 July 2019, Kootenay Lake was drafted to at or below 531.36 m (1,743.3 ft), at which point the IJC compliance gauge switched from Queens Bay to Nelson, and the lake was maintained near 531.27 m (1,743.0 ft) through August 2019.

VI - FLOOD RISK MANAGEMENT AND POWER ACCOMPLISHMENTS

General

During the period covered by this report, the Duncan, Arrow, and Kinbasket reservoirs were operated for power, FRM, and other benefits in accordance with the CRT and operating plans and agreements described in Section III, Operating Agreements. Consistent with all DOPs prepared since the installation of generation at Mica Dam, the 2018-19 DOP was designed to achieve optimum power generation onsite in Canada, and downstream in Canada and the U.S., in accordance with paragraph 7 of Annex A of the CRT.

Power operations for the whole of Canadian Storage are determined by the Operating Rule Curves (ORCs), Mica/Keenleyside project operating criteria, and non-power constraints as implemented in the TSR. The ORC calculation includes the Variable Refill Curves (VRCs) which are dependent upon the water supply in any given water year, and the VRC is updated each month with the development of a new water supply forecast. The monthly VRC calculations for Mica, Keenleyside, and Duncan dams are shown in Tables 2 and 4, and Tables 2M and 4M. The calculations for Libby Dam VRCs are shown in Tables 5 and 5M. Libby Dam VRCs are used in the preparation of the TSR.

The Libby December 2018 water supply forecast for April-August 2019 runoff was 7.2 km^3 (5.8 Maf), or 98 percent of average (based on the 1981-2010 inflow). Based on this forecast, the FRM draft for Lake Koocanusa was 2.2 km^3 (1.8 Maf), to elevation 736.31 m (2,415.7ft) on 31 December 2018. Libby was operated to its VarQ FRM storage reservation diagram and began refill in mid-April according to the Initial Controlled Flow (ICF) date.

Flood Risk Management

Overall, the 2019 water supply for the Columbia Basin was below average. The Snake River Basin's water supply was above average, with the observed April to August 2019 unregulated runoff at Lower Granite Dam at 117 percent of average. However, the unregulated

runoff in all of the other Columbia River Basin sub-basins was below average, ranging between 76 and 94 percent of average. All combined, the unregulated April-August 2019 volume at The Dalles of 99.9 km^3 (81.0 Maf) was 93 percent of the 1981-2010 30-year normal. During the drawdown period, the reservoir system, including the Columbia River Treaty projects, is required to draft for FRM in preparation for the spring rise. Inflow forecasts and reservoir regulation modeling were done throughout the winter and spring. Mica, Keenleyside, and Duncan dams were operated according to the FRM requirements of the May 2003 FCOP. Libby Dam was operated to its VarQ Storage Reservation Diagram and accompanying rules. The unregulated peak flow during the freshet (based on the USACE ResSim program output) at The Dalles, Oregon, shown on Chart 13, was at 13,133 m^3/s (463.8 kcfs) occurring on 04 June 2019, and a regulated daily peak flow for April through July of 9,447 m^3/s (333.6 kcfs) occurred on 19 May 2019 as measured at The Dalles Dam. The regulated peak stage (April – July) at Vancouver, Washington, (VAPW) was observed at 3.23 m (10.6 ft) on 19 May 2019 while the flood stage is 4.88 m (16.0 ft). The peak unregulated stage at Vancouver was at 4.94 m (16.2 ft) on 20 May 2019.

For the 2018-19 Operating Year, the Canadian Entity elected to operate Mica and Keenleyside to the FRM storage allocations of 4.4 km^3 (3.6 Maf) maximum draft at Arrow and 5.1 km^3 (4.1 Maf) maximum draft at Kinbasket, as allowed under the 2003 FCOP. This allocation was first incorporated in the 2006-07 AOP.

Computations of the ICF for system FRM operation were made in accordance with the Treaty FCOP. For 2019, the computed ICFs at The Dalles, based on the various first-of-month water supply forecasts, are as follows:

Initial Controlled Flow at The Dalles

Based on	kcfs	m^3/s
January Forecast	312.0	8,835
February Forecast	285.6	8,087
March Forecast	287.6	8,144
April Forecast	277.2	7,849

Refill at the projects can commence relative to the date[3] when the unregulated flow at The Dalles is expected to equal or exceed the ICF (ICF date). For WY 2019, the ICF date was declared as of 22 April 2019 based on a projection that the unregulated flow would consistently remain above the ICF. The FRM objectives at The Dalles were for regulated flows to stay within a specified range of daily average and instantaneous maximum flows, and for the Grand Coulee Dam elevation to be below a set end-of-month target. Table 6 shows the data used for the April ICF computation.

Canadian Entitlement and Downstream Power Benefits

From 01 August 2018 through 30 September 2019, the U.S. Entity delivered the CE to downstream power benefits from the operation of Canadian Storage to the Canadian Entity, at existing points of interconnection on the Canadian-U.S. border. The amounts returned, before deductions for transmission losses and scheduling adjustments, are listed in Section III Operating Arrangements of this report, under the heading Canadian Entitlement.

For the period 01 August 2018 through 31 July 2019, the CE amount, before deducting transmission losses, was 472.5 aMW of energy, scheduled at rates up to 1,284 MW capacity. From 01 August 2019 through 30 September 2019, the amount, before deducting transmission losses, was 454.3 aMW of energy, scheduled at rates up to 1,141.5 MW capacity. The CE obligation was determined by the 2018-19 and 2019-20 AOP/DDPBs. During the course of the 2018-19 Operating Year, there were no CE delivery curtailment events.

The following Figure 6 shows the historic CE amounts from the DDPB studies as compared to the estimated amount under the 1964 Canadian Entitlement Exchange Agreement (CEEA).

[3] Per the FCOP, projects begin refilling at different times before the ICF Date. For example Libby can start refill 10 days before the declared ICF date, Mica 5 days before and Arrow 2 days before.

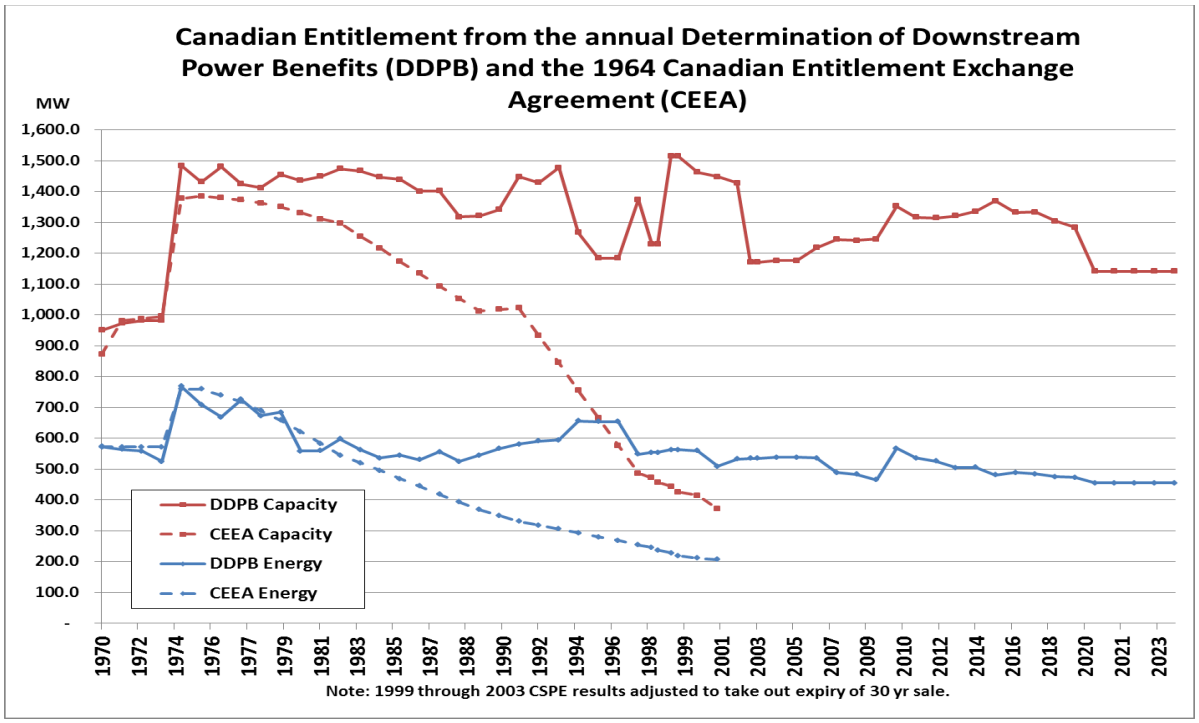


Figure 6: Canadian Entitlements: Agreed CEEA Amounts vs. DDPB Amounts

The CEEA amounts for the CE were based on forecast load growth that was much higher than the subsequent actual load growth. This load growth difference is the main reason for the large difference in the CE between the historic DDPBs (agreed to annually for the sixth succeeding year) and the CE Exchange Agreement amounts (agreed to in 1964).

In accordance with the Canadian Entitlement Allocation Extension Agreement, dated April 1997, the non-federal downstream U.S. projects delivered to BPA their portion of the CE (27.5 percent), and the U.S. Entity granted permission for the non-federal downstream U.S. parties to make use of the U.S. one-half share of the CRT downstream power benefits (U.S. Entitlement).

Power Generation and Other Accomplishments

Actual U.S. power benefits from the operation of Canadian Storage can only be roughly estimated. Canadian Storage has such a large impact on the operation of the U.S. system that its absence would significantly affect operating procedures, nonpower requirements, loads and resources, and market conditions, thus making any benefit analysis highly speculative.

The following Figure 7 shows a rough estimate of the average monthly impact of Canadian Storage on downstream U.S. hydropower generation during the 2018-19 Operating Year, based on the Pacific Northwest Coordination Agreement (PNCA) AER that includes flow and spill requirements for fishery objectives. The increase in average annual U.S. hydropower generation due to the operation of Canadian Storage, as measured by the PNCA AER, was 343 aMW. The increase in hydropower generation occurred primarily in the fall and winter months, October through March. No quantification of this benefit is provided in this report.

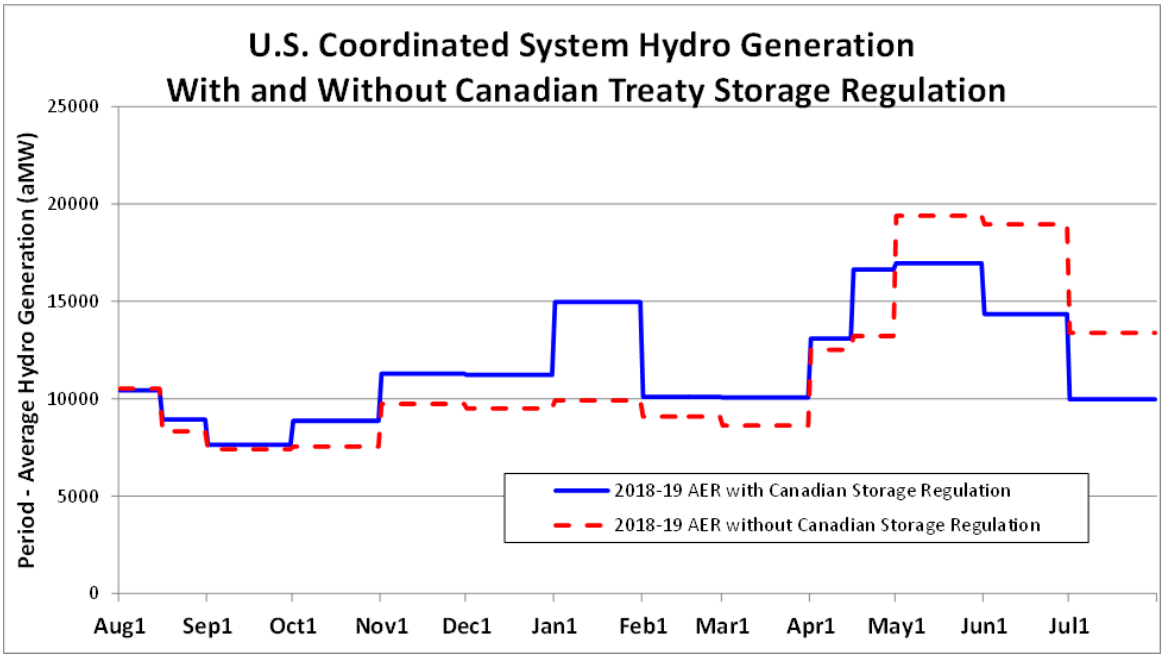


Figure 7: U.S. Coordinated System Hydro Generation

Treaty operating plans are designed to adapt to streamflow and water supply conditions that arise and evolve over the Operating Year. Operating Plans are implemented through the TSR model study which incorporates streamflows, water supply forecasts and other parameters. In the study, Canadian Storage targets are updated twice a month; once a period has passed, target contents for that period is finalized in the first TSR of the subsequent period. This section discusses conditions as realized for the 2018-19 Operating Year and describes the response of Canadian Storage to the observed inflows and water supply conditions which occurred over the year. The risk mitigation benefits associated with the Treaty's flexibility to adapt to the broad

array of water conditions that were possible going into the water year are not addressed or quantified in this report.

Figure 8 compares the actual operation of the composite Canadian Storage to the results of the DOP TSR study. The Canadian Storage operated in proportional draft mode to meet Treaty firm loads from July 2018 to December 2018, in February 2019, and again from July 2019 through the end of this reporting period. The STLA Arrow Provisional Account was drafted and filled as described in Section V between August 2018 and March 2019. By the end of March 2019 the account was drafted to a balance of -1.3 km^3 (-542.5 ksfd) relative to the TSR and remained there until September 2019 when some storage began.

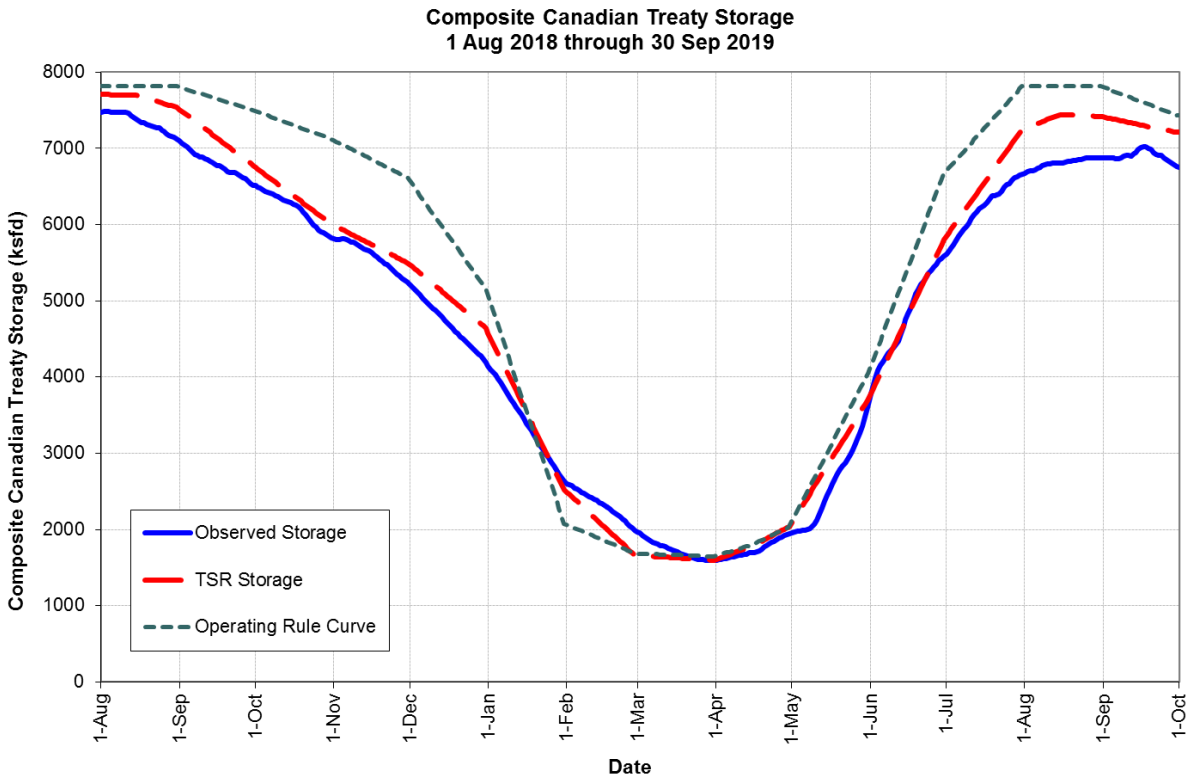


Figure 8: Composite Canadian Storage

Under the 2018-19 NPU agreement, the U.S. stored 1.2 km^3 (504.0 ksfd, 1.0 Maf) above the TSR over five weeks (from 29 December to 01 February) for Flow Augmentation and maintained that balance through May. The Flow Augmentation volume was released evenly, also over five weeks, from 22 June to 26 July per coordination with fish managers. Also under

the NPU agreement, Keenleyside Treaty discharges were shaped/smoothed over February and March, causing February flows to be higher and March flows to be lower than the TSR. There were no trout spawning operations this year. Figure 9 shows the difference in Keenleyside-plus-Duncan regulated outflows per the DOP TSR, vs actual daily treaty outflows. Daily unregulated inflows are also shown for comparison purposes.

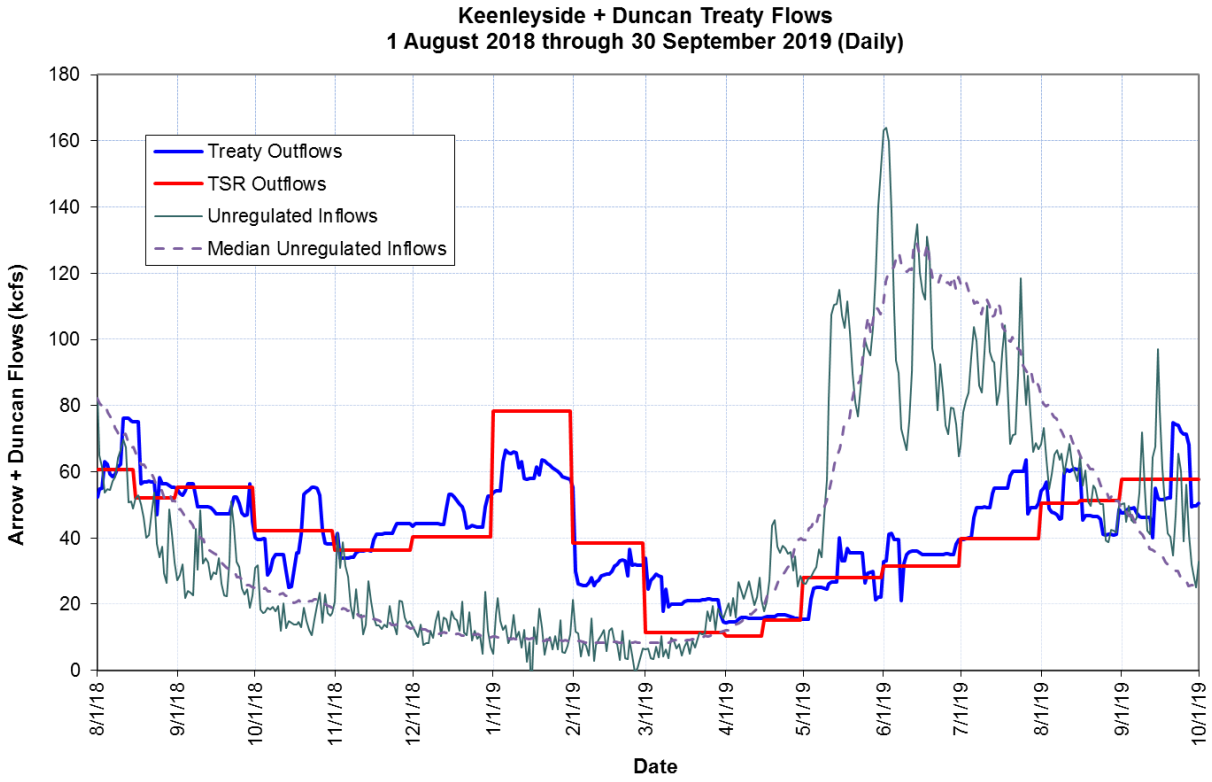


Figure 9: Keenleyside and Duncan Treaty Flows

Figure 10 summarizes the Treaty accounting including supplemental operating agreements throughout the year. Section I shows the difference for each period between the final TSR composite storage and the actual composite Canadian Storage, including the supplementary operating agreements. Section II shows the storage balance for each supplemental operating agreement as they were implemented. Section III shows how the TSR storage content varies over time due to updated forecasts, unexpected weather events, and other factors. The final TSR target results are not available until after the fact, resulting in some inadvertent deviations from the TSR, as shown in Section II, Line 9.

Figure 10: Summary of Treaty Storage Operation

Summary of Treaty Storage Operations
July 2018 through September 2019

All units in KSFD	2018							2019										
I. Composite Treaty Storage (ksfd)	JUL	AU1	AU2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AU1	AU2	SEP
1)Treaty Storage Regulation (Final)	7699.6	7699.9	7535.8	6775.9	6008.1	5502.1	4644.9	2521.8	1662.7	1596.4	1773.9	2039.0	3638.3	5796.5	7247.1	7440.4	7417.4	7207.7
2) Actual Treaty Content (w/SOA's)	7440.7	7378.1	7121.0	6513.8	5823.8	5244.9	4190.0	2628.5	1995.3	1598.1	1697.4	1943.4	3606.8	5585.2	6661.3	6801.6	6871.4	6761.5
3) % full (TSR Comp.Storage/7814.6)	98.5%	98.5%	96.4%	86.7%	76.9%	70.4%	59.4%	32.3%	21.3%	20.4%	22.7%	26.1%	46.5%	74.2%	92.7%	95.2%	94.9%	92.2%
4) Final deviation from TSR	**-258.9**	**-321.8**	**-414.8**	**-262.1**	**-184.3**	**-257.2**	**-454.9**	**106.7**	**332.6**	**1.7**	**-76.5**	**-95.6**	**-31.5**	**-211.3**	**-585.8**	**-638.8**	**-546.0**	**-446.2**

II. Monthly Accounting of Supplemental Operating Agreements Content (ksfd)

	2018							2019										
Balance in each period	JUL	AU1	AU2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AU1	AU2	SEP
5) Short Term Libby Agreement (STLA)	-311.0	-401.0	-455.0	-317.0	-257.0	-346.5	-444.5	-395.5	-486.5	-542.5	-542.5	-542.5	-542.5	-542.5	-542.5	-542.5	-542.5	-419.5
6) Non Power Uses Flow (NPU) FA	0.0	0.0	0.0	0.0	0.0	0.0	43.2	489.6	504.0	504.0	504.0	504.0	504.0	374.4	0.0	0.0	0.0	0.0
7) Total	-311.0	-401.0	-455.0	-317.0	-257.0	-346.5	-401.3	94.1	17.5	-38.5	-38.5	-38.5	-38.5	-168.1	-542.5	-542.5	-542.5	-419.5
8. Inadvertent (Line 4 - Line 7)	**52.1**	**79.2**	**40.2**	**54.9**	**72.7**	**89.3**	**-53.6**	**12.6**	**315.1**	**40.2**	**-38.0**	**-57.1**	**7.0**	**-43.2**	**-43.3**	**-96.3**	**-3.5**	**-26.7**

per 2019 NPU: Feb-Mar Arrow outflows were shaped/smoothed; Feb inadvertant does not apply

III. Summary of TSR Results (Final TSR in green)
Composite Treaty Storage TSR Content (ksfd)

	2018							2019										2019
TSR Date	JUL	AU1	AU2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AU1	AU2	SEP
3-Aug-18	**7699.6**	7701.4	7658.7	6884.7	6563.5	6340.7	5162.9	3029.6	1756.7	1387.1	1257.3	1349.7	3385.2	6181.2	7814.6			
21-Aug-18		**7699.9**	7585.5	6775.9	6535.7	6104.9	5162.9	3029.5	1756.7	1387.0	1023.5	1116.0	3151.4	5947.5	7814.6			
7-Sep-18			**7535.8**	6775.9	6392.4	5774.2	5034.3	2902.2	1756.7	1234.6	862.6	955.0	2990.4	5786.5	7678.8			
20-Sep-18				6775.9	6568.6	5954.7	5162.9	3029.6	1756.7	1373.3	1001.3	1093.7	3129.1	5925.2	7814.6			
4-Oct-18				**6775.9**	6385.8	5705.8	4970.6	2839.3	1756.7	1336.5	964.4	1056.9	3092.3	5888.4	7780.7			
19-Oct-18					6074.6	5252.4	4413.2	2288.0	1622.7	1095.4	723.3	815.8	2851.2	5647.3	7539.6			
8-Nov-18					**6008.1**	5664.9	4953.0	2821.9	1756.7	1231.8	859.7	952.2	2987.6	5783.7	7676.0			
16-Nov-18						5543.4	4711.7	2598.5	1737.9	1210.6	838.5	930.9	2966.3	5762.4	7654.7			
10-Dec-18						**5502.1**	4465.5	2415.0	1723.5	1216.9	844.8	937.3	2972.7	5768.8	7661.1			
19-Dec-18							4641.7	2558.5	1725.2	1239.5	867.5	959.9	2995.3	5791.4	7683.7			
10-Jan-19							**4644.9**	2565.4	1756.7	1624.4	1277.2	1326.9	3082.7	5774.2	7472.8			
22-Jan-19								2545.6	1756.7	1620.7	1275.2	1326.5	3082.3	5773.8	7474.2			
11-Feb-19								**2521.8**	1685.9	1643.4	1739.4	1985.1	3387.9	6033.9	7659.5			
19-Feb-19									1685.9	1647.2	1745.0	1985.1	3391.2	6035.5	7659.5			
11-Mar-19									**1662.7**	1585.0	1672.1	1960.1	3294.0	5998.1	7630.8			
20-Mar-19										1568.0	1671.1	1985.1	3302.7	6001.6	7630.8			
9-Apr-19										**1596.4**	1774.0	2039.0	3357.2	5787.5	7249.1			
22-Apr-19											**1773.9**	2039.0	3479.8	5849.8	7247.5			
9-May-19												**2039.0**	3515.0	5688.8	7263.0			
20-May-19													3601.7	5868.6	7263.1			
11-Jun-19													**3638.3**	5968.9	7230.2			
19-Jun-19														5839.6	6962.0	7052.8		
8-Jul-19														**5796.5**	6897.1	6982.5	6914.8	
19-Jul-19															7049.1	7172.9	7096.1	6773.1
8-Aug-19															**7247.1**	7355.7	7300.6	7011.4
21-Aug-19																**7440.4**	7378.7	7017.5
5-Sep-19																	**7417.4**	7017.8
19-Sep-19																		7080.8
3-Oct-19																		**7207.7**
Proportional Draft Point (PDP)	1.674	3.361	4.021	3.446	2.831	2.544	2.248	1.000	1.481	1.000	1.000	1.000	1.000	1.000	2.513	4.046	4.060	2.561

VII – TABLES

Table 1M (metric): Unregulated Runoff Volume Forecasts Cubic Kilometers

Most Probable 1-April through 31-August 2019 Forecasts in km^3

First of Month Forecast	Duncan	Arrow	Mica	Libby[1]	Columbia River at The Dalles, Oregon
January	2.41	26.7	13.0	6.96	102.8
February	2.50	27.5	13.7	6.56	92.9
March	2.48	26.3	13.5	6.74	94.5
April	2.33	24.4	12.6	5.86	93.2
May	2.34	24.7	12.6	6.15	101.7
June	2.27	24.2	12.4	5.77	101.9
Actual	2.20	24.3	12.8	5.50	99.9

Table 1: Unregulated Runoff Volume Forecasts Million Acre-feet

Most Probable 1-April through 31-August 2019 Forecasts in Maf

First of Month Forecast	Duncan	Arrow	Mica	Libby[2]	Columbia River at The Dalles, Oregon
January	1.96	21.6	10.6	5.64	83.3
February	2.03	22.3	11.1	5.32	75.3
March	2.01	21.3	11.0	5.47	76.6
April	1.89	19.8	10.3	4.75	75.6
May	1.90	20.0	10.2	4.98	82.4
June	1.84	19.6	10.0	4.68	82.6
Actual	1.79	19.7	10.4	4.46	81.0

[1, 2] Final monthly volume forecasts for Libby have been updated from initial forecasts due to updated precipitation values.

Table 2M (metric): 2019 Mica Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE DATE-31JULY INFLOW, km3			11.4	11.6	11.2	10.0	9.4	6.9
PROBABLE DATE-31JULY INFLOW, hm3	**		11373.1	11593.7	11212.3	10019.8	9408.4	6923.4
95% FORECAST ERROR FOR DATE, hm3			2113.3	1837.0	1730.3	1370.1	1215.4	908.7
95% CONF.DATE-31JULY INFLOW, hm3	1/		9259.8	9756.7	9482.0	8649.7	8193.0	6014.7
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, hm3	2/		9037.6					
FEB MINIMUM FLOW REQUIREMENT, m3/s	3/		85.0					
MIN FEB1-JUL31 OUTFLOW, hm3	4/		3596.7					
VRC JAN31 RESERVOIR CONTENT, hm3	5/		3193.7					
VRC JAN31 RESERVOIR CONTENT, METERS	6/		739.0					
JAN31 ORC, m	7/		736.7					
BASE ECC, m	8/	736.7						
LOWER LIMIT, m		732.9						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			98.0	98.0				
ASSUMED MAR1-JUL31 INFLOW, hm3	2/		8852.4	9551.9				
MAR MINIMUM FLOW REQUIREMENT, m3/s	3/		85.0	85.0				
MIN MAR1-JUL31 OUTFLOW, hm3	4/		3391.2	3903.6				
VRC FEB28 RESERVOIR CONTENT, hm3	5/		3173.4	2986.3				
VRC FEB28 RESERVOIR CONTENT, METERS	6/		739.0	738.5				
FEB28 ORC, m	7/		735.8	735.8				
BASE ECC, m	8/	735.8						
LOWER LIMIT, m		729.9						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			95.6	95.6	97.6			
ASSUMED APR1-JUL31 INFLOW, hm3	2/		8630.2	9317.7	9244.9			
APR MINIMUM FLOW REQUIREMENT, m3/s	3/		85.0	85.0	85.0			
MIN APR1-JUL31 OUTFLOW, hm3	4/		3163.7	3676.1	3707.2			
VRC MAR31 RESERVOIR CONTENT, hm3	5/		3168.1	2992.9	3096.9			
VRC MAR31 RESERVOIR CONTENT, METERS	6/		739.0	738.5	738.8			
MAR31 ORC, m	7/		735.9	735.9	735.9			
BASE ECC, m	8/	735.8						
LOWER LIMIT, m		729.7						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			90.7	90.7	92.5	94.8		
ASSUMED MAY1-JUL31 INFLOW, hm3	2/		8176.4	8829.9	8761.3	8199.9		
MAY MINIMUM FLOW REQUIREMENT, m3/s	3/		85.0	85.0	85.0	85.0		
MIN MAY1-JUL31 OUTFLOW, hm3	4/		2943.5	3455.9	3487.0	3509.3		
VRC APR30 RESERVOIR CONTENT, hm3	5/		3401.6	3260.6	3360.3	3944.0		
VRC APR30 RESERVOIR CONTENT, METERS	6/		739.6	739.2	739.5	741.1		
APR30 ORC, m	7/		736.5	736.5	736.5	736.5		
BASE ECC, m	8/	736.5						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			71.8	71.8	73.2	75.0	79.1	
ASSUMED JUN1-JUL31 INFLOW, hm3	2/		6472.6	6985.8	6931.3	6495.9	6488.9	
JUN MINIMUM FLOW REQUIREMENT, m3/s	3/		85.0	85.0	85.0	85.0	85.0	
MIN JUN1-JUL31 OUTFLOW, hm3	4/		2716.0	3228.4	3259.5	3281.8	2840.8	
VRC MAY31 RESERVOIR CONTENT, hm3	5/		4877.9	4877.1	4962.7	5420.4	4986.4	
VRC MAY31 RESERVOIR CONTENT, METERS	6/		743.6	743.6	743.8	745.0	743.9	
MAY31 ORC, m	7/		740.4	740.4	740.4	740.4	740.4	
BASE ECC, m	8/	740.4						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			36.4	36.4	37.0	37.9	40.0	50.6
ASSUMED JUL1-JUL31 INFLOW, hm3	2/		3278.0	3531.9	3508.3	3286.9	3285.4	3043.4
JUL MINIMUM FLOW REQUIREMENT, m3/s	3/		339.8	362.5	490.7	498.5	504.0	393.7
MIN JUL1-JUL31 OUTFLOW, hm3	4/		1776.3	1956.6	1967.5	1975.4	1820.2	1805.5
VRC JUN30 RESERVOIR CONTENT, hm3	5/		7132.9	7059.2	7093.7	7323.0	7169.4	7396.6
VRC JUN30 RESERVOIR CONTENT, METERS	6/		749.3	749.1	749.2	749.7	749.4	749.9
JUN30 ORC, m	7/		748.0	748.0	748.0	748.0	748.0	748.0
BASE ECC, m	8/	748.0						
JUL 31 ORC, m			752.9	752.9	752.9	752.9	752.9	752.9

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (8634.54 hm3) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER OF ARC OR CRC1 IN DOP

Table 2: 2019 Mica Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE DATE-31JULY INFLOW, KAF			9220.3	9399.1	9089.8	8123.1	7627.4	5612.8
PROBABLE DATE-31JULY INFLOW, KSFD	**		4648.5	4738.7	4582.8	4095.4	3845.5	2829.8
95% FORECAST ERROR FOR DATE, KSFD			863.8	750.8	707.2	560.0	496.8	371.4
95% CONF.DATE-31JULY INFLOW, KSFD	1/		3784.8	3987.9	3875.6	3535.4	3348.7	2458.4
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, KSFD	2/		3693.9					
FEB MINIMUM FLOW REQUIREMENT, CFS	3/		3000.0					
MIN FEB1-JUL31 OUTFLOW, KSFD	4/		1470.1					
VRC JAN31 RESERVOIR CONTENT, KSFD	5/		1305.4					
VRC JAN31 RESERVOIR CONTENT, FEET	6/		2424.7					
JAN31 ORC, FT	7/		2417.0					
BASE ECC, FT	8/	2417.0						
LOWER LIMIT, FT		2404.5						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			98.0	98.0				
ASSUMED MAR1-JUL31 INFLOW, KSFD	2/		3618.2	3904.1				
MAR MINIMUM FLOW REQUIREMENT, CFS	3/		3000.0	3000.0				
MIN MAR1-JUL31 OUTFLOW, KSFD	4/		1386.1	1595.5				
VRC FEB28 RESERVOIR CONTENT, KSFD	5/		1297.0	1220.6				
VRC FEB28 RESERVOIR CONTENT, FEET	6/		2424.6	2422.9				
FEB28 ORC, FT	7/		2414.1	2414.1				
BASE ECC, FT	8/	2414.1						
LOWER LIMIT, FT		2394.7						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			95.6	95.6	97.6			
ASSUMED APR1-JUL31 INFLOW, KSFD	2/		3527.4	3808.4	3778.7			
APR MINIMUM FLOW REQUIREMENT, CFS	3/		3000.0	3000.0	3000.0			
MIN APR1-JUL31 OUTFLOW, KSFD	4/		1293.1	1502.5	1515.3			
VRC MAR31 RESERVOIR CONTENT, KSFD	5/		1294.9	1223.3	1265.8			
VRC MAR31 RESERVOIR CONTENT, FEET	6/		2424.5	2422.9	2423.9			
MAR31 ORC, FT	7/		2414.2	2414.2	2414.2			
BASE ECC, FT	8/	2414.2						
LOWER LIMIT, FT		2394.1						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			90.7	90.7	92.5	94.8		
ASSUMED MAY1-JUL31 INFLOW, KSFD	2/		3342.0	3609.0	3581.0	3351.5		
MAY MINIMUM FLOW REQUIREMENT, CFS	3/		3000.0	3000.0	3000.0	3000.0		
MIN MAY1-JUL31 OUTFLOW, KSFD	4/		1203.1	1412.5	1425.3	1434.4		
VRC APR30 RESERVOIR CONTENT, KSFD	5/		1390.3	1332.7	1373.4	1612.0		
VRC APR30 RESERVOIR CONTENT, FEET	6/		2426.6	2425.3	2426.2	2431.4		
APR30 ORC, FT	7/		2416.3	2416.3	2416.3	2416.3		
BASE ECC, FT	8/	2416.3						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			71.8	71.8	73.2	75.0	79.1	
ASSUMED JUN1-JUL31 INFLOW, KSFD	2/		2645.6	2855.3	2833.0	2655.1	2652.2	
JUN MINIMUM FLOW REQUIREMENT, CFS	3/		3000.0	3000.0	3000.0	3000.0	3000.0	
MIN JUN1-JUL31 OUTFLOW, KSFD	4/		1110.1	1319.5	1332.3	1341.4	1161.1	
VRC MAY31 RESERVOIR CONTENT, KSFD	5/		1993.7	1993.4	2028.4	2215.5	2038.1	
VRC MAY31 RESERVOIR CONTENT, FEET	6/		2439.5	2439.5	2440.3	2444.2	2440.5	
MAY31 ORC, FT	7/		2429.0	2429.0	2429.0	2429.0	2429.0	
BASE ECC, FT	8/	2429.0						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			36.4	36.4	37.0	37.9	40.0	50.6
ASSUMED JUL1-JUL31 INFLOW, KSFD	2/		1339.8	1443.6	1434.0	1343.4	1342.8	1243.9
JUL MINIMUM FLOW REQUIREMENT, CFS	3/		12000.0	12801.6	17327.5	17602.7	17799.5	13904.0
MIN JUL1-JUL31 OUTFLOW, KSFD	4/		726.0	799.7	804.2	807.4	744.0	738.0
VRC JUN30 RESERVOIR CONTENT, KSFD	5/		2915.4	2885.3	2899.4	2993.1	2930.3	3023.2
VRC JUN30 RESERVOIR CONTENT, FEET	6/		2458.2	2457.6	2457.9	2459.8	2458.5	2460.3
JUN30 ORC, FT	7/		2454.1	2454.1	2454.1	2454.1	2454.1	2454.1
BASE ECC, FT	8/	2454.1						
JUL 31 ORC, FT			2470.1	2470.1	2470.1	2470.1	2470.1	2470.1

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (3529.2 KSFD) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER OF ARC OR CRC1 IN DOP

Table 3M (metric): 2019 Keenleyside Variable Refill Curve

		INITIAL	JAN 1 Total	FEB 1 Total	MAR 1 Total	APR 1 Total	MAY 1 Total	JUN 1 Total
PROBABLE DATE-31JULY INFLOW, km3			24.8	24.7	23.0	20.4	18.8	12.8
& IN hm3	**		24823.4	24689.9	22997.3	20396.6	18837.8	12820.2
95% FORECAST ERROR FOR DATE, IN hm3			3626.0	2680.3	2333.4	1982.3	1767.6	1660.2
95% CONF.DATE-31JULY INFLOW, hm3	1/		19421.0	21993.7	21259.2	21505.0	20753.4	15788.9
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, hm3	2/		20210.7					
MIN FEB1-JUL31 OUTFLOW, hm3	3/		7535.5					
UPSTREAM DISCHARGE, hm3	4/		6288.7					
VRC JAN31 RESERVOIR CONTENT, hm3	5/		2371.4					
VRC JAN31 RESERVOIR CONTENT, METERS	6/		426.4					
JAN31 ORC, m	7/		426.5					
BASE ECC, m	8/	433.3						
LOWER LIMIT, m		422.9						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			97.7	97.7				
ASSUMED MAR1-JUL31 INFLOW, hm3	2/		19732.9	20688.1				
MIN MAR1-JUL31 OUTFLOW, hm3	3/		7193.0	7193.0				
UPSTREAM DISCHARGE, hm3	4/		6599.0	6599.0				
VRC FEB28 RESERVOIR CONTENT, hm3	5/		2816.9	1861.7				
VRC FEB28 RESERVOIR CONTENT, METERS	6/		427.5	425.2				
FEB28 ORC, m	7/		425.6	425.2				
BASE ECC, m	8/	425.6						
LOWER LIMIT, m		420.3						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			94.8	94.8	97.1			
ASSUMED APR1-JUL31 INFLOW, hm3	2/		19130.6	20052.2	19082.6			
MIN APR1-JUL31 OUTFLOW, hm3	3/		6813.8	6813.8	6813.8			
UPSTREAM DISCHARGE, hm3	4/		6582.8	6582.8	6582.8			
VRC MAR31 RESERVOIR CONTENT, hm3	5/		3023.9	2102.2	3071.9			
VRC MAR31 RESERVOIR CONTENT, METERS	6/		428.0	425.8	428.2			
MAR31 ORC, m	7/		425.1	425.1	425.1			
BASE ECC, m	8/	425.1						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			87.9	87.9	90.1	92.8		
ASSUMED MAY1-JUL31 INFLOW, hm3	2/		17738.9	18589.7	17666.2	16508.4		
MIN MAY1-JUL31 OUTFLOW, hm3	3/		6446.8	6446.8	6446.8	6446.8		
UPSTREAM DISCHARGE, hm3	4/		6366.5	6366.5	6366.5	6366.5		
VRC APR30 RESERVOIR CONTENT, hm3	5/		3832.3	2981.5	3905.0	5062.8		
VRC APR30 RESERVOIR CONTENT, METERS	6/		429.9	427.9	430.1	432.7		
APR30 ORC, Fm	7/		426.6	426.6	426.6	426.6		
BASE ECC, m	8/	426.6						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL			65.3	65.3	66.9	68.9	74.3	
ASSUMED JUN1-JUL31 INFLOW, hm3	2/		13148.4	13778.0	13102.1	12247.6	12457.6	
MIN JUN1-JUL31 OUTFLOW, hm3	3/		6067.6	6067.6	6067.6	6067.6	6067.6	
UPSTREAM DISCHARGE, hm3	4/		4963.7	4963.7	4963.7	4963.7	4963.7	
VRC MAY31 RESERVOIR CONTENT, hm3	5/		6640.7	6011.1	6687.0	7541.5	7331.4	
VRC MAY31 RESERVOIR CONTENT, METERS	6/		436.0	434.7	436.1	437.8	437.4	
MAY31 ORC, m	7/		433.7	433.7	433.7	433.7	433.7	
BASE ECC, m	8/	433.7						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			30.5	30.5	31.3	32.3	34.8	46.8
ASSUMED JUL1-JUL31 INFLOW, hm3	2/		6148.4	6422.7	6118.2	5722.7	5825.9	5245.6
MIN JUL1-JUL31 OUTFLOW, hm3	3/		3792.2	3792.2	3792.2	3792.2	3792.2	3792.2
UPSTREAM DISCHARGE, hm3	4/		2014.0	2014.0	2014.0	2014.0	2014.0	2014.0
VRC JUN30 RESERVOIR CONTENT, hm3	5/		8415.7	8141.5	8445.9	8841.4	8738.2	9318.5
VRC JUN30 RESERVOIR CONTENT, METERS	6/		439.5	438.9	439.6	440.1	440.1	440.1
JUN30 ORC, m	7/		439.5	439.0	439.5	439.5	439.5	439.5
BASE ECC, m	8/	439.8						
JUL 31 ECC, m			440.1	440.1	440.1	440.1	440.1	440.1

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ CUMMULATIVE MINIMUM OUTFLOW FROM DATE TO JULY, USING POWER DISCHARGE REQUIREMENTS
4/ UPSTREAM DISCHARGE REQUIREMENT.
5/ MAXIMUM(FULL CONTENT (8757.85 hm3) MINUS 2/ PLUS 3/ MINUS /4 OR LOWER LIMIT)
6/ ELEV. FROM 5/, INTERP. FROM STORAGE CONTENT TABLE
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER OF ARC OR CRC1 IN DOP

Table 3: 2019 Keenleyside Variable Refill Curve

		INITIAL	JAN 1 Total	FEB 1 Total	MAR 1 Total	APR 1 Total	MAY 1 Total	JUN 1 Total
PROBABLE DATE-31JULY INFLOW, KAF			20124.5	20016.2	18644.0	16535.6	15271.9	10393.4
& IN KSFD	**		10146.1	10091.5	9399.7	8336.7	7699.6	5240.0
95% FORECAST ERROR FOR DATE, IN KSFD			1482.1	1095.5	953.7	810.2	722.5	678.6
95% CONF.DATE-31JULY INFLOW, KSFD	1/		7937.9	8989.5	8689.3	8789.8	8482.5	6453.4
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, KSFD	2/		8260.7					
MIN FEB1-JUL31 OUTFLOW, KSFD	3/		3080.0					
UPSTREAM DISCHARGE, KSFD	4/		2570.4					
VRC JAN31 RESERVOIR CONTENT, KSFD	5/		969.3					
VRC JAN31 RESERVOIR CONTENT, FEET	6/		1399.1					
JAN31 ORC, FT	7/		1399.1					
BASE ECC, FT	8/	1421.6						
LOWER LIMIT, FT		1387.5						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			97.7	97.7				
ASSUMED MAR1-JUL31 INFLOW, KSFD	2/		8065.5	8455.9				
MIN MAR1-JUL31 OUTFLOW, KSFD	3/		2940.0	2940.0				
UPSTREAM DISCHARGE, KSFD	4/		2697.2	2697.2				
VRC FEB28 RESERVOIR CONTENT, KSFD	5/		1151.3	760.9				
VRC FEB28 RESERVOIR CONTENT, FEET	6/		1402.7	1394.9				
FEB28 ORC, FT	7/		1396.4	1394.9				
BASE ECC, FT	8/	1396.3						
LOWER LIMIT, FT		1378.9						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			94.8	94.8	97.1			
ASSUMED APR1-JUL31 INFLOW, KSFD	2/		7819.2	8196.0	7799.6			
MIN APR1-JUL31 OUTFLOW, KSFD	3/		2785.0	2785.0	2785.0			
UPSTREAM DISCHARGE, KSFD	4/		2690.6	2690.6	2690.6			
VRC MAR31 RESERVOIR CONTENT, KSFD	5/		1236.0	859.2	1255.6			
VRC MAR31 RESERVOIR CONTENT, FEET	6/		1404.3	1396.9	1404.7			
MAR31 ORC, FT	7/		1394.6	1394.6	1394.6			
BASE ECC, FT	8/	1394.6						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			87.9	87.9	90.1	92.8		
ASSUMED MAY1-JUL31 INFLOW, KSFD	2/		7250.4	7598.2	7220.7	6747.5		
MIN MAY1-JUL31 OUTFLOW, KSFD	3/		2635.0	2635.0	2635.0	2635.0		
UPSTREAM DISCHARGE, KSFD	4/		2602.2	2602.2	2602.2	2602.2		
VRC APR30 RESERVOIR CONTENT, KSFD	5/		1566.4	1218.6	1596.1	2069.3		
VRC APR30 RESERVOIR CONTENT, FEET	6/		1410.5	1404.0	1411.1	1419.5		
APR30 ORC, FT	7/		1399.6	1399.6	1399.6	1399.6		
BASE ECC, FT	8/	1399.6						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL			65.3	65.3	66.9	68.9	74.3	
ASSUMED JUN1-JUL31 INFLOW, KSFD	2/		5374.1	5631.5	5355.2	5006.0	5091.8	
MIN JUN1-JUL31 OUTFLOW, KSFD	3/		2480.0	2480.0	2480.0	2480.0	2480.0	
UPSTREAM DISCHARGE, KSFD	4/		2028.8	2028.8	2028.8	2028.8	2028.8	
VRC MAY31 RESERVOIR CONTENT, KSFD	5/		2714.3	2456.9	2733.2	3082.4	2996.6	
VRC MAY31 RESERVOIR CONTENT, FEET	6/		1430.4	1426.1	1430.7	1436.3	1434.9	
MAY31 ORC, FT	7/		1422.9	1422.9	1422.9	1422.9	1422.9	
BASE ECC, FT	8/	1422.9						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			30.5	30.5	31.3	32.3	34.8	46.8
ASSUMED JUL1-JUL31 INFLOW, KSFD	2/		2513.0	2625.1	2500.7	2339.0	2381.2	2144.0
MIN JUL1-JUL31 OUTFLOW, KSFD	3/		1550.0	1550.0	1550.0	1550.0	1550.0	1550.0
UPSTREAM DISCHARGE, KSFD	4/		823.2	823.2	823.2	823.2	823.2	823.2
VRC JUN30 RESERVOIR CONTENT, KSFD	5/		3439.8	3327.7	3452.1	3613.8	3571.6	3808.8
VRC JUN30 RESERVOIR CONTENT, FEET	6/		1441.9	1440.1	1442.1	1444.0	1443.9	1444.0
JUN30 ORC, FT	7/		1441.9	1440.1	1442.0	1442.0	1442.0	1442.0
BASE ECC, FT	8/	1442.9						
JUL 31 ECC, FT			1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ CUMMULATIVE MINIMUM OUTFLOW FROM DATE TO JULY, USING POWER DISCHARGE REQUIREMENTS
4/ UPSTREAM DISCHARGE REQUIREMENT.
5/ MAXIMUM(FULL CONTENT (3579.6 KSFD) MINUS 2/ PLUS 3/ MINUS /4 OR LOWER LIMIT)
6/ ELEV. FROM 5/, INTERP. FROM STORAGE CONTENT TABLE
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER OF THE ARC OR CRC1 IN DOP

Table 4M (metric): 2019 Duncan Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE DATE-31JULY INFLOW, km3			2.2	2.2	2.1	2.0	1.8	1.2
& IN hm3	**		2187.9	2190.4	2123.9	1955.3	1802.7	1234.8
95% FORECAST ERROR FOR DATE, IN hm3			434.0	375.9	359.8	285.9	243.6	207.5
95% CONF.DATE-31JULY INFLOW, hm3	1/		1753.8	1814.5	1764.1	1669.4	1559.1	1027.3
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, hm3	2/		1708.2					
FEB MINIMUM FLOW REQUIREMENT, m3/s	3/		2.8					
MIN FEB1-JUL31 OUTFLOW, hm3	4/		351.1					
VRC JAN31 RESERVOIR CONTENT, hm3	5/		369.7					
VRC JAN31 RESERVOIR CONTENT, METERS	6/		554.5					
JAN31 ORC, m	7/		555.3					
BASE ECC, m	8/	559.6						
LOWER LIMIT, m		547.8						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			98.1	98.1				
ASSUMED MAR1-JUL31 INFLOW, hm3	2/		1674.9	1778.2				
MAR MINIMUM FLOW REQUIREMENT, m3/s	3/		2.8	2.8				
MIN MAR1-JUL31 OUTFLOW, hm3	4/		344.2	344.2				
VRC FEB28 RESERVOIR CONTENT, hm3	5/		396.1	292.8				
VRC FEB28 RESERVOIR CONTENT, METERS	6/		555.8	553.8				
FEB28 ORC, m	7/		552.5	552.5				
BASE ECC, m	8/	552.5						
LOWER LIMIT, m		547.4						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			95.7	95.7	97.6			
ASSUMED APR1-JUL31 INFLOW, hm3	2/		1634.6	1734.7	1721.8			
APR MINIMUM FLOW REQUIREMENT, m3/s	3/		2.8	2.8	2.8			
MIN APR1-JUL31 OUTFLOW, hm3	4/		336.7	336.7	336.7			
VRC MAR31 RESERVOIR CONTENT, hm3	5/		428.9	328.8	341.7			
VRC MAR31 RESERVOIR CONTENT, METERS	6/		556.4	554.5	554.7			
MAR31 ORC, m	7/		552.2	551.0	551.0			
BASE ECC, m	8/	552.9						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			89.7	89.7	91.6	93.8		
ASSUMED MAY1-JUL31 INFLOW, hm3	2/		1531.1	1625.8	1614.2	1564.3		
MAY MINIMUM FLOW REQUIREMENT, m3/s	3/		2.8	2.8	2.8	2.8		
MIN MAY1-JUL31 OUTFLOW, hm3	4/		329.3	329.3	329.3	329.3		
VRC APR30 RESERVOIR CONTENT, hm3	5/		525.0	430.3	441.9	491.9		
VRC APR30 RESERVOIR CONTENT, METERS	6/		558.1	556.4	556.6	557.5		
APR30 ORC, m	7/		552.2	551.0	551.0	553.8		
BASE ECC, m	8/	553.8						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			67.5	67.5	69.0	70.6	75.3	
ASSUMED JUN1-JUL31 INFLOW, hm3	2/		1148.8	1221.2	1212.0	1173.6	1170.9	
JUN MINIMUM FLOW REQUIREMENT, m3/s	3/		2.8	2.8	2.8	2.8	2.8	
MIN JUN1-JUL31 OUTFLOW, hm3	4/		321.7	321.7	321.7	321.7	321.7	
VRC MAY31 RESERVOIR CONTENT, hm3	5/		899.8	827.4	836.6	874.9	877.7	
VRC MAY31 RESERVOIR CONTENT, METERS	6/		564.4	563.2	563.4	564.0	564.1	
MAY31 ORC, m	7/		560.8	560.8	560.8	560.8	560.8	
BASE ECC, m	8/	560.8						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			32.5	32.5	33.3	34.0	36.3	48.2
ASSUMED JUL1-JUL31 INFLOW, hm3	2/		552.5	587.9	583.9	564.3	564.4	494.1
JUL MINIMUM FLOW REQUIREMENT, m3/s	3/		51.0	51.0	51.0	51.0	51.0	51.0
MIN JUL1-JUL31 OUTFLOW, hm3	4/		189.6	189.6	189.6	189.6	189.6	189.6
VRC JUN30 RESERVOIR CONTENT, hm3	5/		1364.0	1328.5	1332.5	1352.2	1352.0	1422.3
VRC JUN30 RESERVOIR CONTENT, METERS	6/		571.5	571.0	571.0	571.3	571.3	572.4
JUN30 ORC, m	7/		569.8	569.8	569.8	569.8	569.8	569.8
BASE ECC, m	8/	569.8						
JUL 31 ECC, m			576.7	576.7	576.7	576.7	576.7	576.7

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (1726.81 hm3) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE.
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER THAN THE ARC OR CRC1 IN DOP

Table 4: 2019 Duncan Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE DATE-31JULY INFLOW, KAF			1773.7	1775.8	1721.9	1585.2	1461.4	1001.1
& IN KSFD	**		894.3	895.3	868.1	799.2	736.8	504.7
95% FORECAST ERROR FOR DATE, IN KSFD			177.4	153.7	147.0	116.9	99.6	84.8
95% CONF.DATE-31JULY INFLOW, KSFD	1/		716.8	741.6	721.1	682.3	637.2	419.9
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			100.0					
ASSUMED FEB1-JUL31 INFLOW, KSFD	2/		698.2					
FEB MINIMUM FLOW REQUIREMENT, CFS	3/		100.0					
MIN FEB1-JUL31 OUTFLOW, KSFD	4/		143.5					
VRC JAN31 RESERVOIR CONTENT, KSFD	5/		151.1					
VRC JAN31 RESERVOIR CONTENT, FEET	6/		1819.3					
JAN31 ORC, FT	7/		1821.8					
BASE ECC, FT	8/	1836.1						
LOWER LIMIT, FT		1797.1						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			98.1	98.1				
ASSUMED MAR1-JUL31 INFLOW, KSFD	2/		684.6	726.8				
MAR MINIMUM FLOW REQUIREMENT, CFS	3/		100.0	100.0				
MIN MAR1-JUL31 OUTFLOW, KSFD	4/		140.7	140.7				
VRC FEB28 RESERVOIR CONTENT, KSFD	5/		161.9	119.7				
VRC FEB28 RESERVOIR CONTENT, FEET	6/		1823.4	1816.9				
FEB28 ORC, FT	7/		1812.5	1812.5				
BASE ECC, FT	8/	1812.5						
LOWER LIMIT, FT		1795.8						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			95.7	95.7	97.6			
ASSUMED APR1-JUL31 INFLOW, KSFD	2/		668.1	709.0	703.8			
APR MINIMUM FLOW REQUIREMENT, CFS	3/		100.0	100.0	100.0			
MIN APR1-JUL31 OUTFLOW, KSFD	4/		137.6	137.6	137.6			
VRC MAR31 RESERVOIR CONTENT, KSFD	5/		175.3	134.4	139.6			
VRC MAR31 RESERVOIR CONTENT, FEET	6/		1825.4	1819.2	1820.0			
MAR31 ORC, FT	7/		1811.7	1807.8	1807.8			
BASE ECC, FT	8/	1814.0						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			89.7	89.7	91.6	93.8		
ASSUMED MAY1-JUL31 INFLOW, KSFD	2/		625.8	664.5	659.8	639.4		
MAY MINIMUM FLOW REQUIREMENT, CFS	3/		100.0	100.0	100.0	100.0		
MIN MAY1-JUL31 OUTFLOW, KSFD	4/		134.6	134.6	134.6	134.6		
VRC APR30 RESERVOIR CONTENT, KSFD	5/		214.6	175.9	180.6	201.0		
VRC APR30 RESERVOIR CONTENT, FEET	6/		1831.1	1825.5	1826.2	1829.2		
APR30 ORC, FT	7/		1811.7	1807.8	1807.8	1816.9		
BASE ECC, FT	8/	1817.0						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			67.5	67.5	69.0	70.6	75.3	
ASSUMED JUN1-JUL31 INFLOW, KSFD	2/		469.5	499.1	495.4	479.7	478.6	
JUN MINIMUM FLOW REQUIREMENT, CFS	3/		100.0	100.0	100.0	100.0	100.0	
MIN JUN1-JUL31 OUTFLOW, KSFD	4/		131.5	131.5	131.5	131.5	131.5	
VRC MAY31 RESERVOIR CONTENT, KSFD	5/		367.8	338.2	341.9	357.6	358.7	
VRC MAY31 RESERVOIR CONTENT, FEET	6/		1851.7	1847.9	1848.4	1850.4	1850.6	
MAY31 ORC, FT	7/		1839.9	1839.9	1839.9	1839.9	1839.9	
BASE ECC, FT	8/	1839.9						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			32.5	32.5	33.3	34.0	36.3	48.2
ASSUMED JUL1-JUL31 INFLOW, KSFD	2/		225.8	240.3	238.7	230.6	230.7	202.0
JUL MINIMUM FLOW REQUIREMENT, CFS	3/		1800.0	1800.0	1800.0	1800.0	1800.0	1800.0
MIN JUL1-JUL31 OUTFLOW, KSFD	4/		77.5	77.5	77.5	77.5	77.5	77.5
VRC JUN30 RESERVOIR CONTENT, KSFD	5/		557.5	543.0	544.6	552.7	552.6	581.3
VRC JUN30 RESERVOIR CONTENT, FEET	6/		1875.0	1873.2	1873.4	1874.4	1874.4	1877.8
JUN30 ORC, FT	7/		1869.4	1869.4	1869.4	1869.4	1869.4	1869.4
BASE ECC, FT	8/	1869.5						
JUL 31 ECC, FT			1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

** FORECAST START DATE IS 1FEB OR LATER. OBSERVED INFLOW FROM 1JAN-DATE IS SUBTRACTED.
1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW).
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (705.8 KSFD) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE.
7/ LOWER OF ELEV. FROM 6/ OR BASE ECC (INTIAL), NOT LESS THAN LOWER LIMIT, BUT NOT MORE THAN FLOOD CONTROL.
8/ HIGHER OF ARC OR CRC1 IN DOP

Table 5M (metric): 2019 Libby Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE JAN-31JULY INFLOW, km3			7.1	6.6	6.7	5.9	6.2	6.2
PROBABLE JAN-31JULY INFLOW, hm3			7137.5	6633.5	6689.2	5903.2	6162.7	5818.0
95% FORECAST ERROR FOR DATE, hm3			2246.2	1813.2	1721.4	1251.2	1216.9	1187.1
OBSERVED JAN1-DATE INFLOW, IN hm3			0.0	200.4	349.1	565.9	1095.8	2570.2
95% CONF.DATE-31JULY INFLOW, hm3	1/		4891.2	4619.9	4618.7	4086.3	3850.2	2060.8
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			96.9					
ASSUMED FEB1-JUL31 INFLOW, hm3	2/		4739.6					
FEB MINIMUM FLOW REQUIREMENT, m3/s	3/		113.3					
MIN FEB1-JUL31 OUTFLOW, hm3	4/		3046.0					
VRC JAN31 RESERVOIR CONTENT, hm3	5/		4448.7					
VRC JAN31 RESERVOIR CONTENT, METERS	6/		739.8					
JAN31 ORC, m	7/		738.3					
BASE ECC, m	9/	736.4						
LOWER LIMIT, m		720.5						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			94.1	97.1				
ASSUMED MAR1-JUL31 INFLOW, hm3	2/		4602.5	4485.8				
MAR MINIMUM FLOW REQUIREMENT, m3/s	3/		113.3	113.3				
MIN MAR1-JUL31 OUTFLOW, hm3	4/		2772.0	2772.0				
VRC FEB28 RESERVOIR CONTENT, hm3	5/		4311.6	4428.3				
VRC FEB28 RESERVOIR CONTENT, METERS	6/		739.0	739.7				
FEB28 ORC, m	7/		737.5	737.5				
BASE ECC, m	9/	735.5						
LOWER LIMIT, m		709.3						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			90.6	93.5	96.3			
ASSUMED APR1-JUL31 INFLOW, hm3	2/		4431.3	4319.5	4447.9			
APR MINIMUM FLOW REQUIREMENT, m3/s	3/		113.3	113.3	113.3			
MIN APR1-JUL31 OUTFLOW, hm3	4/		2468.6	2468.6	2468.6			
VRC MAR31 RESERVOIR CONTENT, hm3	5/		4179.3	4291.3	4162.9			
VRC MAR31 RESERVOIR CONTENT, METERS	6/		738.2	738.9	738.1			
MAR31 ORC, m	7/		736.6	736.6	736.6			
BASE ECC, m	9/	734.7						
LOWER LIMIT, m		700.1						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			82.4	85.0	87.5	90.9		
ASSUMED MAY1-JUL31 INFLOW, hm3	2/		4030.3	3926.8	4041.3	3714.4		
MAY MINIMUM FLOW REQUIREMENT, m3/s	3/		113.3	113.3	113.3	113.3		
MIN MAY1-JUL31 OUTFLOW, hm3	4/		2175.0	2175.0	2175.0	2175.0		
VRC APR30 RESERVOIR CONTENT, hm3	5/		4286.9	4390.4	4275.9	4602.8		
VRC APR30 RESERVOIR CONTENT, METERS	6/		738.8	739.5	738.8	740.8		
APR30 ORC, m	7/		736.4	736.4	736.4	736.4		
BASE ECC, m	9/	734.4						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			55.3	57.0	58.7	61.0	67.1	
ASSUMED JUN1-JUL31 INFLOW, hm3	2/		2704.7	2633.3	2711.1	2492.6	2583.4	
JUN MINIMUM FLOW REQUIREMENT, m3/s	3/		283.2	283.2	283.2	283.2	283.2	
MIN JUN1-JUL31 OUTFLOW, hm3	4/		1871.6	1871.6	1871.6	1871.6	1871.6	
VRC MAY31 RESERVOIR CONTENT, hm3	5/		5309.1	5380.6	5302.8	5521.2	5430.5	
VRC MAY31 RESERVOIR CONTENT, METERS	6/		744.9	745.3	744.9	746.1	745.6	
MAY31 ORC, m	7/		742.4	742.4	742.4	742.4	742.4	
BASE ECC, m	9/	741.5						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			19.8	20.3	20.9	21.8	23.9	35.6
ASSUMED JUL1-JUL31 INFLOW, hm3	2/		968.4	937.8	965.4	890.8	920.2	733.7
JUL MINIMUM FLOW REQUIREMENT, m3/s	3/		424.8	424.8	424.8	424.8	424.8	424.8
MIN JUL1-JUL31 OUTFLOW, hm3	4/		1137.7	1137.7	1137.7	1137.7	1137.7	1137.7
VRC JUN30 RESERVOIR CONTENT, hm3	5/		6142.2	6142.2	6142.2	6142.2	6142.2	6142.2
VRC JUN30 RESERVOIR CONTENT, METERS	6/		749.5	749.5	749.5	749.5	749.5	749.5
JUN30 ORC, m	7/		749.5	749.5	749.5	749.5	749.5	749.5
BASE ECC, m	9/	749.5						
JUL 31 ORC, m			749.5	749.5	749.5	749.5	749.5	749.5
JAN1-JUL31 FORECAST,-EARLYBIRD, km3	8/		115.3	104.8	104.2	103.7	112.7	113.6

1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW) MINUS OBSERVED INFLOW.
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (2510.5 KSFD) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE.A143
7/ LOWER OF ELEV. FROM 6/ OR BASE VRC DETERMINED PRIOR TO YEAR (INTIAL),BUT NOT LESS THAN LOWER LIMIT
8/ MEASURED AT THE DALLES USED TO CALCULATE THE POWER DISCHARGE REQUIREMENTS FOR 3/.
9/ HIGHER OF ARC OR CRC1 IN DOP

Table 5: 2019 Libby Variable Refill Curve

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE JAN-31JULY INFLOW, KAF			5786.4	5377.7	5423.0	4785.8	4996.1	4716.6
PROBABLE JAN-31JULY INFLOW, KSFD			2917.3	2711.3	2734.1	2412.8	2518.9	2378.0
95% FORECAST ERROR FOR DATE, KSFD			918.1	741.1	703.6	511.4	497.4	485.2
OBSERVED JAN1-DATE INFLOW, IN KSFD			0.0	81.9	142.7	231.3	447.9	1050.5
95% CONF.DATE-31JULY INFLOW, KSFD	1/		1999.2	1888.3	1887.8	1670.2	1573.7	842.3
ASSUMED FEB1-JUL31 INFLOW, % OF VOL.			96.9					
ASSUMED FEB1-JUL31 INFLOW, KSFD	2/		1937.2					
FEB MINIMUM FLOW REQUIREMENT, CFS	3/		4000.0					
MIN FEB1-JUL31 OUTFLOW, KSFD	4/		1245.0					
VRC JAN31 RESERVOIR CONTENT, KSFD	5/		1818.3					
VRC JAN31 RESERVOIR CONTENT, FEET	6/		2427.3					
JAN31 ORC, FT	7/		2422.3					
BASE ECC, FT	9/	2415.9						
LOWER LIMIT, FT		2363.7						
ASSUMED MAR1-JUL31 INFLOW, % OF VOL.			94.1	97.1				
ASSUMED MAR1-JUL31 INFLOW, KSFD	2/		1881.2	1833.5				
MAR MINIMUM FLOW REQUIREMENT, CFS	3/		4000.0	4000.0				
MIN MAR1-JUL31 OUTFLOW, KSFD	4/		1133.0	1133.0				
VRC FEB28 RESERVOIR CONTENT, KSFD	5/		1762.3	1810.0				
VRC FEB28 RESERVOIR CONTENT, FEET	6/		2424.5	2426.9				
FEB28 ORC, FT	7/		2419.6	2419.6				
BASE ECC, FT	9/	2413.1						
LOWER LIMIT, FT		2327.1						
ASSUMED APR1-JUL31 INFLOW, % OF VOL.			90.6	93.5	96.3			
ASSUMED APR1-JUL31 INFLOW, KSFD	2/		1811.2	1765.5	1818.0			
APR MINIMUM FLOW REQUIREMENT, CFS	3/		4000.0	4000.0	4000.0			
MIN APR1-JUL31 OUTFLOW, KSFD	4/		1009.0	1009.0	1009.0			
VRC MAR31 RESERVOIR CONTENT, KSFD	5/		1708.2	1754.0	1701.5			
VRC MAR31 RESERVOIR CONTENT, FEET	6/		2421.8	2424.1	2421.5			
MAR31 ORC, FT	7/		2416.8	2416.8	2416.8			
BASE ECC, FT	9/	2410.3						
LOWER LIMIT, FT		2297.0						
ASSUMED MAY1-JUL31 INFLOW, % OF VOL.			82.4	85.0	87.5	90.9		
ASSUMED MAY1-JUL31 INFLOW, KSFD	2/		1647.3	1605.0	1651.8	1518.2		
MAY MINIMUM FLOW REQUIREMENT, CFS	3/		4000.0	4000.0	4000.0	4000.0		
MIN MAY1-JUL31 OUTFLOW, KSFD	4/		889.0	889.0	889.0	889.0		
VRC APR30 RESERVOIR CONTENT, KSFD	5/		1752.2	1794.5	1747.7	1881.3		
VRC APR30 RESERVOIR CONTENT, FEET	6/		2424.0	2426.1	2423.8	2430.4		
APR30 ORC, FT	7/		2415.9	2415.9	2415.9	2415.9		
BASE ECC, FT	9/	2409.3						
		2287.0						
ASSUMED JUN1-JUL31 INFLOW, % OF VOL.			55.3	57.0	58.7	61.0	67.1	
ASSUMED JUN1-JUL31 INFLOW, KSFD	2/		1105.5	1076.3	1108.1	1018.8	1055.9	
JUN MINIMUM FLOW REQUIREMENT, CFS	3/		10000.0	10000.0	10000.0	10000.0	10000.0	
MIN JUN1-JUL31 OUTFLOW, KSFD	4/		765.0	765.0	765.0	765.0	765.0	
VRC MAY31 RESERVOIR CONTENT, KSFD	5/		2170.0	2199.2	2167.4	2256.7	2219.6	
VRC MAY31 RESERVOIR CONTENT, FEET	6/		2444.0	2445.3	2443.8	2447.9	2446.2	
MAY31 ORC, FT	7/		2435.6	2435.6	2435.6	2435.6	2435.6	
BASE ECC, FT	9/	2432.7						
		2287.0						
ASSUMED JUL1-JUL31 INFLOW, % OF VOL.			19.8	20.3	20.9	21.8	23.9	35.6
ASSUMED JUL1-JUL31 INFLOW, KSFD	2/		395.8	383.3	394.6	364.1	376.1	299.9
JUL MINIMUM FLOW REQUIREMENT, CFS	3/		15000.0	15000.0	15000.0	15000.0	15000.0	15000.0
MIN JUL1-JUL31 OUTFLOW, KSFD	4/		465.0	465.0	465.0	465.0	465.0	465.0
VRC JUN30 RESERVOIR CONTENT, KSFD	5/		2510.5	2510.5	2510.5	2510.5	2510.5	2510.5
VRC JUN30 RESERVOIR CONTENT, FEET	6/		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
JUN30 ORC, FT	7/		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
BASE ECC, FT	9/	2459.0						
		2287.0						
JUL 31 ORC, FT			2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
JAN1-JUL31 FORECAST,-EARLYBIRD,MAF	8/		93.5	85.0	84.5	84.1	91.4	92.1

1/ PROBABLE INFLOW MINUS (95% ERROR & JAN1-DATE INFLOW) MINUS OBSERVED INFLOW.
2/ PRECEEDING LINE TIMES 1/.
3/ POWER DISCHARGE REQUIREMENTS.
4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,DATE TO JULY.
5/ FULL CONTENT (2510.5 KSFD) PLUS 4/ MINUS /2.
6/ ELEV FROM 5/, INTERP FROM STORAGE CONTENT TABLE.A143
7/ LOWER OF ELEV. FROM 6/ OR BASE VRC DETERMINED PRIOR TO YEAR (INTIAL),BUT NOT LESS THAN LOWER LIMIT
8/ MEASURED AT THE DALLES USED TO CALCULATE THE POWER DISCHARGE REQUIREMENTS FOR 3/.
9/ HIGHER OF ARC OR CRC1 IN DOP

Table 6: Computation of Initial Controlled Flow

Columbia River at The Dalles, OR

Metric and English Units, based on April 2019 forecast

Upstream Storage Corrections	Metric (km^3)	English (Maf)
Mica	7.537	6.110
Arrow	3.668	2.974
Duncan	1.725	1.399
Libby	2.467	2.000
Hungry Horse	0.925	0.750
Flathead Lake	0.617	0.500
Noxon Rapids	0.000	0.000
Pend Oreille Lake	0.617	0.500
Grand Coulee	1.639	1.329
Brownlee	0.142	0.115
Dworshak	0.617	0.500
John Day	0.195	0.158
Total Upstream Storage Corrections	20.148	16.335

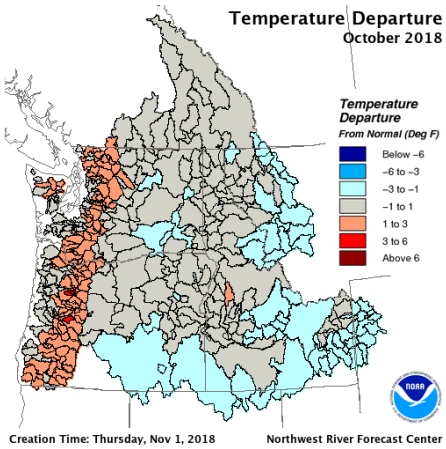
Adjusted TDA May-Aug Runoff Volume	Metric (km^3)	English (Maf)
TDA May-Aug Runoff Volume (1May Forecast)	78.517	63.655
Less Estimated Depletions	-2.502	-2.028
Less Total Upstream Storage Corrections	-20.148	-16.335
Adjusted TDA May-Aug Runoff Volume	55.867	45.292

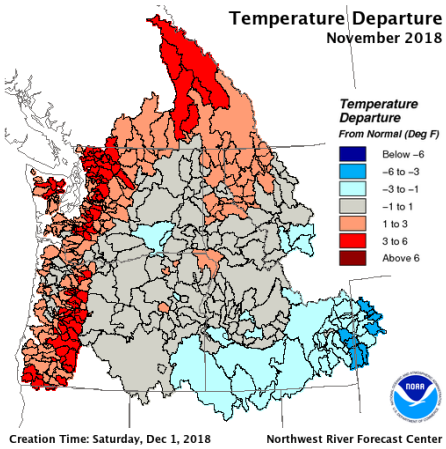
Initial Controlled Flow	m^3/s	kcfs
Determined using 'Adjusted TDA May-Aug Runoff Volume' and Chart 1 of the Flood Control Operating Plan	7849	277.2

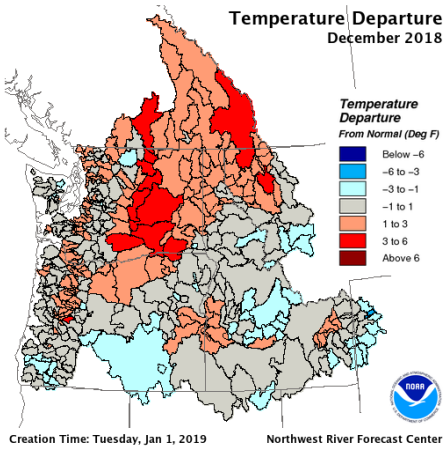
VIII - CHARTS

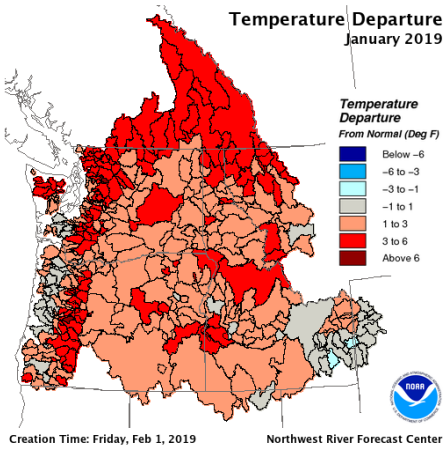
Chart 1: Pacific Northwest Monthly Temperature Departures

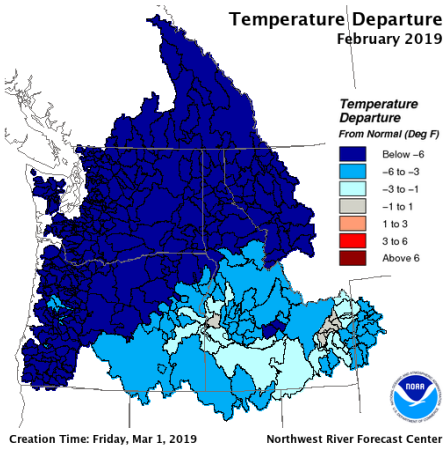
October – March











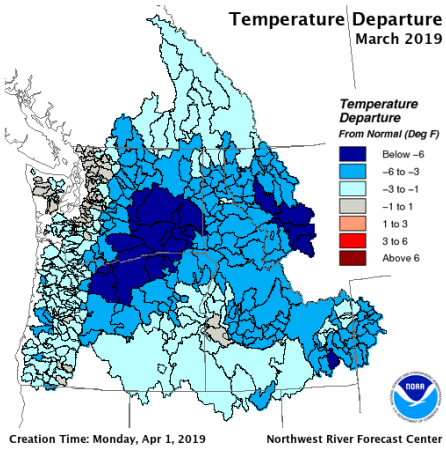
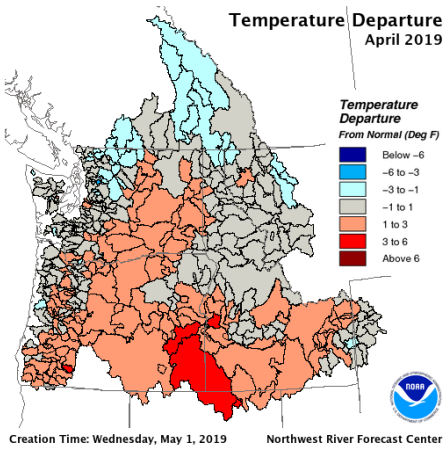
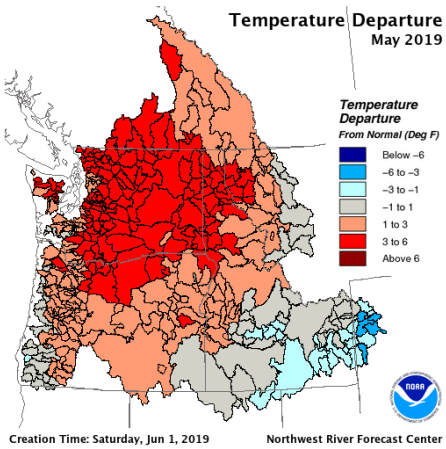
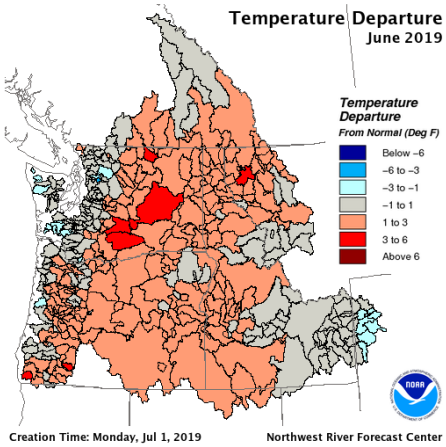


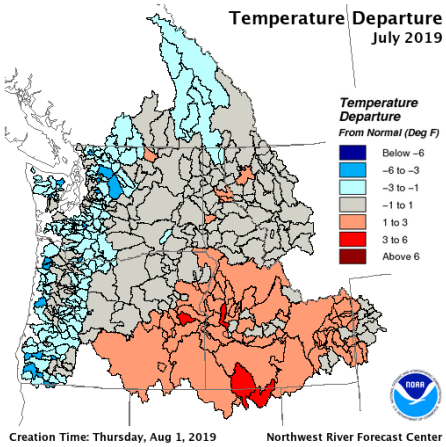
Chart 1: Pacific Northwest Monthly Temperature Departures (Continued)

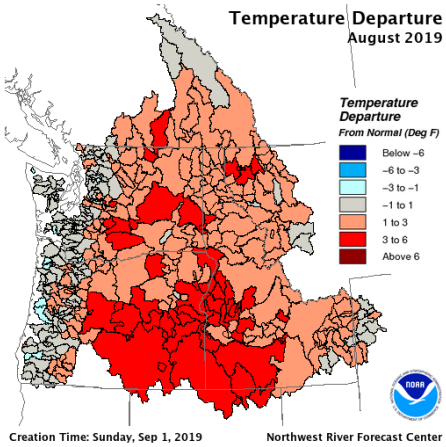
April – September











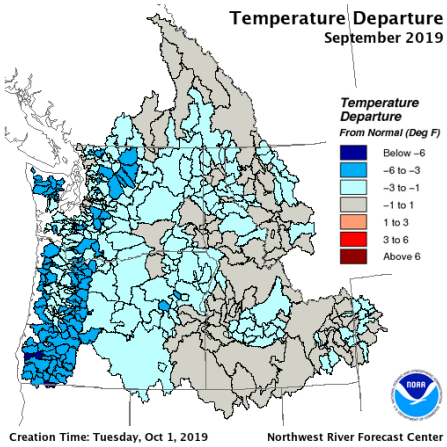
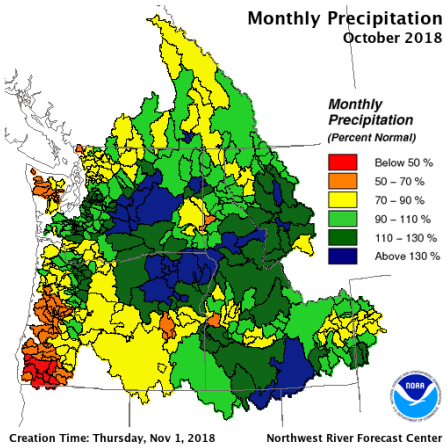
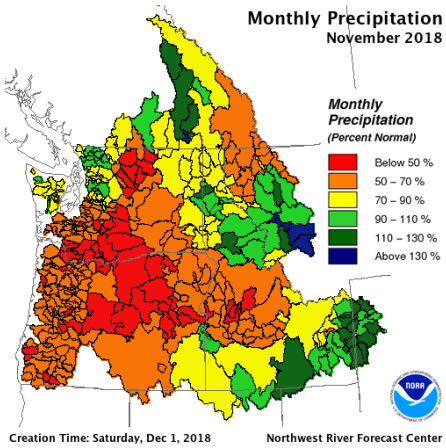
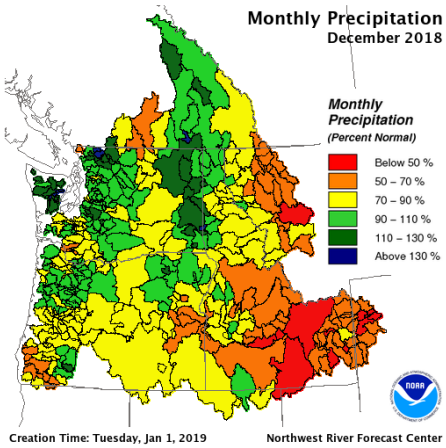


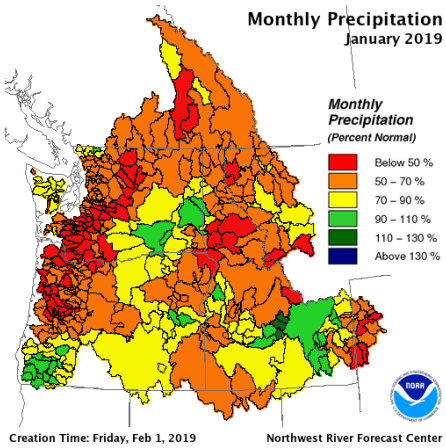
Chart 1 A: Pacific Northwest Monthly Precipitation Departures

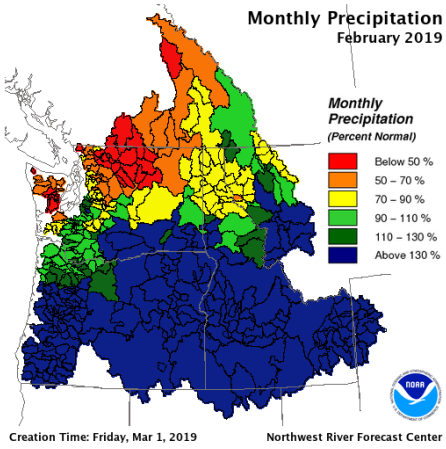
October – March*

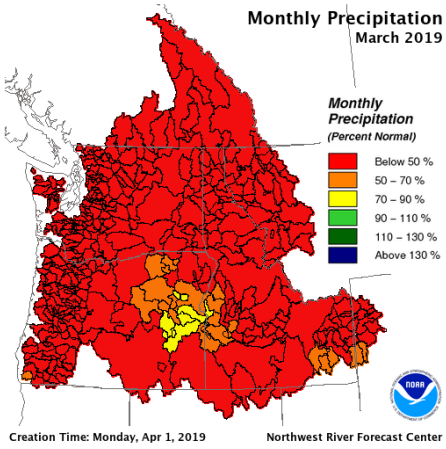








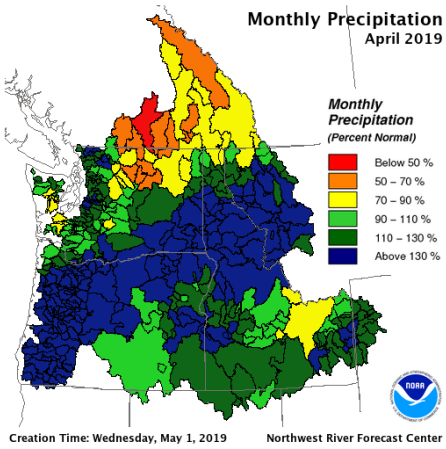


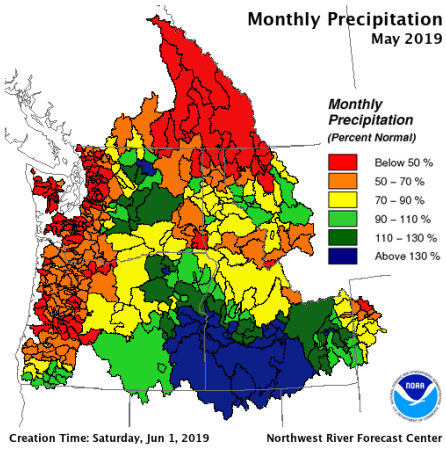


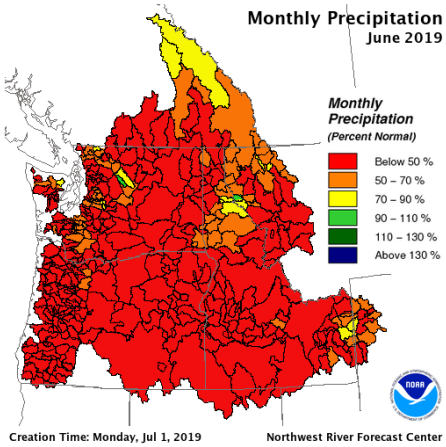
* Note. Precipitation for the months January through April in the Canadian portion of the basin are likely underrepresented as there was an issue with a data feed to the NWRFC

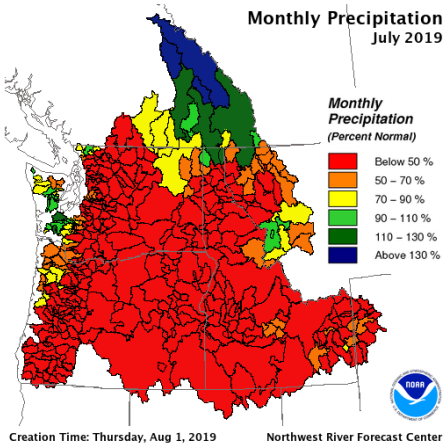
Chart 1 A: Pacific Northwest Monthly Precipitation Departures (Continued)

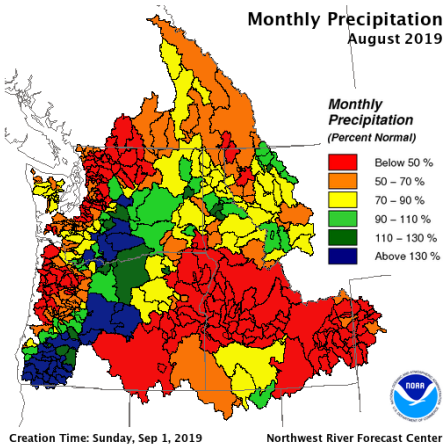
April – September











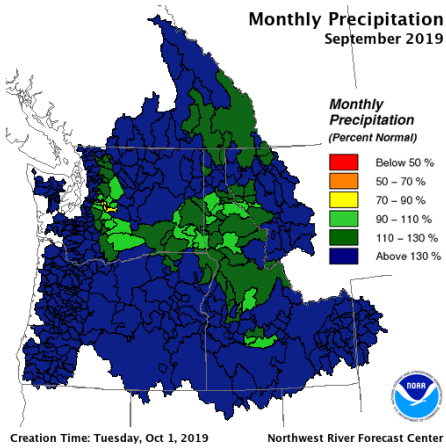


Chart 2: Seasonal Precipitation Columbia River Basin

October 2018 – September 2019

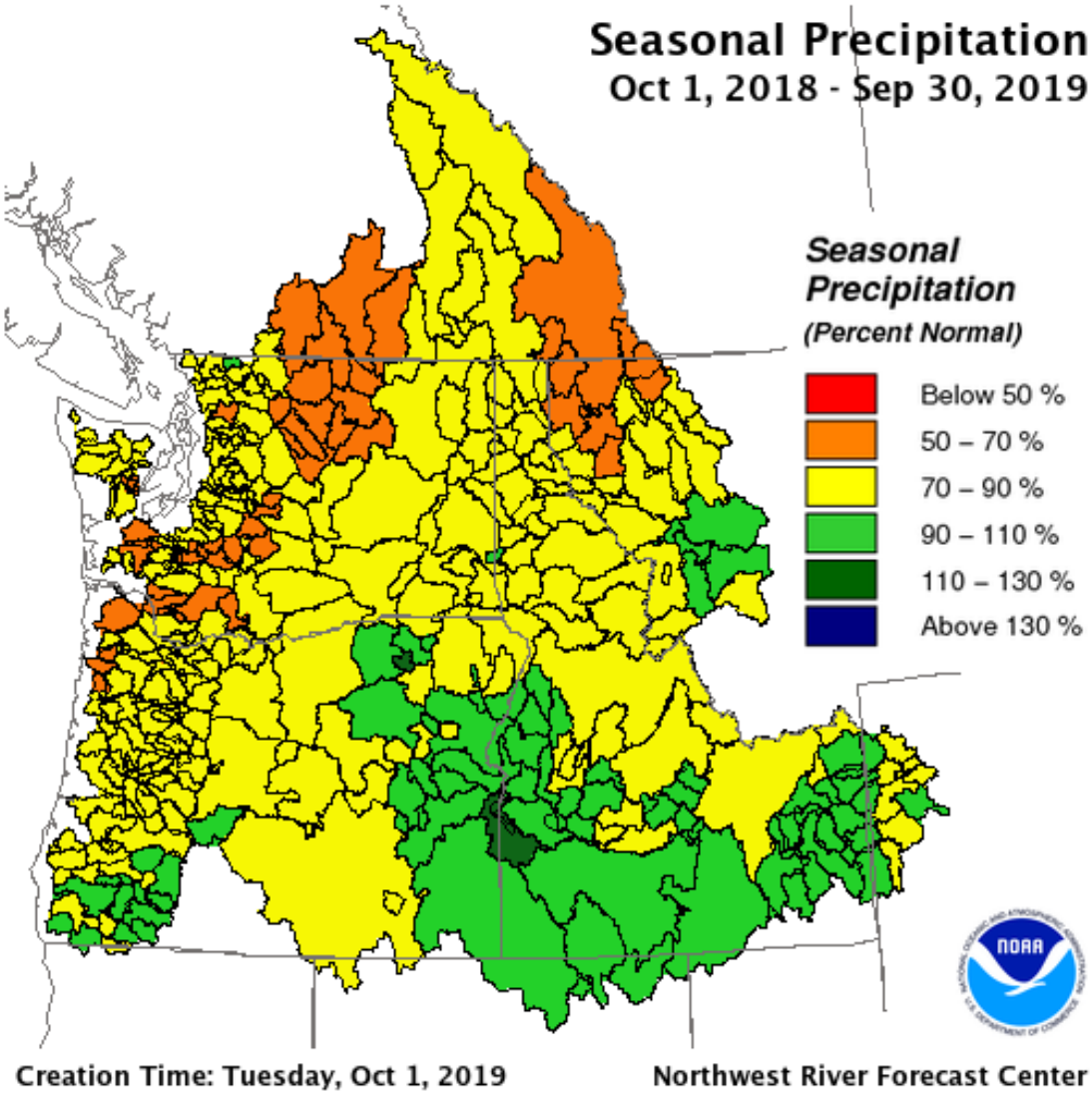
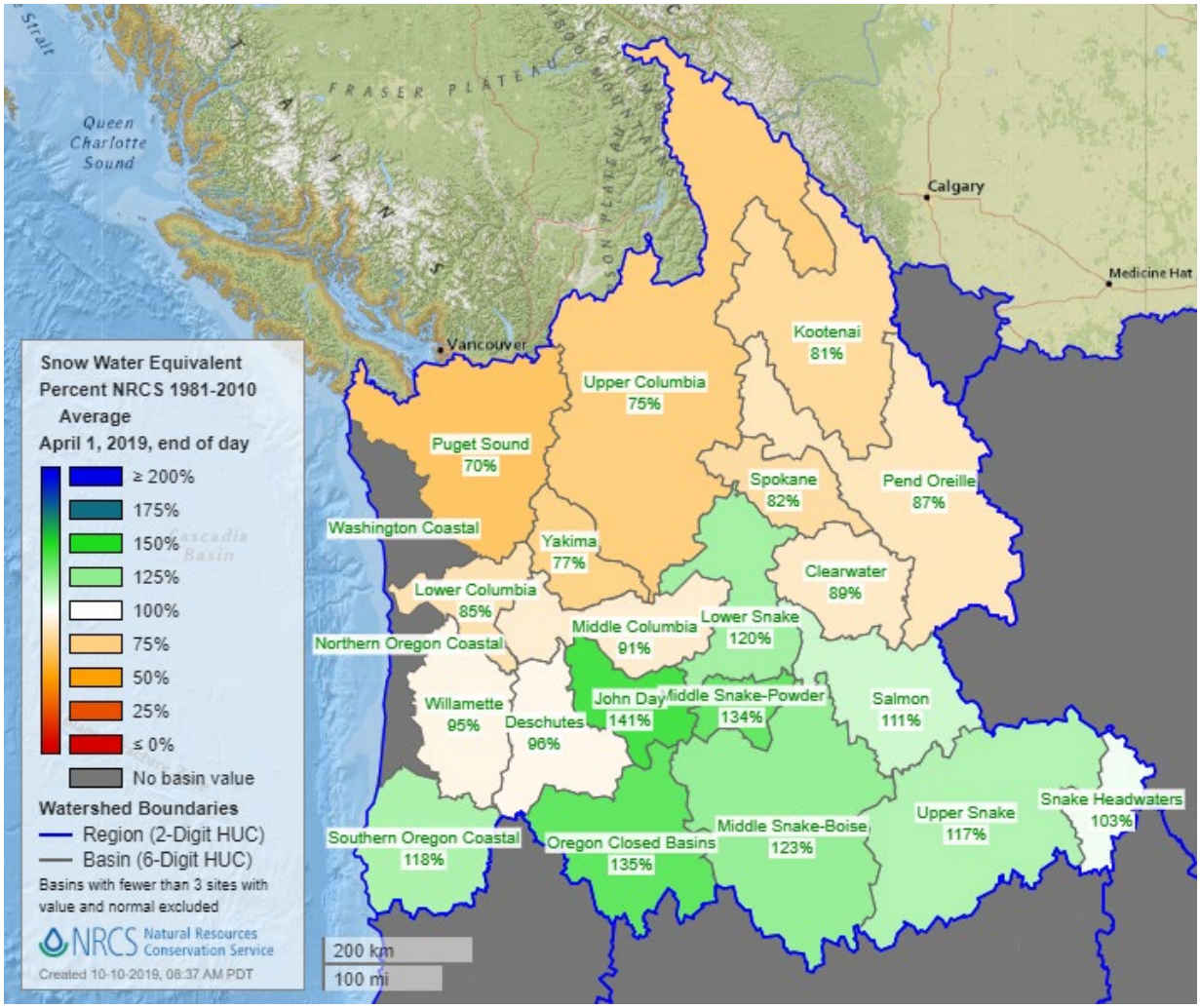


Chart 3: Columbia Basin Snowpack

Columbia River and Pacific Coastal Basins Mountain Snowpack: 01 April 2019



Columbia River and Pacific Coastal Basins Mountain Snowpack: 01 May 2019

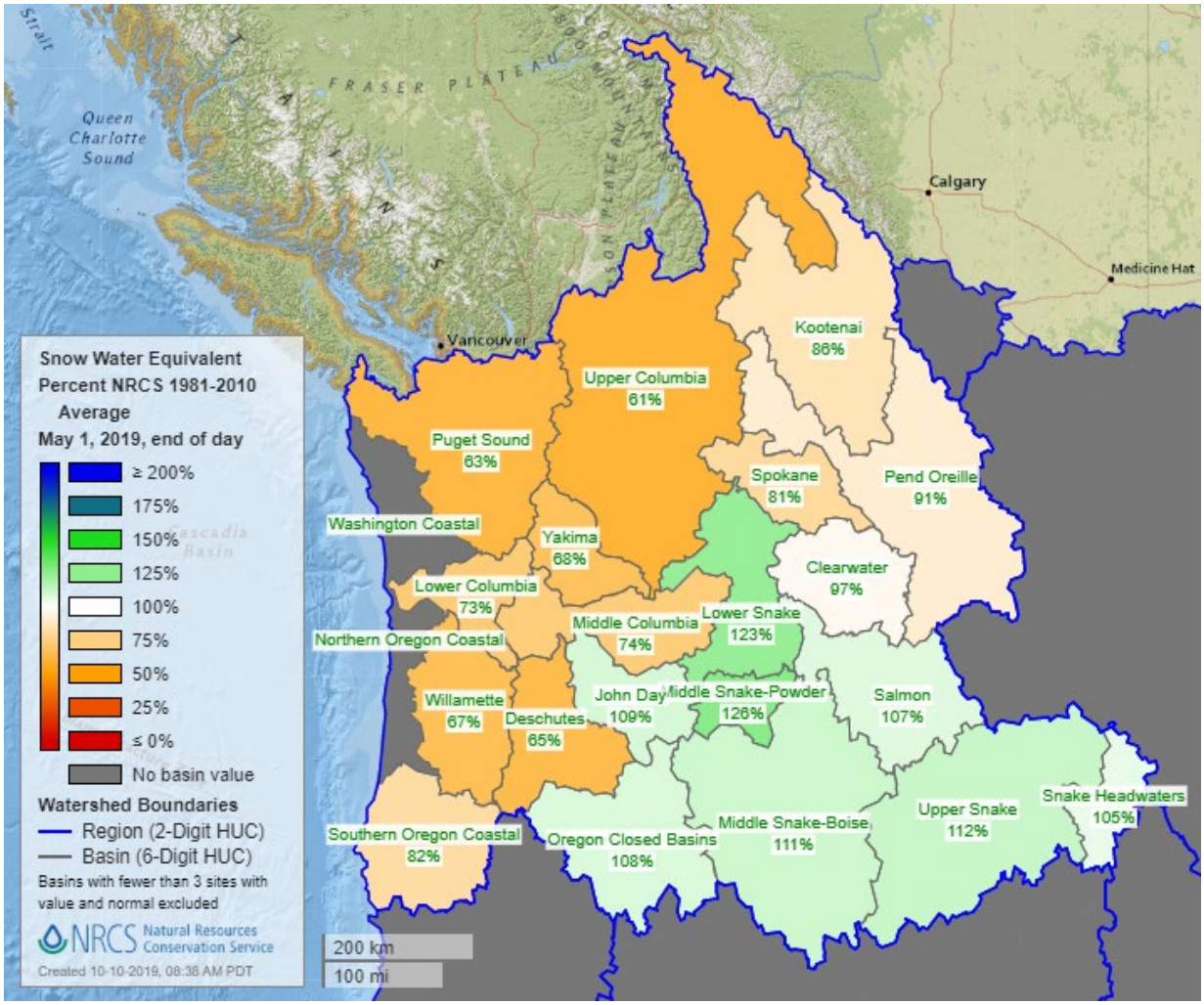


Chart 4: Accumulated Precipitation for WY 2019

At Primary Columbia River Basins

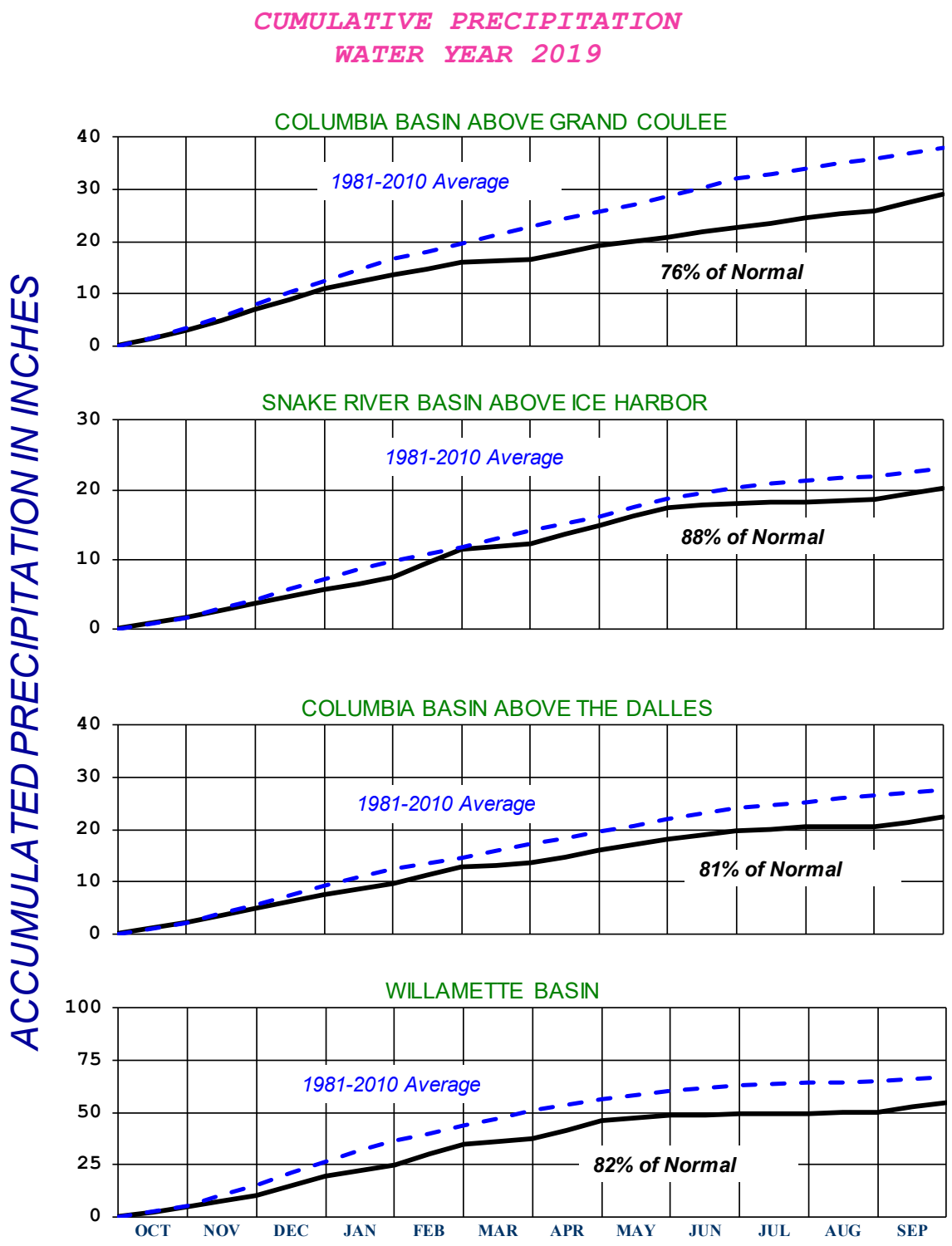


Chart 5: Regulation of Mica

1 August 2018– 30 September 2019

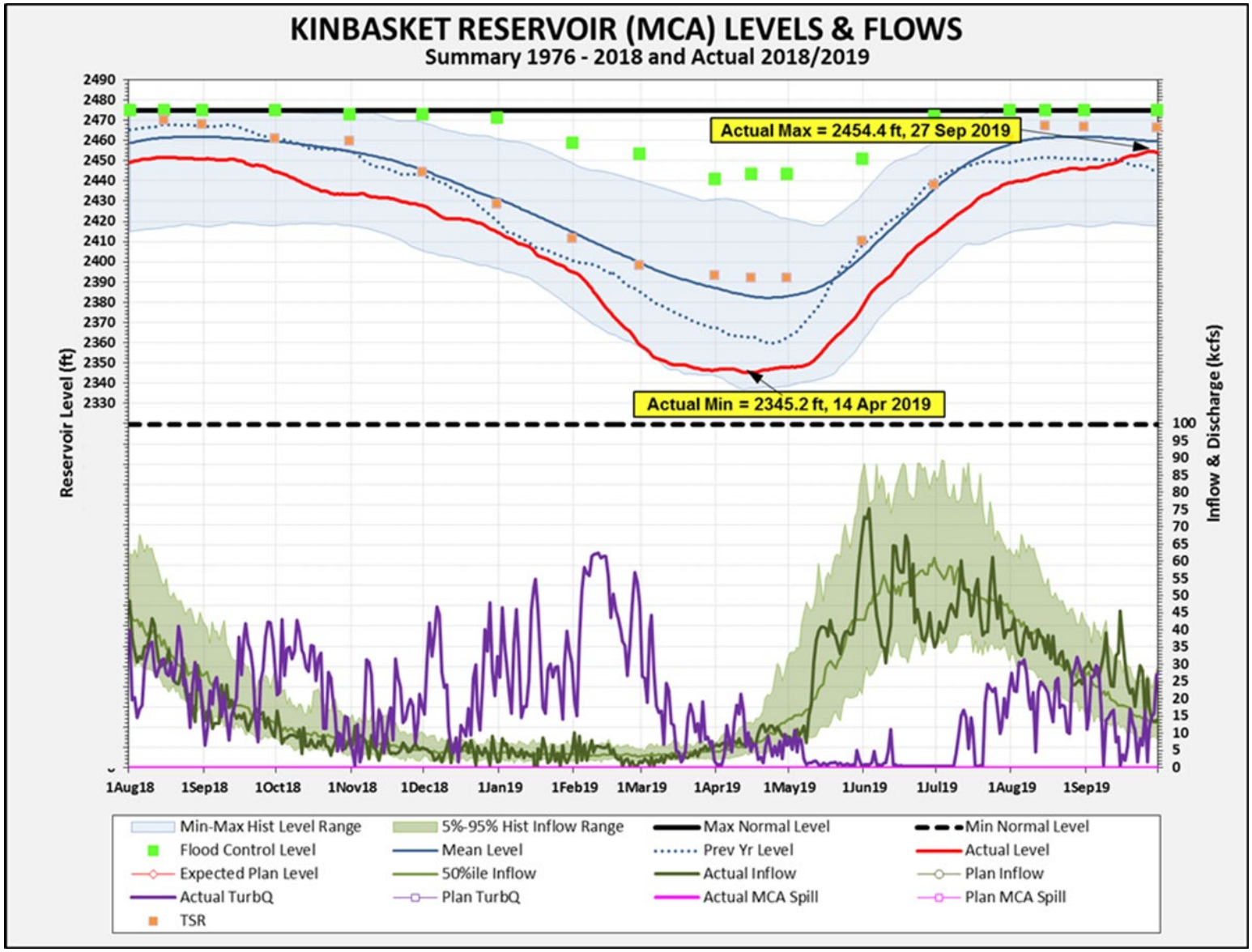


Chart 6: Regulation of Keenleyside

01 August 2018– 30 September 2019

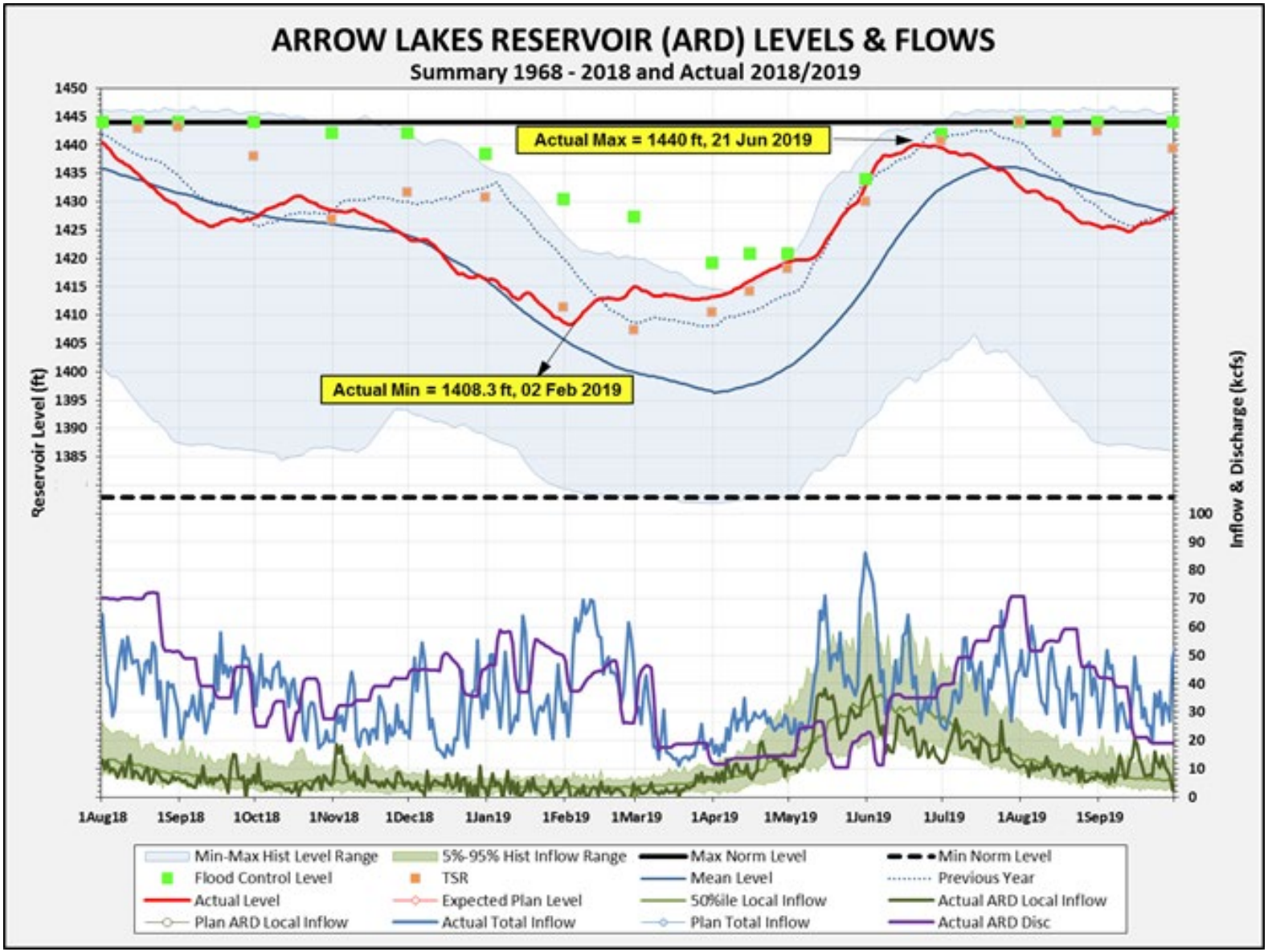


Chart 7: Regulation of Duncan

01 August 2018 – 30 September 2019

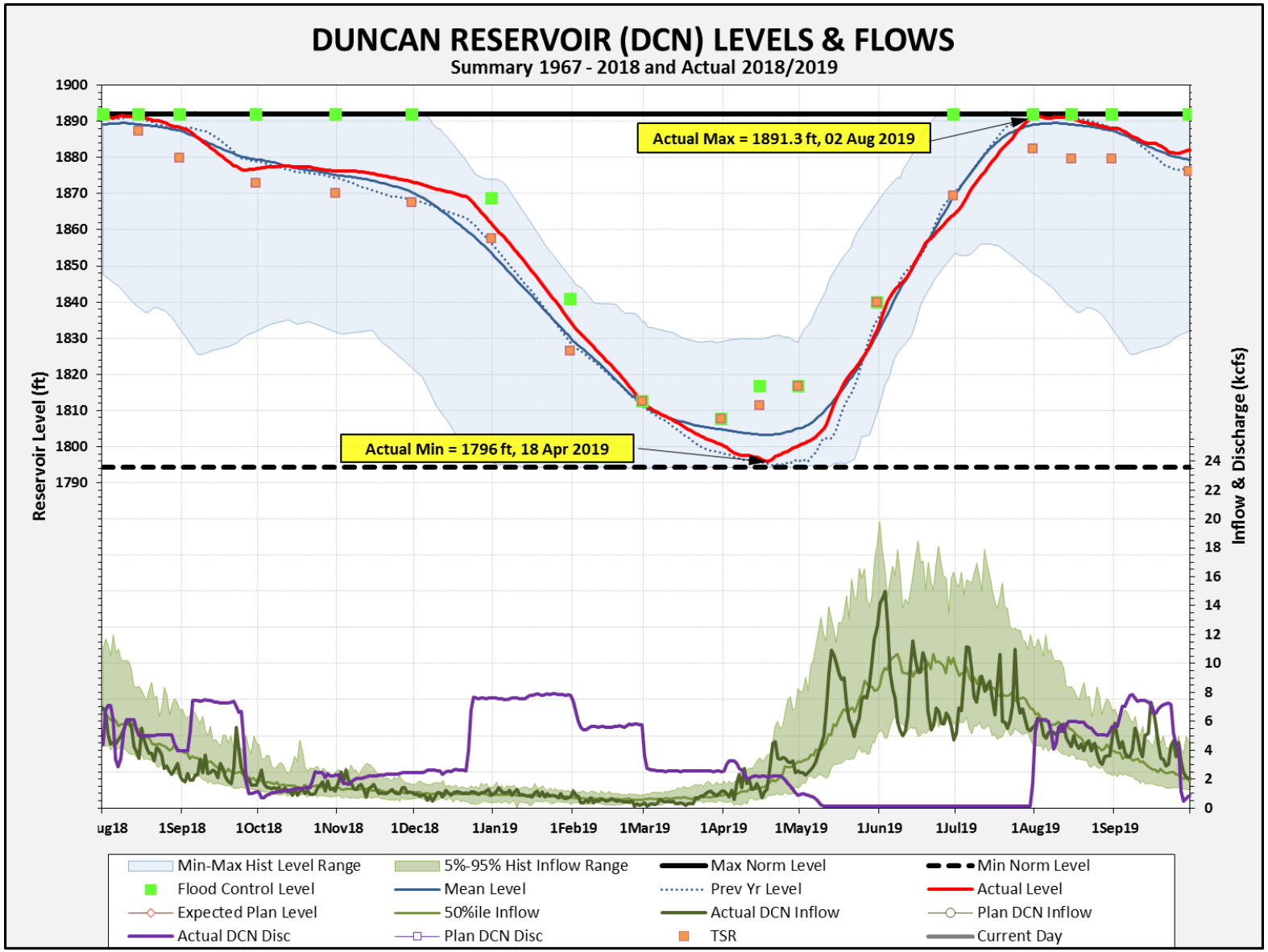


Chart 8: Regulation of Libby

01 August 2018 – 30 September 2019

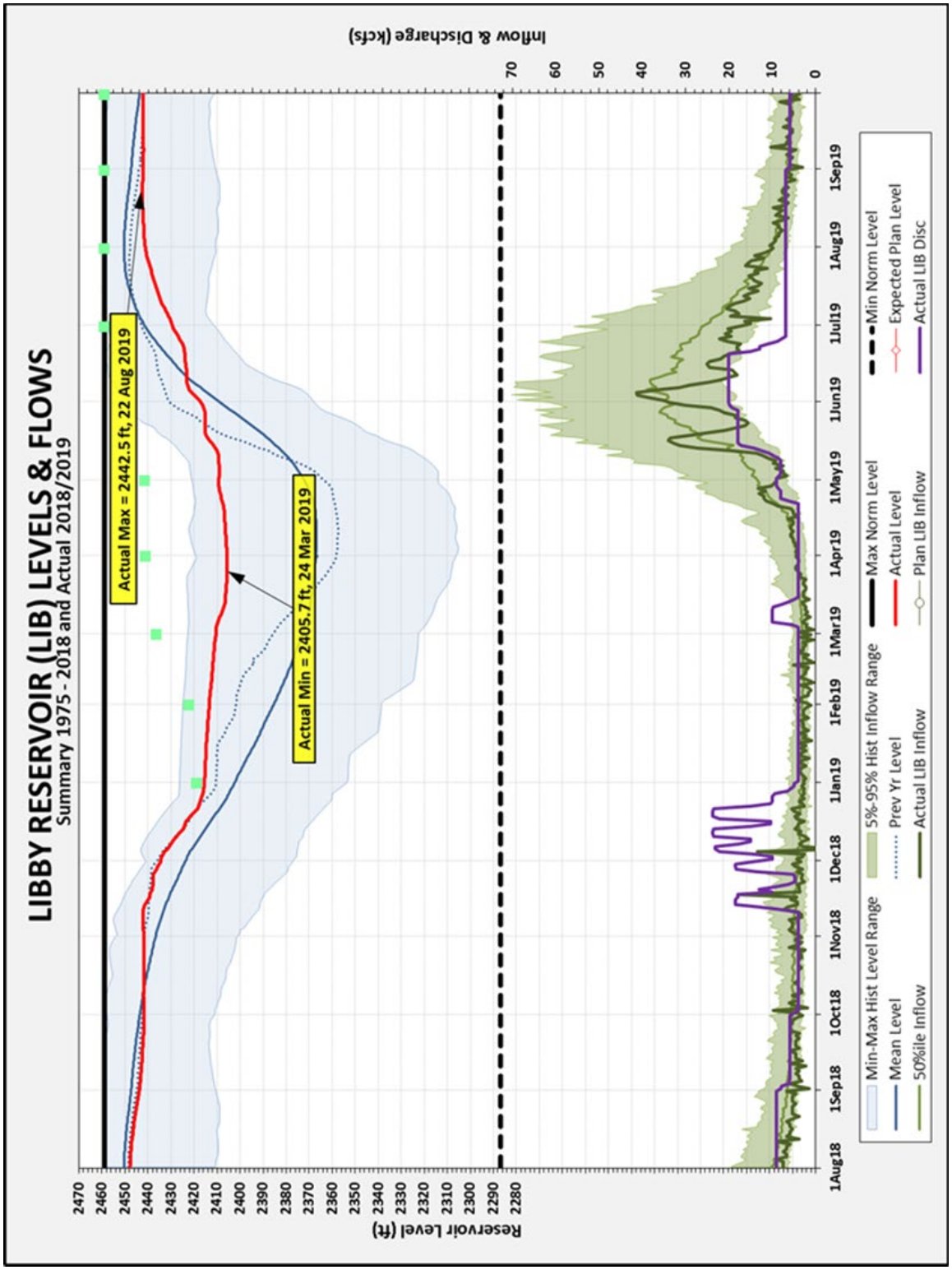


Chart 9: Regulation of Kootenay Lake
01 August 2018 – 30 September 2019

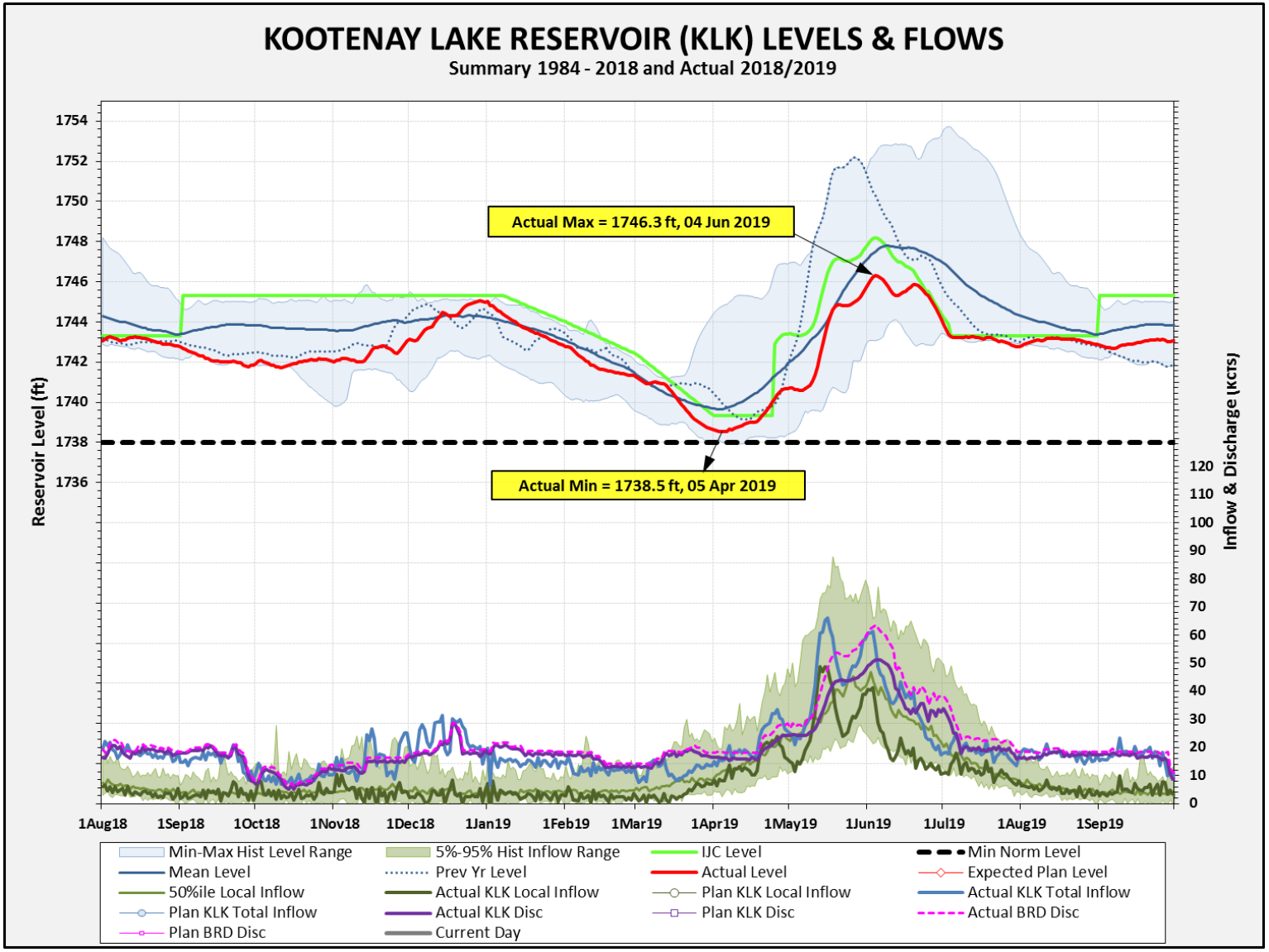


Chart 10: Columbia River at Birchbank

01 August 2018 – 30 September 2019

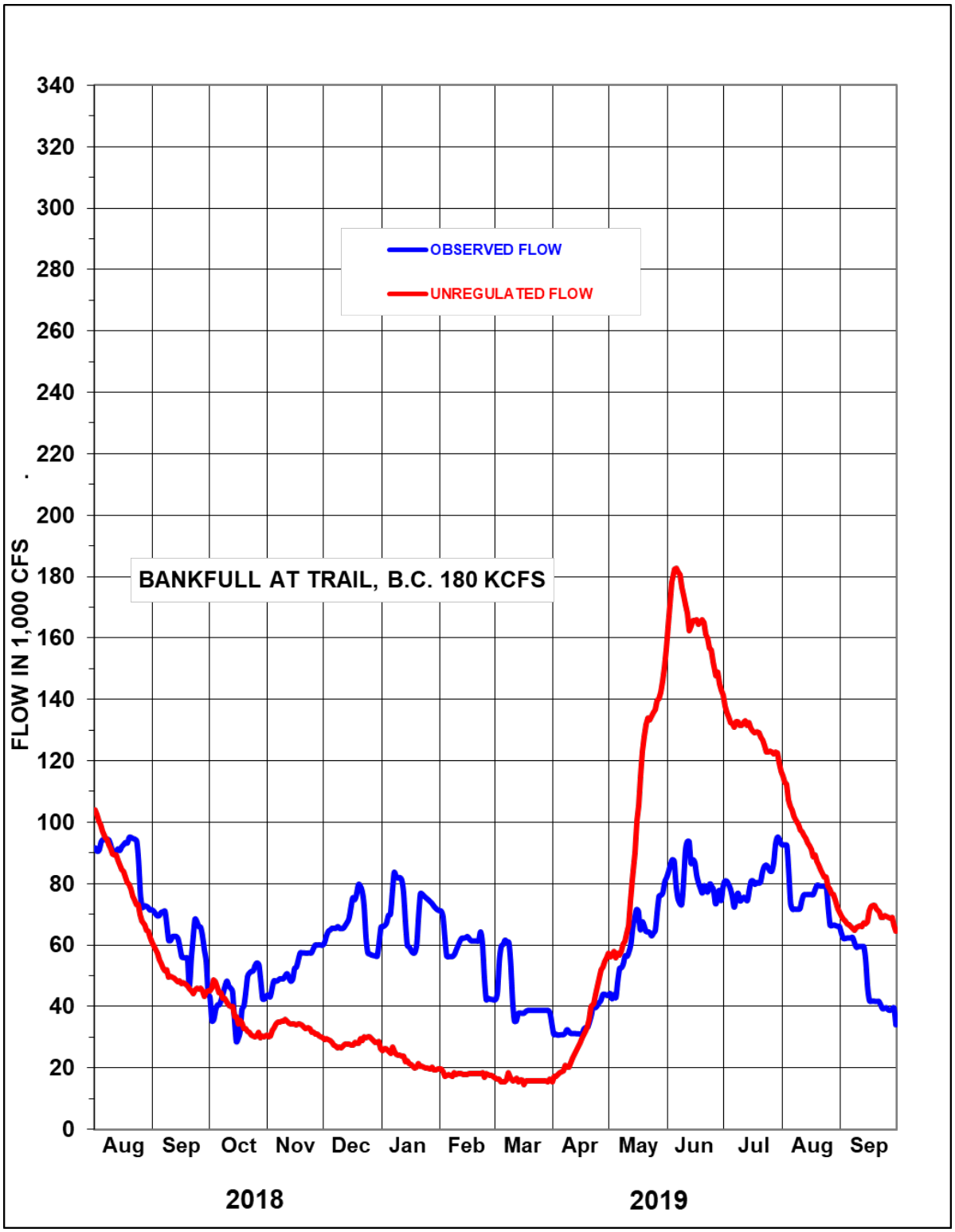


Chart 11: Regulation of Grand Coulee

01 August 2018 – 30 September 2019

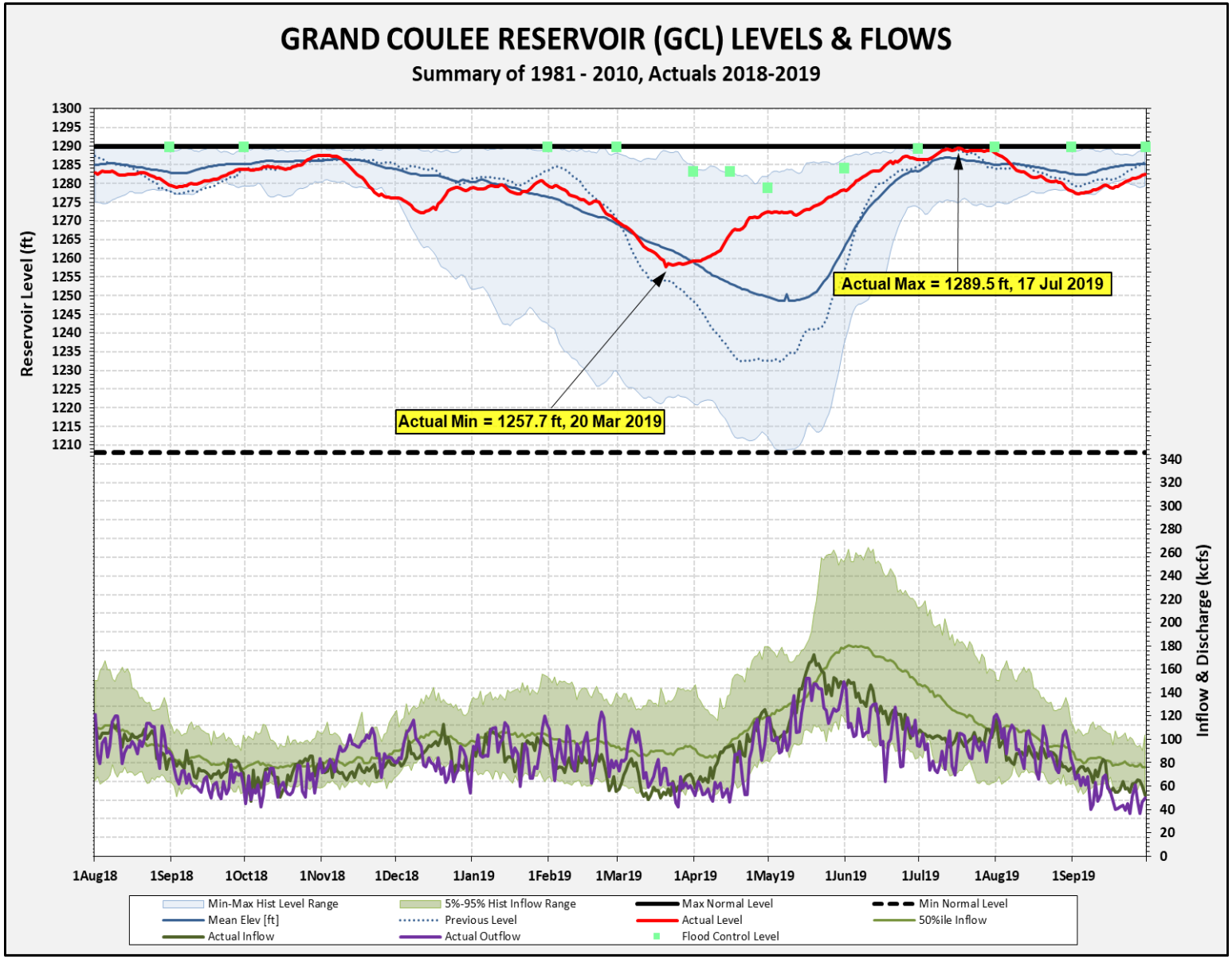


Chart 12: Columbia River at The Dalles (Summary Hydrograph)
01 October 2018 – 30 September 2019

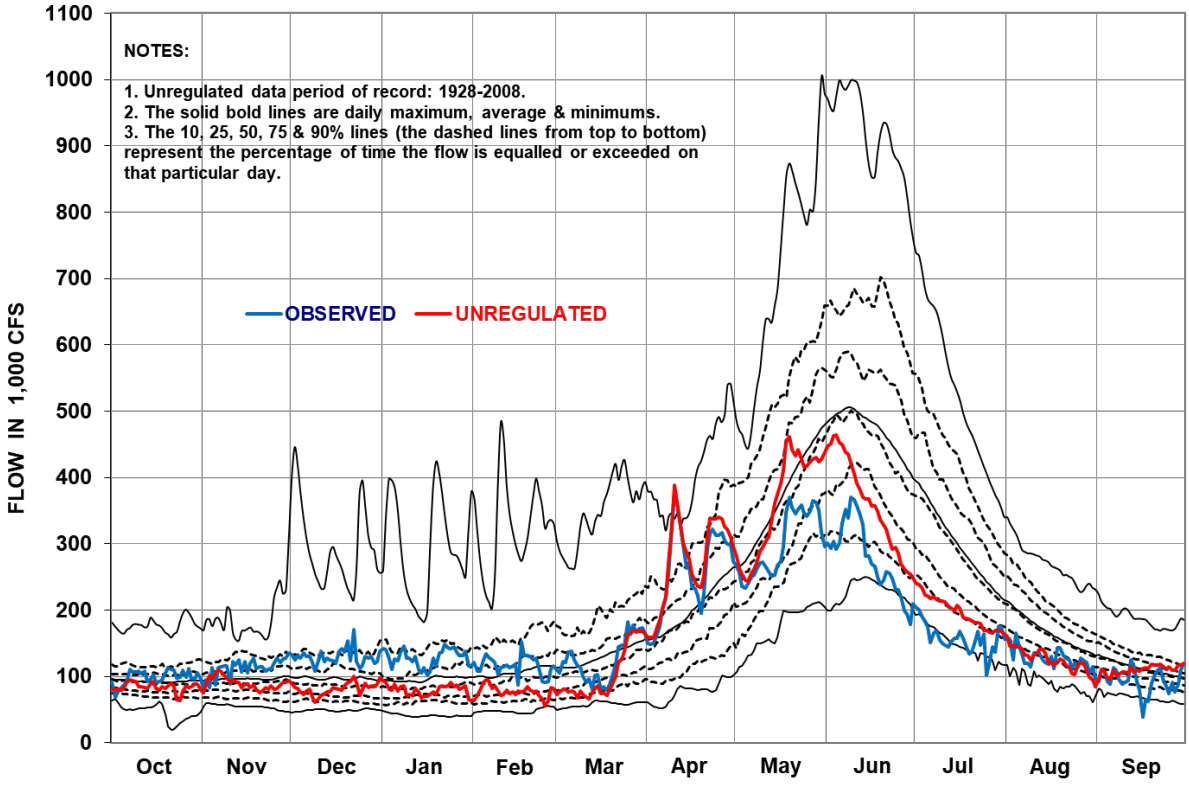
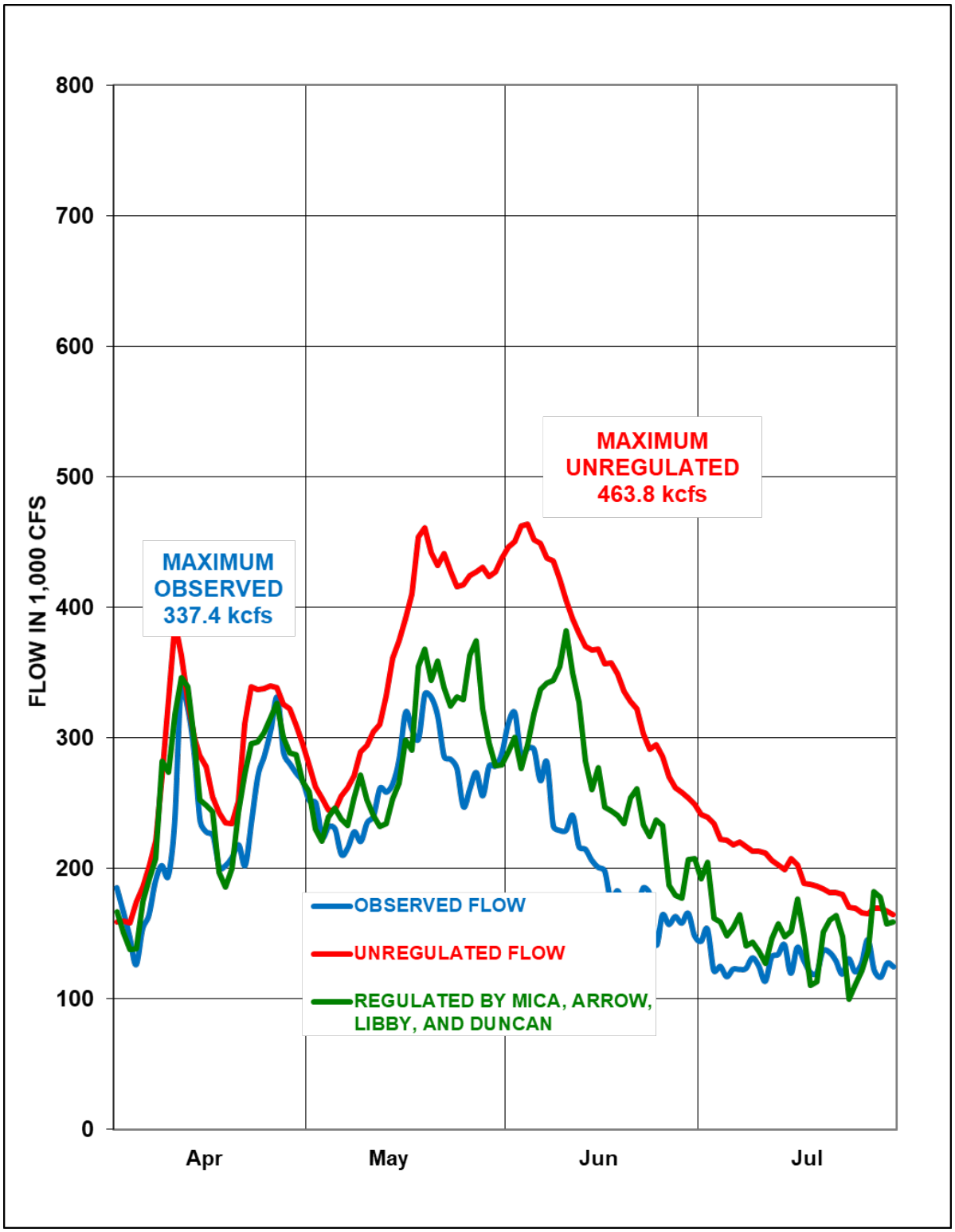



Chart 13: 2019 Columbia River at The Dalles Re-Regulation Plot