

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C.

Ottawa, Ontario

30 September 2018

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COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD
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6 February 2019

The Honorable Michael Pompeo
Secretary of State
Washington, D.C.

The Honourable Amarjeet Sohi
Minister of Natural Resources
Ottawa, Ontario

Dear Secretary Pompeo and Minister Sohi:

We refer you to the Treaty between the United States of America and Canada relating to cooperative development of the water resources of the Columbia River Basin, signed at Washington, D.C., on 17 January 1961.

In accordance with the provisions of Article XV, paragraph 2(e), we are submitting the fifty-fourth Annual Report of the Permanent Engineering Board, dated 30 September 2018. The report documents the results achieved under the Treaty for the period from 1 October 2017 to 30 September 2018.

The Board is pleased to report that, for this reporting period, the objectives of the Treaty were met.

Respectfully submitted:

For the United States

For Canada



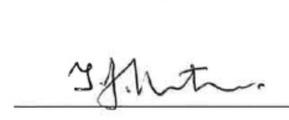
James Dalton, Chair



Marco Presutti, Chair Nominee

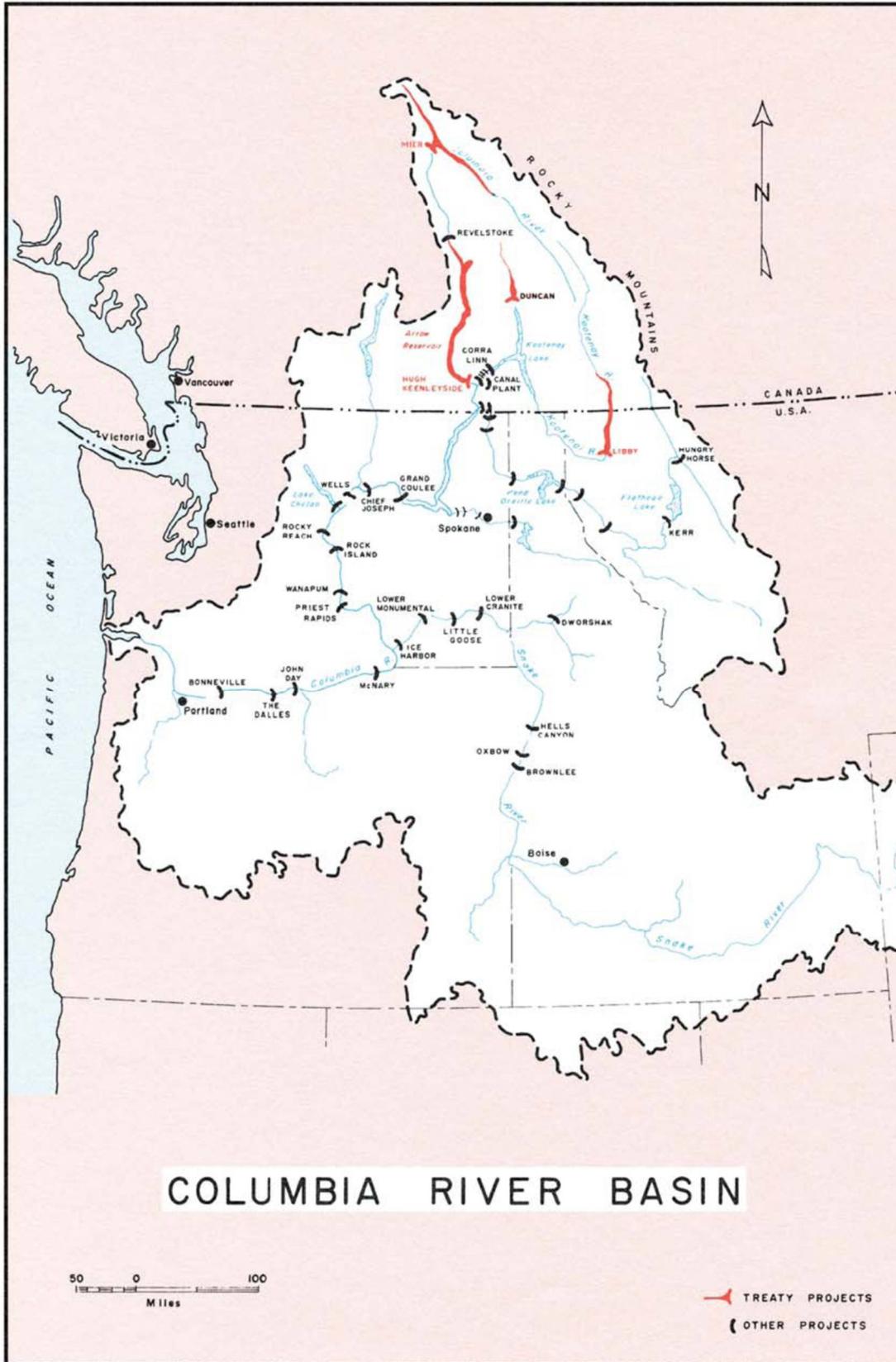


Ed Sienkiewicz



Tim Newton

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EXECUTIVE SUMMARY

The fifty-fourth Annual Report of the Permanent Engineering Board is submitted to the governments of Canada and the United States in compliance with Article XV of the Columbia River Treaty of 17 January 1961. This report describes Treaty projects, storage operations, and the resulting benefits achieved by each country for the period from 1 October 2017 to 30 September 2018.

During the reporting period, the Canadian Treaty projects – Mica, Duncan, and Arrow – were operated according to the 2017-2018 and 2018-2019 Detailed Operating Plans, the 2003 Flood Control Operating Plan, and several supplemental operating agreements. The Libby project was operated consistently with the Libby Coordination Agreement and Short-term Entity Agreement on Coordination of Libby Project Operations, the Libby Operating Plan, United States (U.S.) requirements for power, and U.S. Fish and Wildlife Service's 2006 Biological Opinion (BiOp), as clarified, and U.S. Department of National Oceanic and Atmospheric Administration Fisheries' 2010 and 2014 Supplemental BiOp for operation and maintenance of the Federal Columbia River Power System.

Canadian Treaty storage began the Operating Year on 1 August 2017 at 96.6 percent full, and ended the year on 31 July 2018 at 95.2 percent full. The actual January through July runoff for the Columbia River above The Dalles was 146.4 cubic kilometres (km³) [118.7 million acre-feet (Maf)], or 117 percent of the 1981-2010 average. The actual April through August runoff for the Columbia River above The Dalles was 125.1 km³ [101.5 Maf], or 116 percent of the 1981-2010 average. Snowpack in the Columbia Basin in 2018 was above normal due to a wetter-than-normal early spring primarily in the U.S. Columbia Basin and the lower portion of the Canadian Columbia Basin. The freshet however was unusually brief with many river systems seeing higher-than-normal peak flows in May and then tapering off to below normal from June through September.

The Canadian Entitlement to the downstream power benefits (CE) for the reporting period was determined according to the procedures set out in the Treaty and Protocol. From 1 August 2017 through 31 July 2018, the U.S. Entity delivery of the CE, before deducting transmission losses, was 475 average megawatts (aMW) of energy at rates up to 1,304 megawatts (MW) of capacity. From 1 August 2018 to 30 September 2018, the U.S. Entity delivery of the CE, before deducting transmission losses, was 472.5 aMW of energy at rates up to 1,284 MW of capacity. The CE obligation was determined by the 2017-2018 and 2018-2019 Assured Operating Plans and Determination of Downstream Power Benefits.

During the 14-month reporting period (1 August 2017 through 30 September 2018), the CE was delivered with two curtailments, totalling 1,224 MWh. In both cases, the deliveries were rescheduled and delivered by agreement between the Entities.

CRT Hydrometeorological Committee (CRTHC) continued to work towards better documentation for data exchange, changes to the data networks and staff contact information. New water supply forecast procedures for Canadian projects were implemented in 2017. Forecasts are now made available according to a defined schedule on the third working day of each month. The CRTHC continued to monitor the integrity of the hydrometeorological station network. The Akimina Pass snow pillow site in Alberta was damaged by a forest fire. BC Hydro added several stations to the network, including automated stations at Fauquier and Kaslo, BC.

The CRTHC reviews the adequacy of the hydrometeorological network every year based on the status of the stations and data quality, and if the data meet model input requirements. It considers the current station network adequate for making valid forecasts in the Columbia Basin.

The Entities continue to work toward a long-term solution to address Canadian concerns with variable discharge flood control (VarQ) at the Libby Dam. In the meantime, the Entities have extended the Short-term Entity Agreement on Coordination of Libby Project Operations (STLA) until 31 August 2019. The Agreement provided Canada the option to provisionally store up to 50 thousand cubic feet per day (ksfd) and draft up to 550 ksf. During the report period, coordination between the Entities to refine forecasts and explore discharge operations from Libby and Duncan Dam, combined with declining inflows, minimized both immediate and longer-term flood risk for both Kootenay Lake and Bonners Ferry, Idaho.

Throughout the year, composite Canadian Treaty storage operations targeted the Treaty Storage Regulation (TSR) study levels, plus any operations implemented under mutually agreed upon supplemental operating agreements, namely STLA and the Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses (NPU). As in past years, the CRTOC negotiated an NPU in order to manage Keenleyside outflows to improve conditions for fish in both countries.

The PEB is satisfied that the Treaty objectives have been achieved during this reporting period.

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ABBREVIATIONS AND ACRONYMS

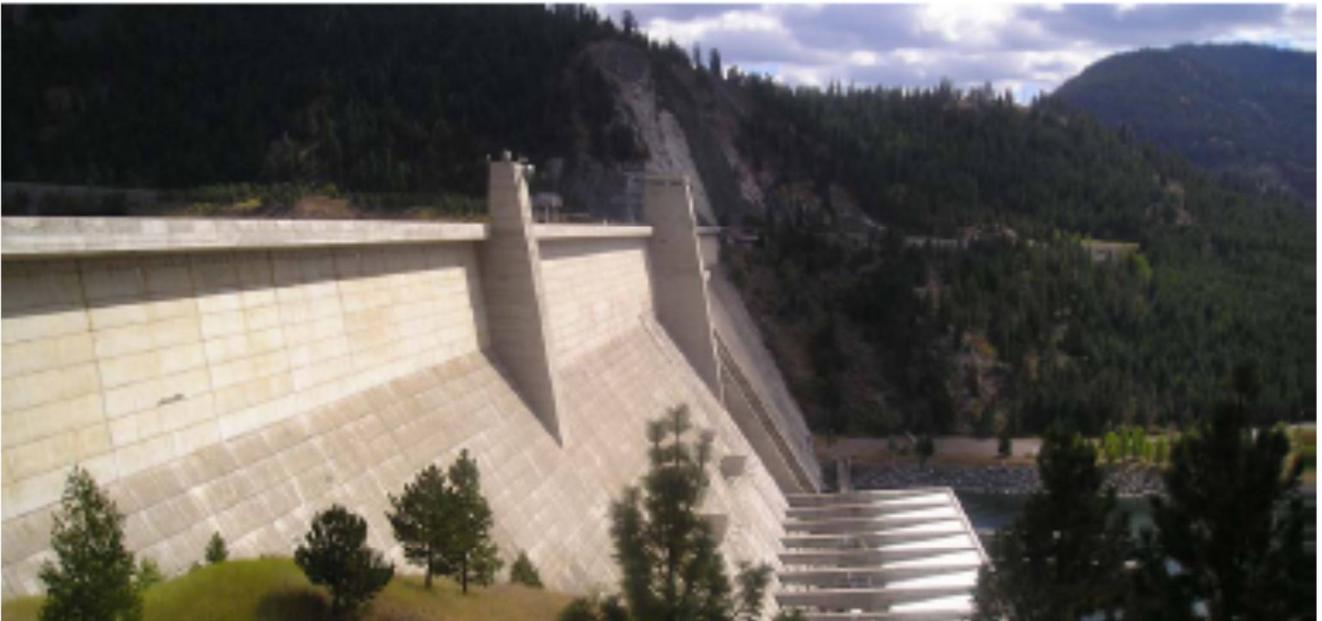
aMW	Average Megawatts
AOP	Assured Operating Plan (from 1 August to 31 July)
BC Hydro	.....	British Columbia Hydro and Power Authority
BiOp	.....	Biological Opinion
BPA	.....	Bonneville Power Administration
CEPA	.....	Canadian Entitlement Purchase Agreement
CRT or Treaty	.....	Columbia River Treaty
CRTHMC	.....	Columbia River Treaty Hydrometeorological Committee
CRTOC	.....	Columbia River Treaty Operating Committee
cfs	.....	Cubic feet per second
DDPB	.....	Determination of Downstream Power Benefits
DOP	.....	Detailed Operating Plan (from 1 August to 31 July)
ESA	.....	Endangered Species Act
ESP	.....	Ensemble Streamflow Prediction
FCOP	.....	Flood Control Operating Plan
FCRPS	.....	Federal Columbia River Power System
ft	.....	Feet
FRM	.....	Flood Risk Management
hm ³	.....	Cubic hectometres
IJC	.....	International Joint Commission
kaf	.....	Thousand acre-feet
kcfs	.....	Thousand cubic feet per second
km	.....	Kilometres
km ³	.....	Cubic kilometres
kV	.....	Kilovolts
LCA	.....	Libby Coordination Agreement
m	.....	Meters
m ³ /s	.....	Cubic meters per second
Maf	.....	Million acre-feet
MW	.....	Megawatts
MWh	.....	Megawatt hour
NMFS	.....	National Marine Fisheries Service
NOAA	.....	U.S. National Oceanic and Atmospheric Administration
NPU	.....	Non-Power Uses Agreement
NTSA	.....	Non-Treaty Storage Agreement
PEB or Board	.....	Permanent Engineering Board
PEBCOM	.....	Permanent Engineering Board Engineering Committee
PNCA	.....	Pacific Northwest Coordination Agreement
POP	.....	Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans
PSANI	.....	Puget Sound Area / Northern Intertie
STLA	.....	Short Term Libby Agreement
TSR	.....	Treaty Storage Regulation
USACE	.....	US Army Corps of Engineers
USFWS	.....	US Fish and Wildlife Service
VarQ	.....	Variable discharge flood control

INTRODUCTION

The Columbia River Treaty provides for the cooperative development of the water resources of the Columbia River Basin. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties is to “make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty.”

This annual report, which covers the period from 1 October 2017 through 30 September 2018, outlines the essential features of the Treaty and Treaty projects, and the responsibilities of the Board and the Entities. It summarizes the Treaty storage operations, flow discharges at the border, and the resulting power and flood control benefits achieved by each country during the reporting period.

The report refers to items currently under review by the Entities; provides a summary of Board activities during the reporting period and presents the conclusions of the Board.



Libby Dam – Kootenai River, Montana

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed at Washington, D.C., on 17 January 1961, and was ratified by the United States Senate in March of that year. In Canada, ratification was delayed. Further negotiations between the two countries resulted, on 22 January 1964, in a formal agreement by an exchange of notes to a Protocol to the Treaty, and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement, Canada's share of downstream power benefits resulting from the first 30 years of scheduled operation of each of the Canadian storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964, the Treaty and Protocol were formally ratified by an exchange of notes between the two countries. The sum of US\$253.9 million was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date, at a ceremony at the Peace Arch Park on the International Boundary, the Treaty and its Protocol were proclaimed by President Johnson of the United States, Prime Minister Pearson of Canada, and Premier Bennett of British Columbia.

Features of the Treaty

The essential undertakings of the Treaty are as follows:

- (a) Canada will provide 19.1 km³ (15.5 Maf) of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes, and Duncan Lake in British Columbia.
- (b) The United States will maintain and operate the hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved streamflow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with the procedures and operating plans specified in the Treaty.
- (c) The United States and Canada will share equally the additional power benefit available in the United States as a result of river regulation by upstream storage in Canada.
- (d) On commencement of the respective storage operations, the United States will make payments to Canada totalling US\$64.4 million for flood control provided by Canada during the sixty years following ratification.
- (e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby Reservoir would extend some 67.6 km (42 miles) into Canada, and Canada would make the necessary Canadian land available for flooding.

(f) Both Canada and the United States have the right to make diversions of water for consumptive use and, in addition, after September 1984, Canada has the option of making specific diversions of the Kootenay River into the headwaters of the Columbia River for power purposes.

(g) Differences arising under the Treaty that cannot be resolved by the two countries may be referred by either country to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.

(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964. The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that, under certain terms, Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Exchange of Notes and Attachment Relating to Terms of Sale of January 1964 and the CEPA of 13 August 1964 (the Sales Agreement) provided that the Treaty storage would be operative for power purposes on the following dates: Duncan storage on 1 April 1968; Arrow storage on 1 April 1969; and Mica storage on 1 April 1973. All sales under the Sales Agreement have now expired.

Termination Provisions

Article XIX describes the period of the Treaty and provisions for its termination at any time after the Treaty has been in force for sixty years. While the Treaty has no official termination date, Canada or the United States may issue notice to terminate most of the provisions of the Treaty with at least ten years' written notice. Certain provisions of the Treaty terminate automatically in 2024, while other continue for the useful life of the Treaty facilities.

PERMANENT ENGINEERING BOARD

General

Article XV of the Columbia River Treaty establishes a Permanent Engineering Board consisting of two members to be appointed by Canada and two members to be appointed by the United States. The duties and responsibilities of the Board are also stipulated in the Treaty and related documents.

Establishment of the Board

On 7 December 1964, pursuant to Executive Order No. 11177, dated 16 September 1964, the Secretary of the Army and the Secretary of the Interior each appointed a member and an alternate member to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977, the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671, dated 29 October 1964. Each Canadian member was authorized to appoint an alternate member. On 11 December 1964, the two governments announced the composition of the Board.

The names of Board members, alternate members, and secretaries are shown in Appendix A, as are the names of the current members of the Board's Engineering Committee.

Duties and Responsibilities

The general duties and responsibilities of the Board to the governments, as set forth in Article XV(2) of the Treaty and related documents, include:

- (a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada–United States of America boundary;
- (b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and, if appropriate, including in the report recommendations for remedial action and compensatory adjustments;
- (c) assisting in reconciling differences concerning technical or operational matters that may arise between the Entities;
- (d) making periodic inspections and requiring reports as necessary from the Entities, with a view to ensuring that the objectives of the Treaty are being met;
- (e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter that it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America; and

(g) consulting with the Entities on the establishment and operation of a hydrometeorological system as required by Annex A of the Treaty.



Hugh Keenleyside Dam (Arrow Lakes) – Columbia River, British Columbia
Concrete spillway and discharge works with navigation locks and earthfill dam.
The new 185-MW power plant is on the north abutment (right-hand side).

ENTITIES

General

Article XIV(1) of the Columbia River Treaty provides that Canada and the United States of America shall each designate one or more Entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the Entities are specified in the Treaty and its related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration (BPA), the Department of the Interior (moved by a later Executive Order to the Department of Energy), and the Division Engineer, North Pacific (now Northwestern) Division, Corps of Engineers, Department of the Army, as the United States Entity, with the Administrator to serve as Chair. Pursuant to the Department of Energy Organization Act of 4 August 1977, the BPA was transferred to the Department of Energy. Order in Council P.C. 1964-1407, dated 4 September 1964, designated the British Columbia Hydro and Power Authority (BC Hydro) as the Canadian Entity.

The names of the members of the Entities are shown in Appendix B.

Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents, Article XIV(2) of the Treaty requires that the Entities be responsible for the following:

- (a) coordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty;
- (b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control;
- (c) calculation of the amounts payable to the United States of America for standby transmission services;
- (d) consultation on requests for variations made pursuant to articles XII(5) and XIII(6);
- (e) establishment and operation of a hydrometeorological system as required by Annex A;
- (f) assisting and cooperating with the Permanent Engineering Board in the discharge of its functions;
- (g) periodic calculation of accounts;

- (h) preparation of the hydroelectric operating plans and flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled;
- (i) preparation of proposals to implement Article VIII, and carrying out of any disposal authorized or exchange provided for therein;
- (j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled, including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss; and
- (k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the Entities with any other matter coming within the scope of the Treaty.

ACTIVITIES OF THE BOARD

Meetings

The Board held its 85th meeting on 6 – 7 February 2018 in Portland, Oregon. In conjunction with this meeting, the Board also held its 66th joint meeting with the Entities.

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), Canadian Entitlement Delivery, FRM issues and other topics requested by the PEB. The STLA was extended for another year allowing additional time to complete and review studies.

Reports and Agreements Received

Throughout the reporting year, the Entities maintained contact with the Board and the Board's Engineering Committee (PEBCOM). Information pertinent to the operation of Treaty storage projects was made available to the Board.

- Extension of the Columbia River Treaty Short-term Entity Agreement on Coordination of Libby Project Operations, signed February 2018.

This document is Amendment 4 to original agreement and provides for mutually agreeable storage and release of water and specified the associated financial payments through 31 August 2019.

- Columbia River Treaty Agreement on the Detailed Operating Plan (DOP) for Canadian Storage, signed July 2018.

This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the Operating Year from 1 August 2018 through 31 July 2019

- Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 01 December 2017 through 31 July 2018.

This is a supplemental agreement to the DOP that provides mutual benefits in the form of storage and release of water for nonpower uses, such as whitefish and rainbow trout spawning in Canada and salmon migration in the US.

- Annual Report of the Columbia River Treaty, Canadian and United States Entities, for the period 1 August 2017 through 30 September 2018.

This report summarizes the operation of Treaty projects and other activities of the Entities for the period of 1 August 2017 through 30 September 2018.

Report to the Governments

In accordance with Article XV, paragraph 2(e) of the Treaty, the fifty-first Annual Report of the Board, dated 30 September 2017, was submitted to the governments of Canada and the United States.



Duncan Dam – Duncan River, British Columbia
The earthfill dam with discharge tunnels to the left and spillway to the right.

TREATY IMPLEMENTATION

General

Implementation of the Treaty resulted in the construction of the Treaty projects, development of the hydrometeorological network, and annual preparation of power and flood control operating plans, and annual preparation of operating plans for power and calculation of downstream power benefits. The three Treaty storage projects in British Columbia (Duncan, Arrow, and Mica) and the Libby storage project in the United States have been operated accordingly to produce flood control and power benefits in both Canada and the United States. The locations of the Treaty projects are shown in Plate No.1 in Appendix D.

In the United States, the increased flow regulation provided by Treaty projects facilitated the installation of additional generating capacity at existing plants on the Columbia River.

In Canada, completion of the Canal Plant on the Kootenay River in 1976, installation of four turbines at Mica Dam by 1977 and two additional turbines in 2014 and 2015, completion of the Revelstoke dam including four turbines in 1984 (and a fifth turbine installed in 2010), and installation of two turbines adjacent to the Keenleyside Dam in Arrow Lakes in 2002, have resulted in approximately 5400 MW of generation capacity in British Columbia that might not have been installed without the Treaty. An additional generation unit at Revelstoke is also being planned.

The Treaty provides Canada with an option to divert the Kootenay River at Canal Flats into the headwater of the Columbia River starting 1984. BC Hydro undertook engineering feasibility and environmental studies but no further work has been done in recent years.

Further to the expiration of the Sales Agreements in 1998, 1999 and 2003, the Board has monitored issues relating to the transmission and return of the Canadian entitlement, and the restructuring of electricity markets. It has also reviewed the impacts of U.S. resource agencies' biological opinions (BiOps) on Treaty operations.

Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled to begin operation by 1 April 1968. It was the first of the Treaty projects to be completed and became fully operational on 31 July 1967, well in advance of Treaty requirement. The Sales Agreement for Duncan expired 31 March 1998.

The earthfill dam is situated 9.7 km (6 mi) north of Kootenay Lake and rises 39.6 m (130 ft) above its foundation. The reservoir behind the dam extends for as much as 43.5 km (27 mi) and provides 1.73 km³ (1.40 Maf) of usable storage, which is all committed under the Treaty. No power generation facilities have been installed.

The project is shown on page 11, and project data are provided in Appendix D, Table 1.

Arrow Project

Hugh Keenleyside Dam, at the outlet of the Arrow Lakes, was the second Treaty project to be completed. It became operational on 10 October 1968, well ahead of the starting date of 1 April 1969 for the 30-year Sales Agreement.

The dam consists of two main components: a concrete gravity structure that extends 366 m (1200 ft) from the north bank of the river and includes the spillway, low-level outlets, and navigation lock; and an earthfill section that rises 52 m (170 ft) above the riverbed and extends 503 m (1650 ft) from the navigation lock to the south bank of the river. The reservoir extends 233 km (145 mi) upstream when full, including both the Upper and Lower Arrow lakes, and provides 8.8 km³ (7.1 Maf) of Treaty storage.

A 185-MW power plant located on the north abutment (left bank) of the Arrow Project was completed in 2002. It is licensed to Arrow Lakes Power Corporation which is owned by Columbia Basin Trust and Columbia Power Corporation, both Crown Corporations in British Columbia. A 1493 m (4900 ft) intake approach channel runs along the north end of the concrete dam and diverts the water of the Arrow Lakes through a powerhouse located in a rock outcrop 396 m (1300 ft) downstream. The generating facility contains two 92.5 MW Kaplan turbines. The facility is connected by a new 230 kV transmission line to the Selkirk substation integrate into BC Hydro's existing power grid. The power production at this generating facility is incidental to releases for Treaty purposes. This new power plant reduces spill at Keenleyside Dam and provides environmental benefits by reducing the total gas pressure in the releases, which could be harmful to fish.

The project is shown on page 52, and project data are provided in Appendix D, Table 2 on page 54.

Mica Project

Mica Dam, the largest of the Treaty projects, was scheduled under the 30-year Sales Agreement to begin operation on 1 April 1973. The project was declared operational and commenced to store water on 29 March 1973. The dam is located on the Columbia River 137 km (85 mi) north of the town of Revelstoke in British Columbia. The earthfill dam rises more than 244 m (800 ft) above its foundation and extends 793 m (2600 ft) across the Columbia River valley. It is one of the tallest dams in North America. It creates a reservoir, the Kinbasket Lake, that is up to 217 km (135 mi) long with a storage capacity of 24.7 km³ (20 Maf). The project is operated within 14.8 km³ (12 Maf) of live storage, of which 8.6 km³ (7 Maf) is committed under the Treaty.

The generating station has six Francis turbines; four 435 MW units, and two 520 MW units. The 2nd 520 MW unit was commissioned in early 2016. The total capacity, with 6 units, is estimated to be 2780 MW.

The project is shown on page 19, and project data are provided in Appendix D, Table 3 on page 55.

Libby Project in the United States

Libby Dam is located on the Kootenai River, 27.4 km (17 mi) northeast of the town of Libby, Montana. Construction began in the spring of 1966, and storage has been fully operational since 17 April 1973. Commercial generation of power began on 24 August 1975, which coincided with the formal dedication of the project. The concrete gravity dam is 931 m (3055 ft) long, rises 113 m (370 ft) above the riverbed, and creates Lake Koocanusa, which is up to 145 km (90 mi) long and extends 67.6 km (42 mi) into Canada. Lake Koocanusa has a gross storage of 7.2 km³ (5.9 Maf), of which 6.1 km³ (5.0 Maf) is usable for flood control and power purposes. When completed in 1976, the Libby powerhouse had four units with a total installed capacity of 420 MW.

Construction of four additional generating units was initiated during fiscal year 1978, but Congressional restrictions imposed in the 1982 Appropriations Act provided for completion of only one of these units. That unit became available for service late in 1987. The total installed capacity for the five units is 600 MW. Recent US legislation (Public Law 104-303, 12 Oct. 1996) authorizes the US Army Corps of Engineers (USACE) to complete generating units six through eight. No action was taken in this regard during this reporting period.

The Libby project is shown on page 2, and project data are provided in Appendix D, Table 4.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 68 km (42 mi) portion of Lake Koocanusa in Canada. British Columbia is responsible for reservoir debris clean-up on the Canadian side of the border.

Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is to establish and operate, in consultation with the Permanent Engineering Board, a hydrometeorological system to obtain data for the planning of flood control and power operations. This system includes snow courses, meteorological stations, and reservoir level and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities in 1968, makes recommendations on further development of the Treaty hydrometeorological system. The CRTHMC also assists the Entities in water supply forecasting.

The 2018 Annual Report of CRTHMC was completed in early-December 2018. The CRTHMC turned 50 in September 2018.

In this reporting year, the CRTHMC continued to work towards better documentation for data exchange, changes to the data networks, and staff contact information. The CRTHMC reviews the adequacy of the hydrometeorological network for Treaty purposes each year, and concludes that the current station network is adequate for making valid forecasts in the Columbia Basin.

New water supply forecast procedures for Canadian projects were implemented in 2017, and Appendix 8, Table 1, of the Principles and Procedures document was updated with new hedges. As different units of measure are used between the entities, the CRTHMC developed a protocol specifying the calculations and precision to carry through the conversion process to support the recent Principles and Procedures update.

To continue to provide more timely input to flood risk management decisions, water supply forecasts were made available as per a defined schedule, on the third working day of each month in 2018. This advanced schedule was found to improve operational guidance.

The first half of the month of May saw a significant portion of the runoff occurring earlier than normally expected. As a result, it caused a change to the expected distribution of flows in the spring months and required a modification to the way that monthly flows are coordinated for the TSR. In June, the snow water equivalent inputs to the BC Hydro water supply forecasts were adjusted (lowered) to again better reflect conditions.

Akimina Pass snow pillow site in Alberta, which is used in the Libby water supply equation and is designated as a Treaty station, was damaged by a forest fire. A technique for estimating snow water equivalent inputs for the Libby water supply forecasting procedure was developed as an interim solution and will be reviewed prior to the 2019 water supply forecasting season. Alberta Environment, who operates the Akimina Pass site, has indicated they will restore the station.

BC Hydro added several stations to the network during the year. In the fall of 2018, an automated station at Fauquier was installed to eventually replace the current manually reported observer station at the same location. The observer station is used in several water supply forecast procedures, so a technique for harmonizing the new automated station data with the long term historic observer data will need to be agreed upon by the CRTHMC. An automated station was added at Kaslo for collecting climatological parameters. A second, redundant water level sensor at Kinbasket was added at Garrett Creek. In addition, a high elevation alpine station was installed at Conrad Glacier, BC. Data collected include snow depth, wind velocity and direction and temperature.

Operating Plans and Determination of Downstream Power Benefits

The Treaty and related documents require the Entities to develop and agree on an Assured Operating Plan (AOP) annually for the sixth succeeding year from the current year. This AOP, prepared five years in advance, represents the commitment of the Canadian Entity to operate the Treaty storage in Canada (Duncan, Arrow, and Mica) and provides the Entities with a basis for system planning. The determination of downstream power benefits accrued to each country under the Treaty is also prepared five years in advance based on the Treaty operation criteria in the AOP. At the beginning of each operating year, a Detailed Operating Plan (DOP) for the three Treaty projects in Canada is prepared. This plan accounts for projected resources and demands to determine operations that are more advantageous to both countries than those in accordance with the AOP. To supplement the DOP, the Entities may enter into agreements throughout the year regarding the operation of Treaty storage that provide mutual benefits to both Entities. The operating plan for the Libby project in the United States has been prepared separately since 2000 and has not been included in the DOP thereafter. Details on Libby operations are discussed further below.

During the reporting year, operation of Treaty storage in Canada was regulated under the rule curves set out in the Entities' Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2017 through 31 July 2018 dated June 2017, and the Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2018 through 30 September, dated June 2018, as well as in accordance with the Columbia River Treaty Short-Term Entity Agreement on Coordination of Libby Project Operations (STLA) signed in September 2013 and extended in February 2018 to 31 August, 2019, and CRTOC Agreement on Operation of Canadian Storage for Nonpower Uses for 1 December 2017 through 31 July 2018, signed on 14 November 2017. These documents were based on the operating criteria and studies contained in the corresponding AOPs.

The Libby operating criteria and expected operation of the Libby project are no longer included in the annual DOP beginning in the 2000-2001 operating year. Information on Libby operations is provided separately in the Libby Operating Plan prepared by the U.S. Entity. Operation at Libby takes non-power considerations into account as required in the BiOps of the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic & Atmospheric Administration (NOAA) Fisheries Service. Compared to operations prior to 2000–2001, the BiOps requires higher releases from Libby Dam in the spring and summer and lower releases in the fall and winter. In January 2003, USACE adopted, on an interim basis, a new approach to determine operations at Libby. This approach, referred to as VarQ, applies only when dry-to-moderate hydrologic runoff conditions are forecasted. It uses (encroaches) flood control storage space to store water to increase flows for fisheries during the spring period. In June 2008, USACE issued a Record of Decision for Libby Dam Flood Control and Fish Operations and incorporated the VarQ Flood Control Procedures into the Libby Dam Water Control Manual. Canada believes that these operations result in loss of power generation and increased flood risk in Canada. USACE will continue to coordinate with Canada on the operation of Libby Dam pursuant to provisions in the Columbia River Treaty.

The Libby Coordination Agreement (LCA), signed on 16 February 2000, addressed some of the Treaty issues associated with salmon and white sturgeon fisheries operations of the Libby Project. It allowed the Entities to coordinate reservoir releases and agree to AOPs and DDPBs without having to fully resolve outstanding issues of disagreement. The LCA could be terminated by either Entity on 30 days' notice. Details of the LCA are presented later in this report under "Operations under the Treaty". The Entities have successfully implemented the LCA since signing. The Entities continue to pursue full long term resolution of the VarQ operational impacts on power and flood control. In the meantime, the Entities have entered into STLA, which includes and furthers the flexibility that is existing under the LCA.

A lengthy dispute between the Entities during the early 1990s regarding the calculation of downstream power benefits was resolved by signing the Entity Agreement on Resolving the Dispute on Critical Period Determination, the Capacity Entitlement for the 1998–1999, 1999–2000, and 2000–2001 AOP/DDPBs, and Operating Procedures for the 2001–2002 and Future AOPs. If circumstances so require in the future, the Board will re-examine the matter by using its earlier recommendations as guidelines for appropriate Treaty interpretations, and for the application of the critical streamflow period definition and the established operating procedures. A more detailed discussion of this issue is contained in the 1996 and 1997 annual reports of the Board.

In addition to the delivery agreement referenced above, the terms and conditions for the disposal of portions of the Canadian entitlement within the United States are based on the Agreement on Disposals of the Canadian Entitlement within the United States for April 1, 1998 through September 15, 2024 between Bonneville Power Administration, Acting on Behalf of the U.S. Entity, and the Province of British Columbia, signed 29 March 1999. Both the delivery agreement and the disposal agreement became effective on 31 March 1999 through an exchange of diplomatic notes between Canada and the United States.

Delivery of Canadian Entitlement

The arrangements for returning the Canadian Entitlement to British Columbia across existing transmission lines are based on the Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for April 1, 1998 through September 15, 2024, signed 29 March 1999. This agreement provides arrangements for the delivery of the Canadian entitlement, including the point of delivery, method of accounting for transmission losses, and guidelines for scheduling.

During the course of the 2017-2018 Operating Year, there were two Canadian Entitlement delivery curtailment events. On 16 October and 26 October 2017, two separate deliveries of Canadian Entitlement were curtailed, along with all other schedules between BC and the U.S. The cause of the curtailment was a fault in the transmission caused by routine maintenance that islanded BC and Alberta from the U.S. The first curtailment of Canadian Entitlement was 664 MWh, and the second curtailment was 560 MWh with both deliveries returned successfully within 24 hours.

The Board will continue to keep the governments informed of transmission developments that may impact Treaty implementation.

Flood Control Operating Plan

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada. The Columbia River Treaty Flood Control Operating Plan, dated October 1972, was received from the Entities and reviewed by the Board in the 1973 reporting year, and was in effect until October 1999. The revised plan, dated October 1999 and updated in May 2003, defines the flood control operations of the Duncan, Arrow, Mica, and Libby reservoirs during the period covered in this report.

Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenai rivers at the Canada-U.S. boundary. Flows for this reporting year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia.

Non-Treaty Storage

The Long Term Non-Treaty Storage Agreement (NTSA), executed in April 2012, was used by BPA and BC Hydro for power purposes through Operating Year 2017-2018. 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 impact the operation of CRT storage required by the DOPs. For the reporting period, NTSA water was released and stored by both parties into their respective accounts. There was no activity under the Recallable accounts.

Fisheries Operations

Many U.S. reservoirs are presently operated in accordance with BiOps issued by the USFWS and the NMFS under the Endangered Species Act. Treaty reservoirs in Canada are operated in accordance with the requirements of Fisheries and Oceans Canada. These efforts continue to evolve. In this regard, the Board notes that the AOP and DDPB are to be based on optimal operations for power and flood control in accordance with the requirements of the Treaty. The Board continues to maintain its long-standing position that the Treaty permits the Entities to develop DOPs to address fisheries' needs, to the extent that these actions do not conflict with Treaty objectives.



Mica Dam and Lake Kinbasket – Columbia River, British Columbia
The spillway is on the right of the earthfill dam, and the underground powerhouse on the left.

OPERATIONS UNDER THE TREATY

General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storage, and to direct the operation of this storage in accordance with the terms of the Treaty and subsequent Entity agreements. These plans follow the Operating Year from August to July of the following year. Although the Permanent Engineering Board reporting period is 1 October 2017 to 30 September 2018, Treaty operations are based on the Treaty Operating Year of 1 August 2017 to 31 July 2018. Additional information for 1 August 2018 to 30 September 2018 is based on the Treaty Operating Year 1 August 2018 to 31 July 2019.

For the 1 August 2017 through 30 September 2018 reporting period, the Canadian Storage were operated according to the 2017-2018 and the 2018-2019 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, and U.S. Fish and Wildlife Service's 2006 Biological Opinion (BiOp), as clarified, and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service's (NOAA Fisheries') 2010 and 2014 Supplemental BiOp for operation and maintenance of the Federal Columbia River Power System (FCRPS).

Treaty storage in Canada was operated by the Canadian Entity in accordance with the documents listed below.

- *Columbia River Treaty Entity Agreement on Principles for Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits*, dated July 1988

This agreement states the principles for changes to the preparation of the AOP and DDPB. These changes involve revisions to the information to be used in studies, such as the definition of the power loads and generating resources in the Pacific Northwest area, stream flows to be used, estimates of irrigation withdrawals and return flows, and other related information.

- *Columbia River Treaty Entity Agreement on Changes to Procedures for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefit Studies*, dated August 1988.

This agreement states the specific procedures to be used in implementing the previous agreement on Principles for Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits.

- *Agreement executed by the United States of America Department of Energy, acting by and through the Bonneville Power Administration, and the British Columbia Hydro and Power Authority relating to: (a) Use of Columbia River Non-Treaty Storage, (b) Mica and Arrow Refill Enhancement, and (c) Initial Filling of non-Treaty Reservoirs*, signed 9 July 1990

This agreement provides information relating to the initial filling of Revelstoke Reservoir, the coordinated use of some of the Columbia River non-Treaty storage, and actions taken to enhance the refill of the reservoirs impounded by the Mica and Arrow dams.

- *Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for 1 April 1998 through 15 September 2024*, signed 29 March 1999

This agreement provides arrangements for the delivery of the Canadian entitlement, including the point of delivery, method of accounting for transmission losses, and guidelines for scheduling. The Agreement became effective on 31 March 1999 through an exchange of diplomatic notes between the United States and Canada. Execution of this agreement supersedes and terminates the Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for 1 April 1998 through 15 September 2024 between the Canadian Entity and the United States Entity, dated 20 November 1996, and the Entity Agreement of the same name, dated 26 March 1998, which never reached its effective date.

- *Agreement on Disposals of the Canadian Entitlement Within the United States for 1 April 1998 through 15 September 2024 between the Bonneville Power Administration, Acting on Behalf of the U.S. Entity, and the Province of British Columbia*, signed 29 March 1999

This agreement describes the arrangements by which the Province of British Columbia may dispose of the Canadian entitlement in the United States.

- *Columbia River Treaty Entity Agreement Coordinating the Operation of the Libby Project with the Operation of Hydroelectric Plans on the Kootenay River and Elsewhere in Canada*, signed 16 February 2000

The LCA addresses issues concerning the operation of the Libby project and allows the Entities to coordinate reservoir operations and agree to AOPs and DDPBs without having to alter their respective positions on the validity of the Libby fisheries operations under the Treaty.

- *Columbia River Treaty Flood Control Operating Plan*, updated May 2003

This plan prescribes the criteria and procedures by which the Canadian Entity will operate the Mica, Duncan, and Arrow reservoirs to achieve desired flood control objectives in the United States and Canada. Criteria for the Libby Reservoir were included in the plan to meet the Treaty requirement to coordinate its operation for flood control protection in Canada. The plan was originally prepared in October 1972. The 1999 plan provides current information, incorporates new storage reservation diagrams, and clarifies procedures. The plan was updated in May 2003.

- *U.S. Entity Approval Relating to Amendatory Agreement No. 1 to the 1997 Pacific Northwest Coordination Agreement*, signed 13 June 2003

This agreement amends the 1997 Pacific Northwest Coordination Agreement to include definitions; adds text related to previously received interchange energy; and replaces text related to interchange pricing, accounting, and review of charges.

- *Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans for Operation of Canadian Treaty Storage*, dated 16 December 2003

This document serves as a guide for the preparation and use of hydroelectric operating plans, such as the AOP and DOP, for operation of the Columbia River Treaty storage.

- *Columbia River Treaty Operating Committee Agreement on Changes to Attachment B to the Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for 1 April 1998 through 15 September 2024 between the Canadian Entity and the United States Entity*, dated 29 March 1999, signed 19 December 2007

This agreement amends the scheduling guidelines for delivery of the Canadian Entitlement contained in Attachment B in the Aspects of Delivery Agreement.

- *Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2017-2018*, dated November 2011

This document provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2017 through 31 July 2018.

- *Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2018–2019*, dated April 2013

This document provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2018 through 31 July 2019.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2017 through 31 July 2018*, dated June 2017

This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the Operating Year from 1 August 2017 through 31 July 2018.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2018 through 31 July 2019*, dated 12 July 2018

This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the Operating Year from 1 August 2018 through 31 July 2019.

- *Extension of the Columbia River Treaty Short-Term Entity Agreement on Coordination of Libby Project Operations (STLA)*, signed 7 February 2018

This document partially addresses, until 31 August 2019, issues raised by the Canadian Entity regarding VarQ operations at Libby. The STLA provides the Canadian Entity additional flexibility to draft and store at Arrow reservoir.

The CRTOC completed the following supplemental operating agreement during the reporting period:

- *Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Non-power Uses for 1 December 2017 through 31 July 2018*, signed 14 November 2017.

This agreement is similar to previous agreements implemented to utilize Treaty storage for non-power uses. These uses include providing flows for Canadian whitefish and trout spawning for the January through June period and enhancing the capability in the U.S. of providing spring and summer flow augmentation for salmon and steelhead.

System Storage

The 2017-18 Operating Year began on 1 August 2017 with the Canadian Storage at 18.5 km³ (15.0 Maf), or 96.6 percent full. Canadian Storage drafted to a minimum of 3.2 km³ (2.6 Maf), or 16.5 percent full on 10 April 2018, and refilled to 18.2 km³ (14.8 Maf), or 95.2 percent full, on 31 July 2018. Canadian Storage operated in proportional draft mode during August 2017 through November 2017 and again during July 2018 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), Arrow Summer Shaping Agreement and the Non-power 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 km³ (504 thousand second-foot-days (ksfd), 1 Maf) of flow augmentation water by the end of January 2018. Operation under the agreement helped to manage flows downstream of Keenleyside for Canadian whitefish and trout spawning protection during the January through June period. The majority of flow augmentation in 2018 was forced out earlier than desired due to FRM constraints. The remaining flow augmentation water was subsequently released May through July 2018 to help meet U.S. salmon flow objectives. From January until the end of July 2018, Canadian Storage remained above TSR-specified levels.

The January 2018 water supply forecast for the Columbia River above The Dalles for January through July was 122.6 km³ (99.4 Maf), or 98 percent of the 1981–2010 average. After the water supply forecast increased to 138.3 km³ (112.1 Maf) in March, or 111 percent of the 1981-2010 average, the forecasts continued to increase in April to 148.7 km³ (120.5 Maf), or 119 percent of 1981-2010 average. In June 2018, the (January-July) runoff forecast had maintained at 149.1 km³ (120.8 Maf), or 119 percent of the 1981-2010 average. The actual January through July runoff for the Columbia River above The Dalles was 146.4 km³ (118.7 Maf), or 117 percent of the 1981-2010 average. The actual April through August runoff for the Columbia River above The Dalles was 125.1 km³ (101.5 Maf), or 116 percent of the 1981-2010 average.

Operations of the three Canadian projects (Mica, Keenleyside, and Duncan) and Libby in the United States are illustrated later in the report for the 14-month period from 01 August 2017 to 30 September 2018. The hydrographs show actual reservoir levels, discharges, inflows, and the 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.

Mica (Kinbasket Reservoir)

Kinbasket reached a maximum elevation in 2017 of 752.18 m (2,467.8 ft), 2.19 m (7.2 ft) below normal full pool, on 19 August 2017. Early November 2017 was unusually cold followed by colder-than-normal temperatures across the province in December and January similar to winter of 2016-17. As a result of low temperatures and high system loads, Columbia Basin generation ran much harder than normal. This caused the reservoir to draft below normal from December 2017 through February 2018. In 2018, the minimum level reached was 719.24 m (2,359.7 ft) on 23 April 2018, about 9.48 m (31.1 ft) lower than the 2017 minimum level.

Reservoir inflows for the period February to August 2018 were about average. However, electricity demand was much higher in the summer due to widespread hot weather in July/August 2018 across the Pacific Northwest. As a result, the reservoir did not fully refill in the summer. It reached a maximum of 747.25 m (2,451.6 ft) on 17 August 2018, 7.13 m (23.4 ft) below normal full pool.

Hugh Keenleyside (Arrow Lakes Reservoir)

In Operating Year 2017 Arrow reached a maximum level of 439.58 m (1,442.2 ft), or 0.55 m (1.8 ft) below full pool, on 27 July 2017. Arrow releases are regulated under the Columbia River Treaty (CRT) and its supplemental operating agreements. Under dry conditions, more Treaty water is released from Arrow according to the principles of proportional draft under the CRT. This operation resulted in relatively high discharges from August through September 2017. However, as the draft began from a near-full storage, Arrow summer levels were above average and were within recreation range through 04 September 2017 (Labour Day).

With the onset of fall rain in the Columbia system from October through November 2017, the coordinated system proportional draft ended resulting in reduced discharges from Arrow as low as 425 m³/s (15.0 kcfs) which was also the lowest discharge for the operating year. Arrow storage subsequently refilled to reach a second peak of about 436.9 m (1433.4 ft) by early January 2018. Arrow then went on to draft across the winter to reach its minimum level of 429.16 m (1,408 ft) on 28 March 2018. By comparison, in the previous year, Arrow reached a minimum level of 427.15 m (1,401.4 ft) on 04 February 2017.

Snowpack in the Columbia Basin in 2018 was above normal due to a wetter-than-normal early spring primarily in the U.S. Columbia Basin and the lower portion of the Canadian Columbia Basin. The freshet however was unusually brief with many river systems seeing higher-than-normal peak flows in May and then tapering off to below normal from June through September. Overall, 2018 runoff in the entire Columbia basin was above normal at 116 percent at The Dalles for April to August runoff. By comparison, in 2017, the Columbia runoff for the same period was 125 percent of normal.

Arrow refilled to 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. This is about 0.15 m (0.5 ft) above the 2017 maximum level. Since then, Arrow drafted across the summer to reach about 435.62 m (1,429.2 ft) on 31 August 2018 and 435.00 m (1,427.2 ft) on 30 September 2018.

Duncan Dam (Duncan Reservoir)

Duncan began the operating year at near-full pool operation, 576.50 m (1,891.4 ft), 0.18 m (0.6 ft) below full pool on 13 August 2017. By comparison in the previous year, the reservoir reached a similar maximum level of 576.47 m (1,891.3 ft), 0.21 m (0.7 ft) below full pool on 08 August 2016. From September 2017 through April 2018, 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, 547.09 m (1,794.9 ft) on 19 April 2018. By comparison, the reservoir reached a similar minimum level of 547.30 m (1,795.6 ft) on 11 April 2017.

The reservoir discharge was reduced to its minimum of 2.8 m³/s (0.1 kcfs) in late 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 late July, when discharges were gradually increased to manage the rate of reservoir refill. In 2018, Duncan refilled to a maximum of 576.59 m (1,891.7 ft), 0.09 m (0.3 ft) below full pool on 01 August 2018. Duncan discharges were increased during August to facilitate drafting the reservoir to reach the summer recreation target of 575.46 m (1,888.0 ft) between 10 August and Labour Day as per the Duncan Water Use Plan Order.

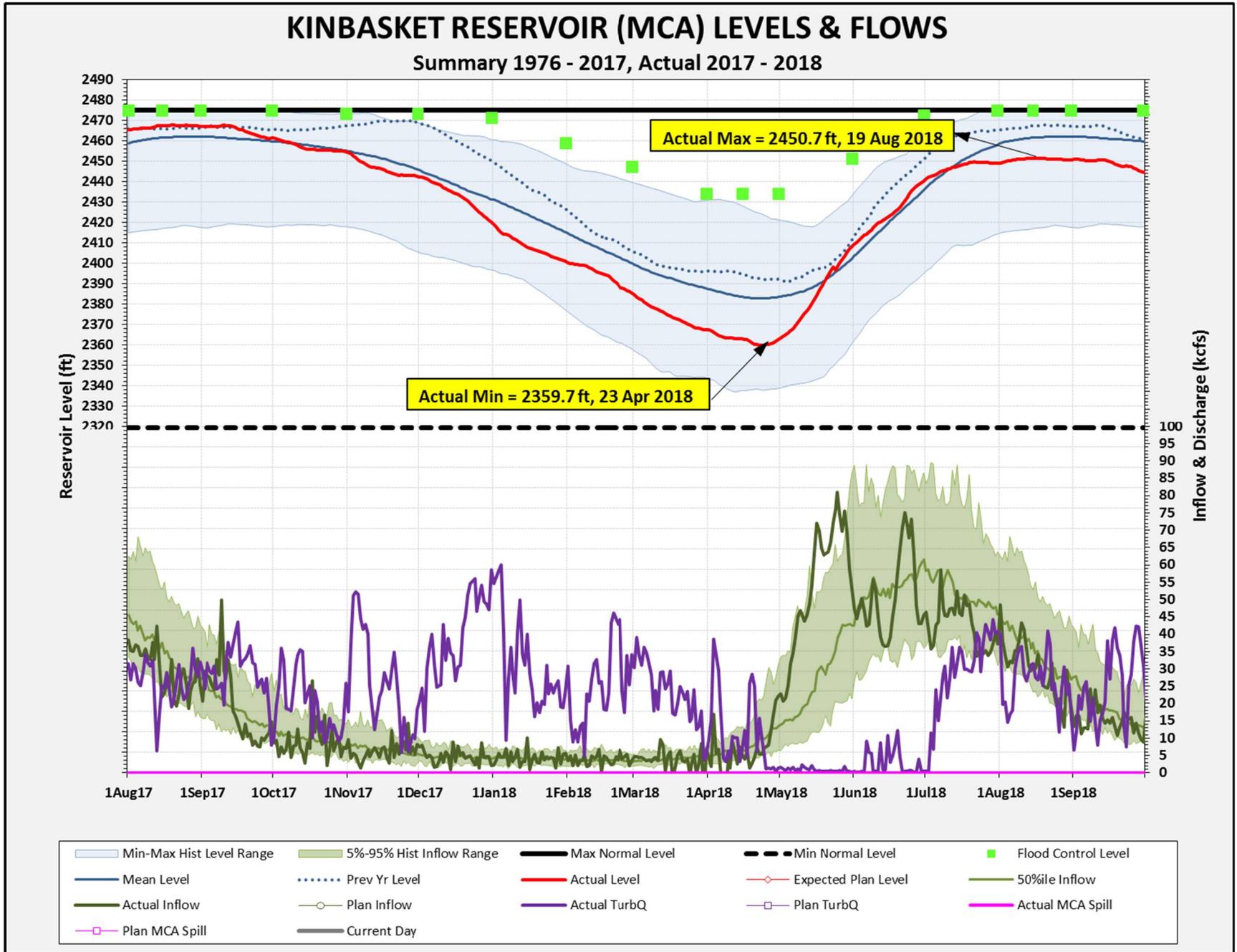
Libby Dam (Lake Koocanusa)

Lake Koocanusa ended July 2017 at elevation 746.33 m (2,448.6 ft). The project was drafted to elevation 745.27 m (2,445.1 ft) at the end of August 2017. From September 2017 through April 2018, the project was operated to meet minimum bull trout flows and FRM requirements. On 08 April 2018, Libby Dam reached its minimum elevation for the year of 718.57 m (2,357.5 ft) then operated to the Variable Flow (VarQ) FRM rules until the start of the sturgeon pulse. On 15 May 2018, Libby began to release the sturgeon volume 1.54 km³ (1.2 Maf) set by the May water supply forecast of 9.1 km³ (7.4 Maf), or 125 percent of average. The 2018 sturgeon volume was released in a single pulse operation with the goal of maintaining a stage greater than 9.1 m (30 ft) at Bonners Ferry. The pulse began on 15 May 2018 with project outflows ramping up to 566 m³/s (20.0 kcfs) for approximately 10 days followed by a peak flow of 651 m³/s (23.0 kcfs) for 8 days. The outflows then went back down to 566 m³/s (20.0 kcfs) for 5 days followed by a gradual ramp down to 340 m³/s (12.0 kcfs) as the sturgeon volume was expended on 26 June 2018. Lake Koocanusa ended the month of June at elevation 744.50 m (2,442.6 ft).

The operation for the rest of the summer, July through August 2018, was to try to refill Libby in so far as possible and meet the 746.46 m (2,449.0 ft) target by the end of September 2018, as required in the NOAA Fisheries BiOp and coordinated through the Technical Management Team (TMT). Libby reached its peak elevation for the summer on 23 July 2018, 746.18 m (2,448.1 ft), which was 3.32 m (10.9 ft) below full pool. Due to low inflows, the project kept releases to the minimum bull trout flow of 255 m³/s (9.0 kcfs) through August 2018 then ramped down to 170 m³/s (6.0 kcfs), the minimum bull trout flow for September 2018. Libby elevations were 744.87 m (2,443.8 ft) and 744.20 m (2,441.6 ft) at the end of August and September 2018, respectively. The 170 m³/s (6.0 kcfs) flow in September 2018 was also the requested release from Libby to help with the ongoing in-stream habitat work for the Kootenai Tribe of Idaho (KTOI). Libby held this minimum release through the end of September.

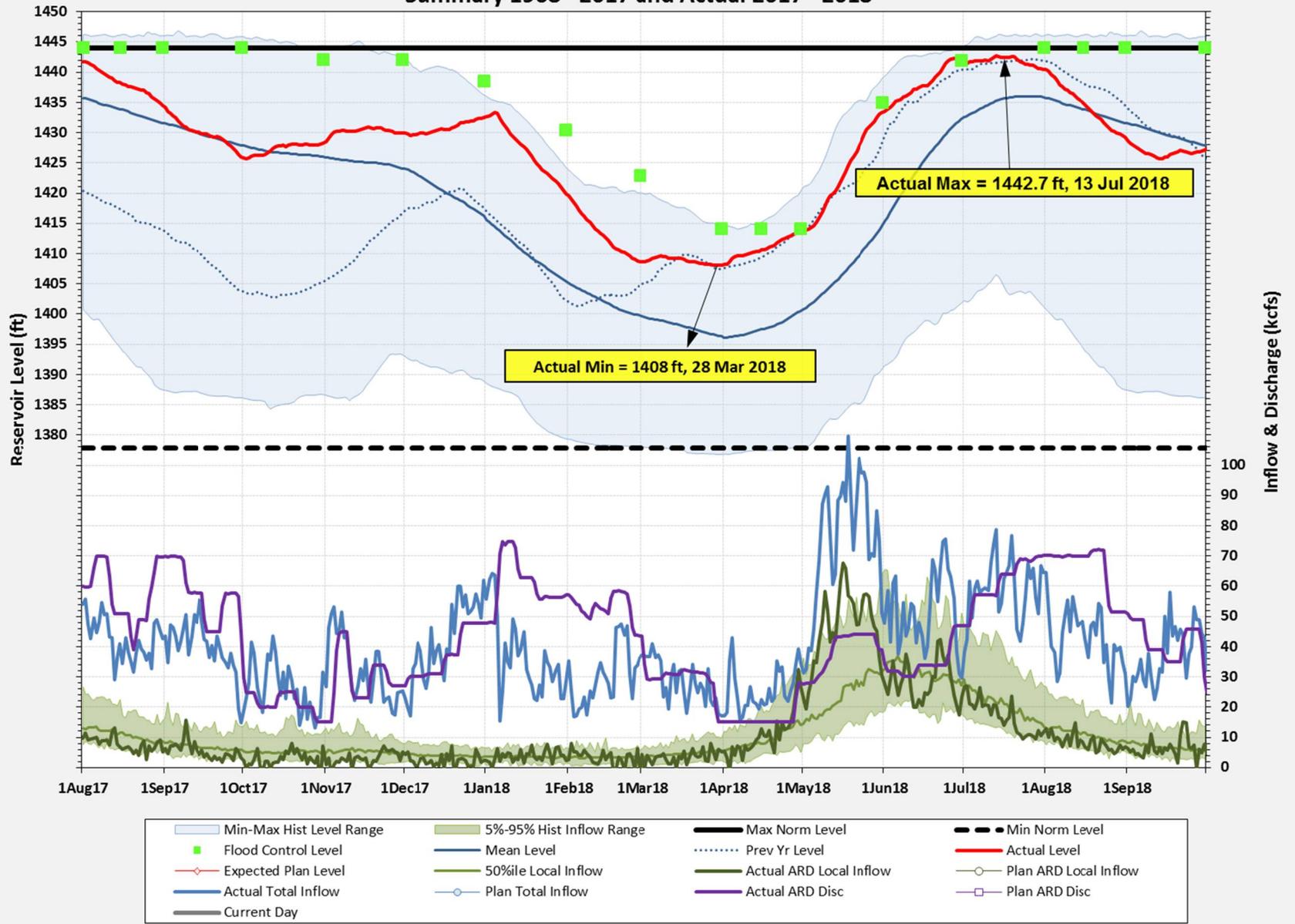
Flood Risk Management Operations

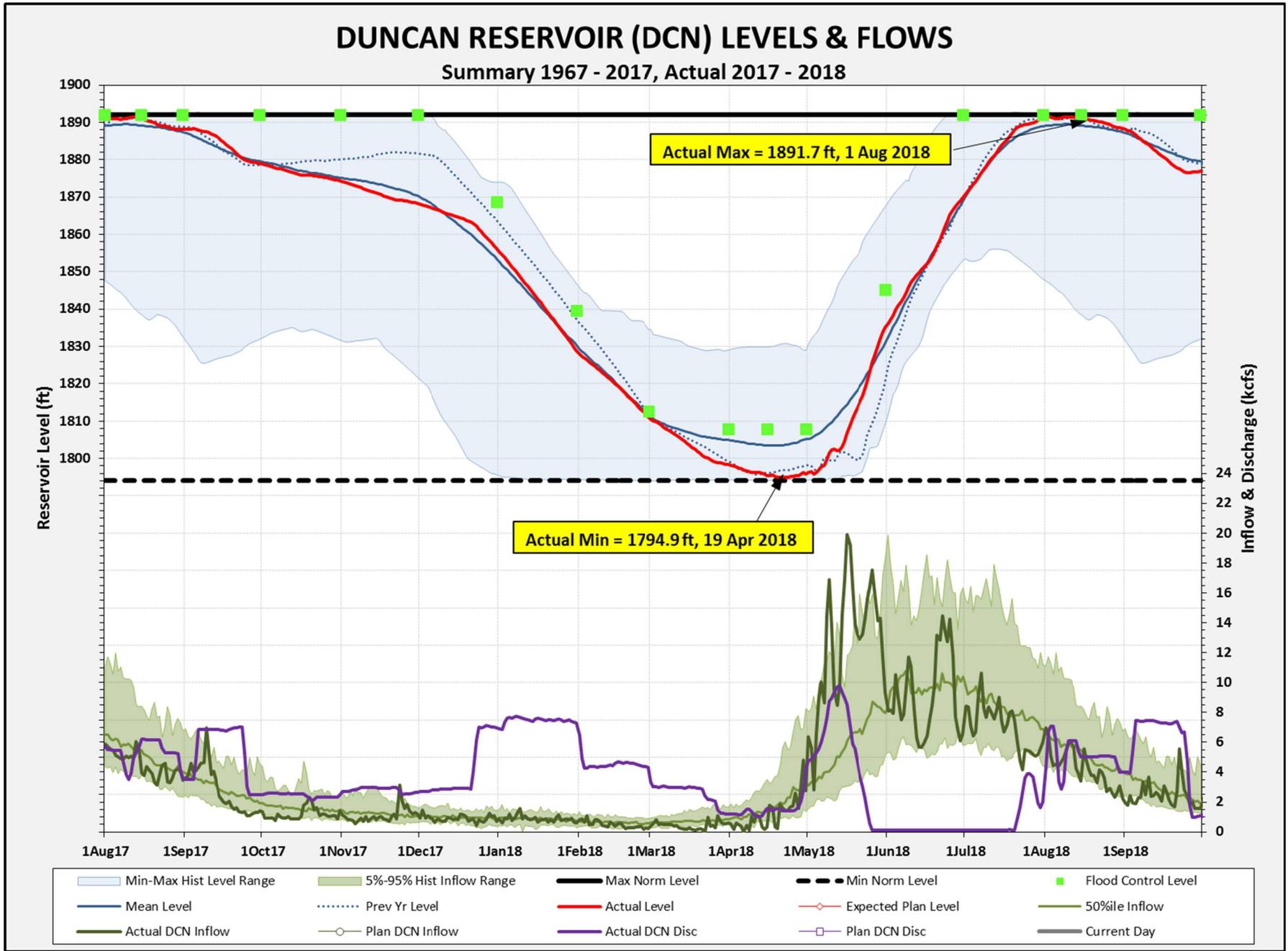
Columbia River Basin projects were operated for FRM objectives according to the May 2003 FCOP. The 2018 runoff volumes were above normal across the Columbia River Basin. The regulated peak outflow during the freshet from The Dalles Dam was 13,705 m³/s (484.0 kcfs) on 17 May 2018, and the unregulated peak flow was estimated at 21,464 m³/s (758.0 kcfs) on 19 May 2018. The peak stage observed during the freshet at Vancouver, Washington, was 4.88 m (16.0 ft) on 17 May 2018, and the estimated peak unregulated stage was 7.71 m (25.3 ft) on 19 May 2018, while the flood stage is 4.88 m (16.0 ft).



ARROW LAKES RESERVOIR (ARD) LEVELS & FLOWS

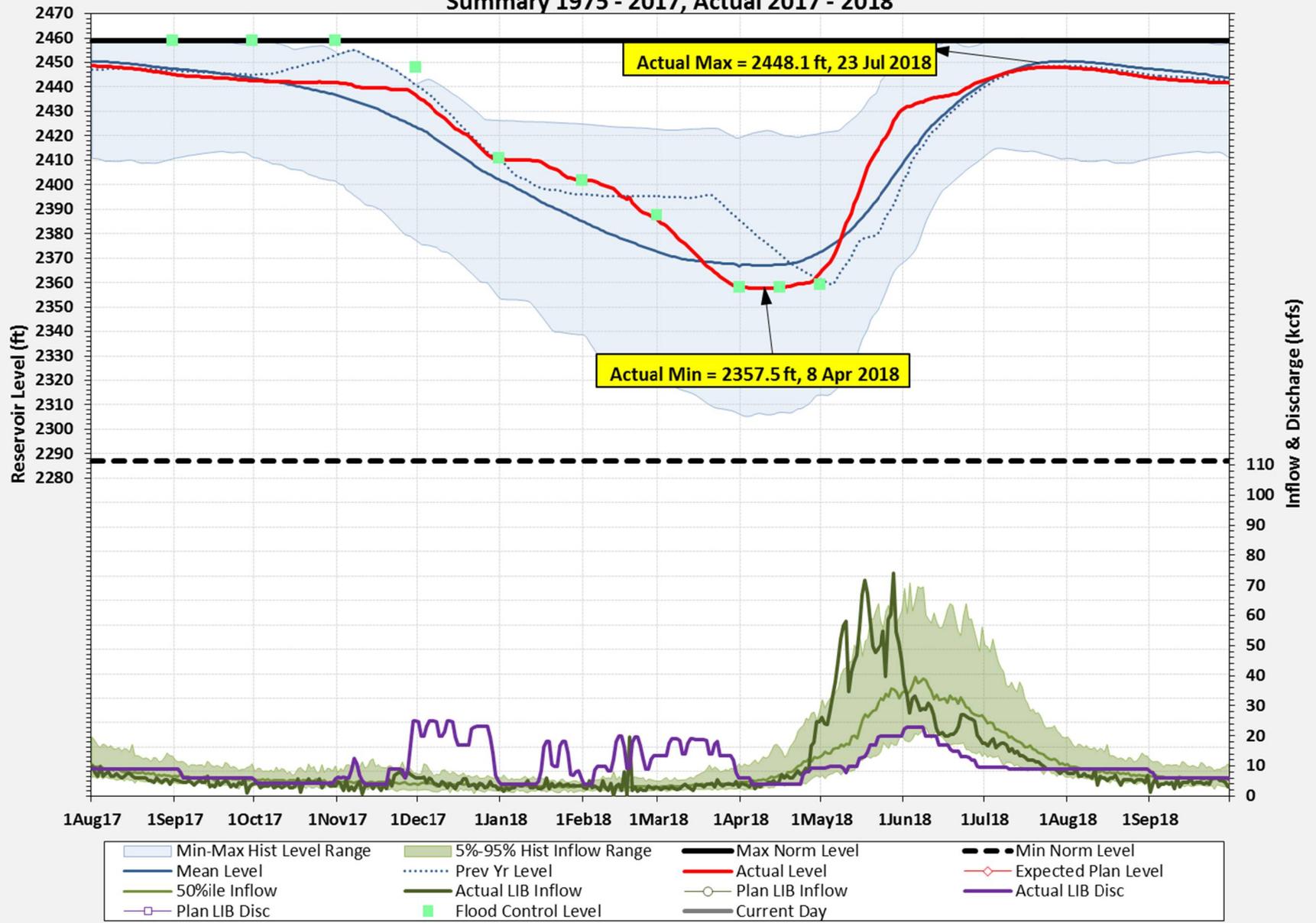
Summary 1968 - 2017 and Actual 2017 - 2018



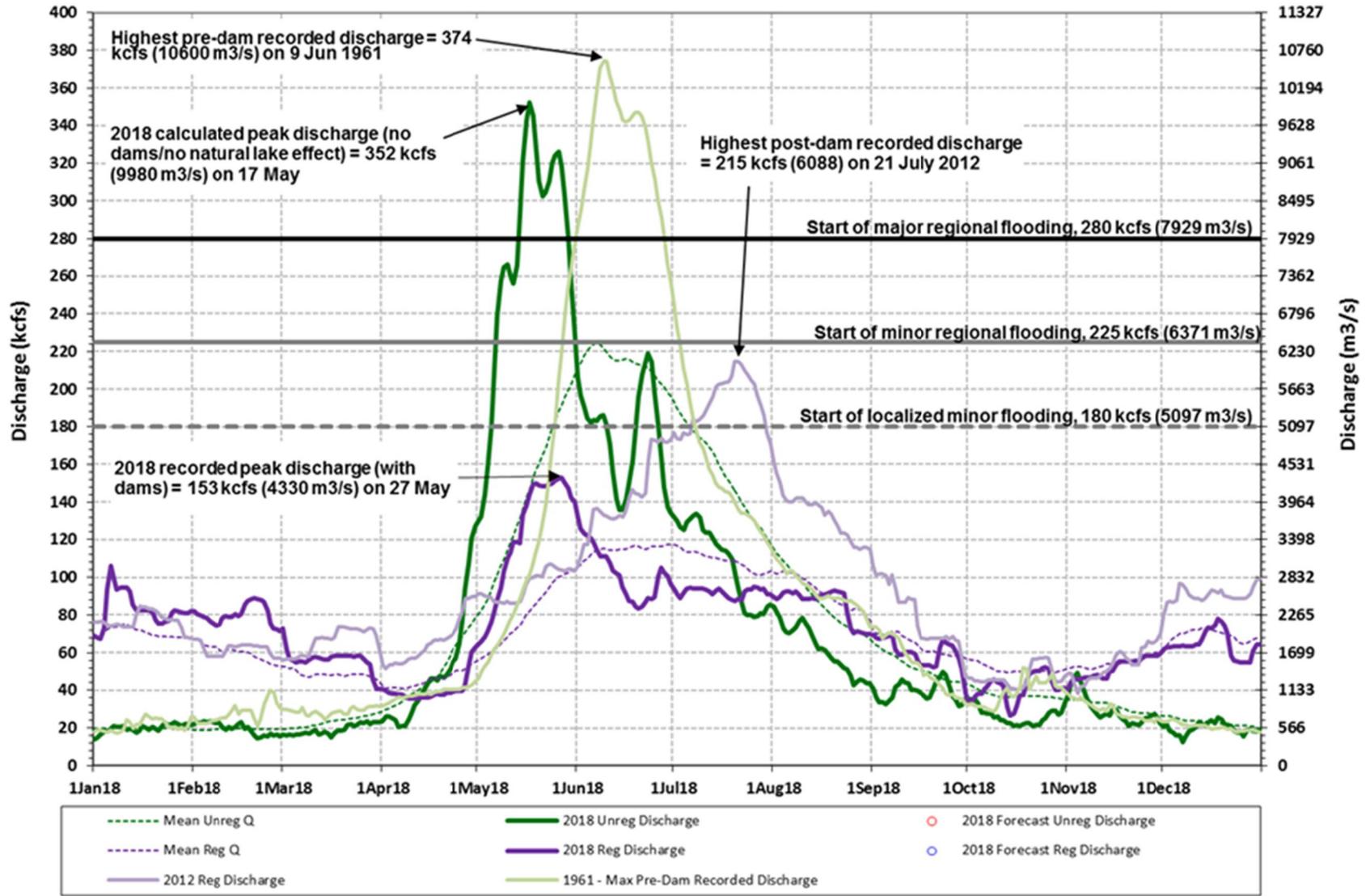


LIBBY RESERVOIR (LIB) LEVELS & FLOWS

Summary 1975 - 2017, Actual 2017 - 2018



COLUMBIA RIVER AT BIRCHBANK AVERAGE DAILY DISCHARGE (Brilliant Project + Brilliant Expansion + Brilliant Spill + Arrow Lakes Hydro + Hugh Keenleyside)



TREATY BENEFITS

Water Year 2018 was an active FRM season due to the well-above-average seasonal volumes. Higher-than-average amounts of low-level snow pack (particularly in the Snake River Basin), rain on snow, and elevated baseflow in parts of the basin were carefully managed to meet system needs and to achieve local FRM objectives as detailed below. Reservoirs throughout the Columbia River Basin, including the Canadian Storage projects, were drafted during the winter and spring in preparation for flood season. The actual unregulated runoff for the overall Columbia River Basin (U.S. and Canada combined) measured at The Dalles for January through July 2018 was 146.4 km³ (118.7 Maf), 117 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 Estimated	Date	Peak Regulated Flow
19 May 2018	21,464 m ³ /s (758.0 kcfs)	17 May 2018	13,705 m ³ /s (484.0 kcfs)

Columbia River Stage at Vancouver, Washington

Flood Stage is 4.88 m (16.0 ft)

Date	Peak Unregulated Stage Estimated	Date	Peak Regulated Stage
19 May 2018	7.71 m (25.3 ft)	17 May 2018	4.88 m (16.0 ft)

Hydroregulation by the Duncan and Libby projects limited the peak level of Kootenay Lake at Queen's Bay to 534.1m (1,752.2 ft) on 27 May 2018. Without regulation from those Treaty dams, the peak level would have been approximately 536.05 m (1,758.7 ft). As documented in the 2003 FCOP, flood damages commence at Nelson when the Kootenay Lake elevation reaches 534.92 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 4,474 m³/s (158.0 kcfs) on 27 May 2018. Absent the dams, but with natural lake effects at Kootenay Lake, the flow would have been approximately 8,294 m³/s (292.9 kcfs). For reference as per the DOP16, the bankfull flow at Birchbank is estimated to be 5,097.0 m³/s (180 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 2017 through 31 July 2018, the CE amount, before deducting transmission losses, was 475.0 average Megawatts (aMW) of energy, scheduled at rates up to 1,304 Megawatts (MW). From 01 August 2018 through 30 September 2018, the amount, before deducting transmission losses, was 472.5 aMW of energy, scheduled at rates up to 1,284 MW.

During the course of the 2017-2018 Operating Year, there were two CE delivery curtailment events. On 16 October and 26 October 2017 two separate deliveries of Canadian Entitlement were curtailed, along with all other schedules between BC and the U.S. The first curtailment of Canadian Entitlement was 664 megawatt hours (MWh), and the second curtailment was 560 MWh. Both deliveries were returned successfully within the next 24 hours.

Actual U.S. power benefits from the operation of CRT storage are unknown and can only be roughly estimated. Canadian Storage has such a large impact on the U.S. system operation that its absence would significantly affect operating procedures, non-power requirements, loads and resources, and market conditions, thus making any benefit analysis highly speculative. A rough estimate of the impact on downstream U.S. power generation during the 2017-18 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 1,069 aMW. The increase in hydro power generation occurred primarily in the winter months of January and February. No quantification of this benefit is provided in this report.

Other Benefits

During 2017-18, the CRTOC completed a supplemental operating agreement, the Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 01 December 2017 through 31 July 2018 (NPU), for the mutual benefit of both countries, signed 14 November 2017. This agreement fulfilled the Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) requirement that supports the 2010 and 2014 Biological Opinions and provided for storing 1 Maf of flow augmentation water by the end of January 2018 then releasing later in the year for downstream salmon migration. Provisions under the NPU maintained stream flows downstream of Keenleyside Dam, from April through June, at or above 15 kcfs for protection of rainbow trout spawning in Canada. Water that was stored in January under the NPU is intended to enhance conditions for the downstream migration of salmon in the U.S. from May – July. Although still a benefit in 2018, most of flow augmentation in 2018 was forced out earlier than desired due to FRM constraints. The remaining flow augmentation water was subsequently released May through July 2018 to help meet U.S. salmon flow objectives.



Revelstoke Dam, Columbia River, BC



Cora Linn Dam (FortisBC) at the outflow of Kootenay Lake, British Columbia

APPENDIX A

**COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD**

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

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Directorate of Civil Works
US Army Corps of Engineers
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Consultant
Newberg, Oregon

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Engineering and Construction
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

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Consultant
Lake Oswego, Oregon

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Principal Hydrologic & Hydraulic Engineer
Engineering & Construction
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

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Director General
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

Mr. Tim Newton, P.Eng.
Consultant
Vancouver, British Columbia

Mr. Les MacLaren
Assistant Deputy Minister
Electricity and Alternative Energy Branch
BC Ministry of Energy and Mines
Victoria, British Columbia

Ms. Renata Kurschner
Consultant
Delta, British Columbia

Mr. Darcy Blais
Associate Director
Renewable and Electrical Energy Division
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

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Mr. Ronald Wilkerson 1988–2005
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Mr. Thomas Weaver 1979–1997
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Mr. George Bell 1997–2014
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Mr. Robert Pietrowsky 2004-2017
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Dr. Niall O’Dea* 2015-

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Mr. Hugh Hunt 1966–1988
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Mr. Vic Niemela 1992–1994
Mr. David Burpee 1994–2007
Mr. Jack Farrell 1996–1997
Mr. Prad Kharé 1997–1999
Mr. James Mattison 1999–2009
Mr. Ivan Harvie 2007–2015
Mr. Glen Davidson 2009-2017
Mr. Les MacLaren 2015-
Ms. Renata Kurschner 2017-

Mr. Mac Clark 1964–1992
Mr. David Burpee 1992–2003
Ms. Eve Jasmin 2003–2007
Mr. Darcy Blais 2007-

*Chair

**COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
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Manager
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Washington, DC

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Vice President, Technical Services
Headquarters
Western Area Power Administration
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Mr. John Roache
Manager
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Pacific Northwest Regional Office
Bureau of Reclamation
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Associate Director
Renewable and Electrical Energy Division
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Victoria, British Columbia

Ms. Tracey Kutney
Senior Technical Advisor
Renewable and Electrical Energy Division
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

**COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
ENGINEERING COMMITTEE**

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Mr. James Fodrea 1997-2009
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Mr. Robert Bank* 2000-2004
Mr. Kamau Sadiki 2001-2017
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Mr. Daniel Rabon 2017-
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Mr. David Burpee* 1992-2000
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Mr. Bruno Gobeil 1995-1997
Mr. Larry Adamache 1996-2001
Ms. Myriam Boudreault 1997-2001
Ms. Donna Clarke 2001-2003
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Ms. Eve Jasmin 2003-2007
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Mr. KT Shum 2008-2018
Mr. Chris Trumpy 2015-2017
Ms. Tracey Kutney 2016-
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*Chair

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

COLUMBIA RIVER TREATY ENTITIES

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Department of Energy
Portland, Oregon

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Division Engineer
US Army Engineer Division
Northwestern
Portland, Oregon

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

Mr. David Ponganis, USACE Coordinator
Regional Director of Programs
Programs Directorate
US Army Engineer Division
Northwestern
Portland, Oregon

Secretaries

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

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President and Chief Operating Officer
British Columbia Hydro and Power Authority
Vancouver, British Columbia

Ms. Heather Matthews, Coordinator
Director
Generation Systems Operations
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Chris Revell, Secretary
Planning and Licensing Generation
Management System Operation
British Columbia Hydro and Power Authority
Burnaby, British Columbia

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Bonneville Power Administration
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Portland, Oregon

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Regional Coordination
Power and Operations Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

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Columbia Basin Water Management Division
US Army Engineer Division
Northwestern
Portland, Oregon

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System Optimization
Generation Resource Management
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Burnaby, British Columbia

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Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Ms. Gillian Kong, Member
Specialist Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Herbert Louie, Member
Specialist Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

COLUMBIA RIVER TREATY ENTITIES HYDROMETEOROLOGICAL COMMITTEE

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Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. William Proctor, Co-chair
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Hydrologic Engineering and Power Branch
US Army Engineer Division
Northwestern
Portland, Oregon

Canada

Ms. Stephanie Smith, Chair
Manager
Hydrologic and Technical Services
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Georg Jost, Member
Senior Engineer
Hydrology and Technical Services
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

APPENDIX C

RECORD OF FLOWS AT THE INTERNATIONAL BOUNDARY

KOOTENAI RIVER AT PORTHILL, IDAHO**Daily discharges in thousands of cubic feet per second for the year ending 30 September 2018**

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	6.93	7.04	28.80	7.42	9.66	16.90	12.10	30.40	34.20	13.70	10.60	9.78
2	5.95	7.21	27.30	6.63	7.97	17.10	12.00	29.40	35.20	13.70	10.20	9.10
3	5.40	7.58	23.60	6.44	7.77	17.00	11.70	29.20	34.20	13.40	9.97	8.27
4	5.23	7.36	23.50	6.48	8.31	16.80	11.50	31.50	34.20	13.20	9.93	7.18
5	5.22	7.37	25.50	6.79	9.22	16.90	11.10	36.40	34.40	13.10	10.10	7.18
6	5.35	7.41	26.30	6.84	14.30	20.60	9.87	39.60	33.50	13.00	10.10	6.93
7	5.28	10.10	27.30	6.63	15.10	21.90	9.43	43.10	32.70	12.70	10.20	7.03
8	5.19	13.30	27.40	6.42	15.10	22.40	9.67	45.30	32.30	12.80	10.10	7.05
9	5.34	11.70	26.40	6.41	16.80	22.50	10.00	47.40	31.70	12.60	10.20	7.06
10	5.12	8.24	23.20	6.62	16.70	21.60	10.50	47.10	30.20	12.20	10.20	6.79
11	5.13	6.34	22.60	6.84	15.00	18.20	11.00	43.20	29.40	12.10	10.40	6.93
12	5.33	5.53	24.20	6.89	14.10	17.90	11.70	38.80	28.80	12.20	9.80	6.98
13	5.37	5.65	27.10	6.61	17.20	21.10	12.60	36.60	28.00	12.10	9.95	6.74
14	5.24	5.72	27.40	6.66	22.90	22.10	12.50	37.30	26.90	11.40	10.00	6.74
15	5.28	5.52	26.50	6.70	24.60	22.20	12.90	39.80	24.90	11.60	9.96	6.75
16	5.30	5.77	22.70	7.30	23.90	22.10	14.60	44.00	24.30	11.50	9.97	6.88
17	5.88	5.55	20.20	10.90	21.30	22.30	17.60	46.20	24.00	11.50	10.00	6.75
18	5.46	5.50	19.80	18.50	14.20	22.40	17.60	45.30	23.60	11.30	9.85	6.78
19	5.64	5.52	19.90	20.80	13.90	22.40	16.20	42.40	22.00	11.10	9.89	6.94
20	6.10	5.44	20.30	20.20	21.00	21.40	15.40	40.00	21.30	11.00	9.99	6.78
21	5.93	9.18	20.10	13.70	22.80	18.40	15.30	38.50	20.80	10.50	9.88	6.71
22	6.20	10.60	24.50	12.50	23.00	18.40	16.20	38.80	20.40	10.70	9.79	6.61
23	6.38	14.60	25.50	12.80	20.00	22.20	16.40	41.50	19.70	10.50	9.84	6.90
24	5.99	21.90	25.30	19.20	15.60	22.60	16.40	42.70	19.30	10.50	9.91	6.70
25	5.67	18.60	25.20	20.60	12.70	19.60	19.60	43.80	18.30	10.50	9.80	6.76
26	5.87	14.80	25.00	20.50	12.50	19.00	22.20	43.30	18.10	10.60	9.86	6.86
27	5.74	12.20	25.20	16.40	15.60	18.50	25.60	41.40	17.20	10.80	9.93	6.81
28	5.50	14.80	25.20	10.60	16.70	18.50	30.30	39.60	16.40	10.70	9.83	6.72
29	5.64	23.50	21.50	10.20	0.00	18.50	32.80	38.10	14.70	10.50	9.75	6.57
30	5.51	28.50	16.20	11.60		16.60	32.30	36.20	14.10	10.50	9.98	6.49
31	5.49		9.34	11.90		13.70		34.30		10.60	9.94	
Mean	5.60	10.42	23.65	10.91	15.45	19.74	15.90	39.72	25.49	11.70	10.00	7.06

COLUMBIA RIVER AT BIRCHBANK, BC

Daily discharges in thousands of cubic feet per second for the year ending 30 September 2018

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	53.33	47.68	50.86	52.63	50.86	42.03	36.73	56.87	134.92	144.81	111.61	71.35
2	52.98	47.68	52.27	52.98	51.21	42.03	36.03	58.28	136.69	143.75	110.20	69.23
3	52.63	47.68	53.33	53.33	50.51	41.68	36.38	59.69	138.81	142.34	109.49	68.87
4	52.27	47.68	54.39	54.39	49.45	42.03	36.38	61.10	140.57	140.57	108.79	68.17
5	50.86	47.68	55.10	55.45	49.09	40.97	36.73	62.87	142.69	138.81	107.73	67.46
6	50.15	46.98	56.16	55.81	49.09	39.56	36.73	64.28	144.46	138.10	106.67	68.17
7	49.45	46.62	56.16	56.16	48.74	39.21	36.38	66.05	146.22	137.75	105.61	68.52
8	48.74	46.27	55.81	56.16	48.74	38.50	36.73	68.17	146.93	137.04	104.19	68.17
9	48.04	45.92	56.51	56.87	48.04	39.21	37.44	70.64	147.64	135.98	102.43	67.81
10	47.68	46.27	56.87	57.57	47.33	39.91	37.79	72.76	147.64	134.57	100.66	66.75
11	47.33	46.27	56.51	57.22	47.68	39.56	38.50	75.23	147.28	133.16	99.25	65.34
12	46.98	46.62	56.51	56.87	48.39	39.21	38.85	77.70	147.64	132.45	97.13	64.64
13	46.98	46.98	57.22	56.16	48.39	39.21	39.21	80.53	147.99	131.74	95.72	63.93
14	46.98	46.98	57.22	55.81	48.04	39.21	40.26	83.36	148.70	131.39	94.30	62.87
15	46.98	46.98	56.87	55.45	47.68	39.21	41.32	86.53	149.05	130.33	92.54	61.81
16	46.98	45.92	56.51	55.10	47.68	39.21	42.38	89.71	149.76	129.62	91.13	60.40
17	46.62	46.27	56.16	54.75	47.33	39.56	43.09	92.89	150.46	129.27	90.42	59.69
18	46.62	46.98	55.81	54.04	47.33	39.56	43.44	95.72	150.82	128.92	89.71	59.34
19	46.98	46.98	55.45	53.33	46.62	39.21	43.80	98.54	150.82	128.21	88.65	58.98
20	46.98	47.33	55.10	52.98	45.92	39.21	44.50	101.72	150.46	127.51	86.89	58.98
21	47.33	47.33	54.39	52.98	44.86	39.56	45.21	104.55	149.40	126.09	85.47	57.92
22	47.33	47.33	54.04	52.98	44.50	39.56	46.62	108.08	148.34	124.33	84.77	57.22
23	46.98	46.98	53.69	52.63	43.80	39.91	48.04	111.26	148.34	122.56	83.71	56.51
24	47.33	47.33	51.92	52.63	43.44	39.91	49.45	114.79	148.34	120.79	82.30	56.16
25	46.98	47.68	51.21	52.63	43.09	39.91	49.80	118.32	148.34	118.68	81.59	55.45
26	46.98	48.39	50.86	52.27	42.74	40.26	50.51	121.85	147.99	116.91	81.59	55.10
27	46.98	48.74	51.21	52.27	42.38	40.26	51.57	124.33	146.93	115.50	81.94	55.10
28	46.98	49.80	51.92	52.27	42.03	40.26	52.98	126.80	146.58	114.79	80.88	55.10
29	47.33	49.80	52.63	51.92	0.00	39.56	54.39	129.27	146.22	113.73	79.47	54.75
30	47.33	49.80	52.98	51.92		38.85	55.45	131.04	145.52	113.38	78.06	54.04
31	47.68		52.98	51.92		37.79		133.16		113.02	75.58	
Mean	48.22	47.36	54.47	54.18	45.34	39.81	42.89	91.81	146.52	128.91	93.18	61.93

APPENDIX D

PROJECT INFORMATION

Power and Storage Projects

Northern Columbia Basin

Plate No. 1

Project Data

Duncan Project

Table No. 1

Arrow Project

Table No. 2

Mica Project

Table No. 3

Libby Project

Table No. 4

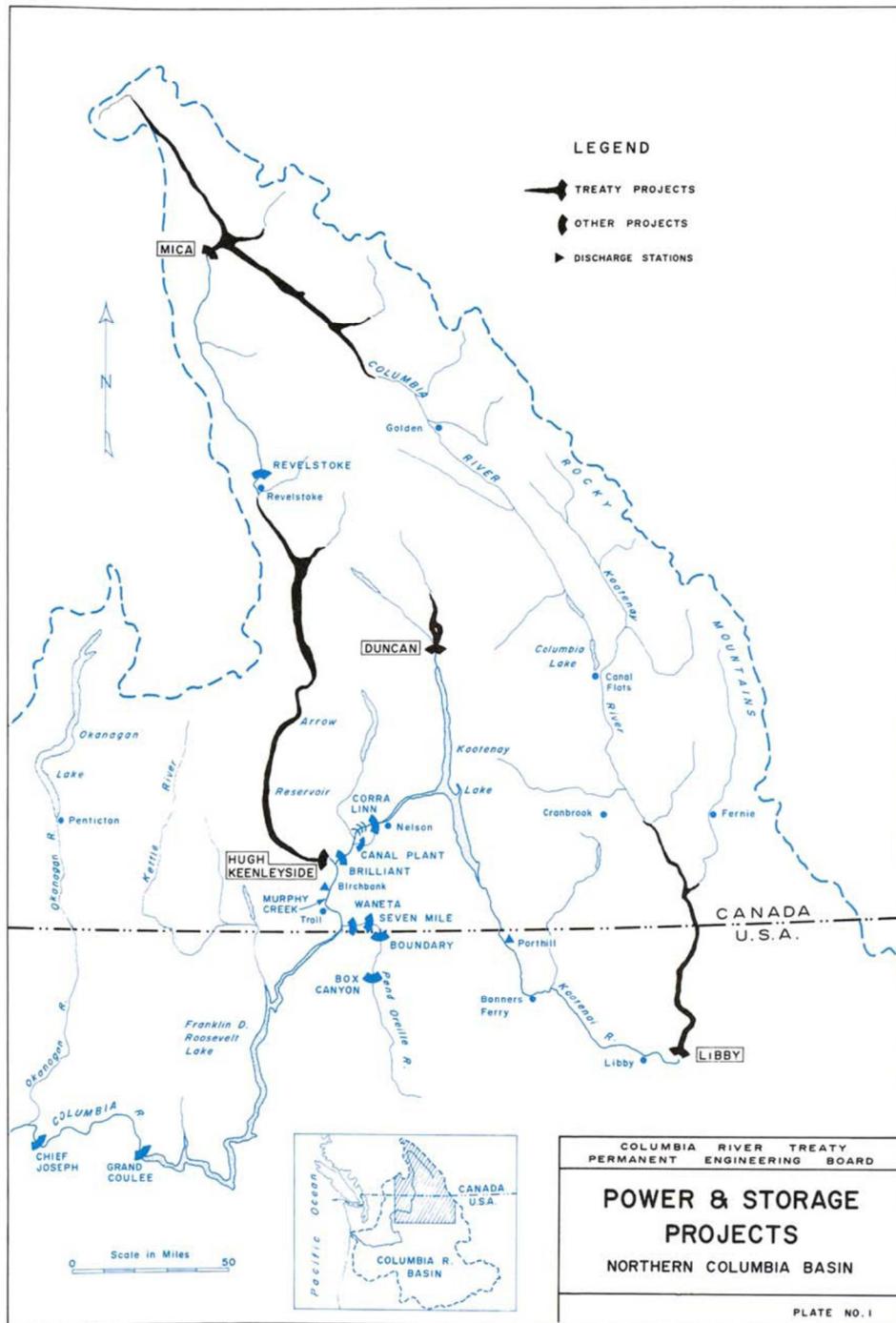


TABLE 1

DUNCAN PROJECT

Duncan Dam and Duncan Lake

Storage Project

Construction began	17 September 1964
Storage became fully operational	31 July 1967

Reservoir

Normal full pool elevation	577 m (1892 ft)
Normal minimum pool elevation	547 m (1794 ft)
Surface area at full pool	7290 hectares (18,000 acres)
Total storage capacity	1.77 km ³ (1.43 Maf)
Usable storage capacity	1.73 km ³ (1.40 Maf)
Treaty storage commitment	1.73 km ³ (1.40 Maf)

Dam, Earthfill

Crest elevation	581 m (1907 ft)
Length	792 m (2600 ft)
Approximate height above riverbed	39.6 m (130 ft)
Spillway – Maximum capacity	1350 m ³ /sec (47.7 kcfs)
Discharge tunnels – Maximum capacity	570 m ³ /sec (20.0 kcfs)

Power Facilities

None

TABLE 2
ARROW PROJECT**Hugh Keenleyside Dam and Arrow Lakes****Storage Project**

Construction began	March 1965
Storage became fully operational	10 October 1968

Reservoir

Normal full pool elevation	440 m (1444 ft)
Normal minimum pool elevation	420 m (1378 ft)
Surface area at full pool	52,610 hectares (130,000 acres)
Total storage capacity	10.3 km ³ (8.34 Maf)
Usable storage capacity	8.8 km ³ (7.10 Maf)
Treaty storage commitment	8.8 km ³ (7.10 Maf)

Dam, Concrete Gravity and Earthfill

Crest elevation	445 m (1459 ft)
Length	869 m (2850 ft)
Approximate height above riverbed	52 m (170 ft)
Spillway – Maximum capacity	6800 m ³ /sec (240 kcfs)
Low-level outlets – Maximum capacity	3740 m ³ /sec (132 kcfs)

Power Facilities

Currently installed:

2 units at 92.5 MW	185 MW
Power commercially available	2002
Head at full pool (Gross maximum head)	23.5 m (77 ft)
Maximum turbine discharge	1200 m ³ /sec (42.4 kcfs)

TABLE 3**MICA PROJECT****Mica Dam and Kinbasket Lake****Storage Project**

Construction began	September 1965
Storage became fully operational	29 March 1973

Reservoir

Normal full pool elevation	754.4 m (2475 ft)
Normal minimum pool elevation	707.1 m (2320 ft)
Surface area at full pool	42,900 hectares (106,000 acres)
Total storage capacity	24.7 km ³ (20 Maf)
Usable storage capacity	14.8 km ³ (12 Maf)
Treaty storage commitment	8.6 km ³ (7 Maf)

Dam, Earthfill

Crest elevation	762.0 m (2500 ft)
Length	792.5 m (2600 ft)
Approximate height above foundation	244 m (800 ft)
Spillway – Maximum capacity	4250 m ³ /sec (150 kcfs)
Outlet works – Maximum capacity	1060 m ³ /sec (37.4 kcfs)

Power Facilities

Currently installed:

Authorized diversion in the project's water licence limits generation to 2750 MW.

Head at full pool 183 m (600 ft)

4 units at 451 MW	1805 MW
Power commercially available	1976
Maximum turbine discharge of 4 units at full pool	1080 m ³ /sec (38.2 kcfs)

2 units at 520 MW	1040 MW
Power commercially available	2014-15
Maximum turbine discharge of 2 units at full pool	330 m ³ /sec (37.4 kcfs)

TABLE 4**LIBBY PROJECT****Libby Dam and Lake Koocanusa****Storage Project**

Construction began	June 1966
Storage became fully operational	17 April 1973

Reservoir

Normal full pool elevation	749.5 m (2459 ft)
Normal minimum pool elevation	697.1 m (2287 ft)
Surface area at full pool	18,820 hectares (46,500 acres)
Total storage capacity	7.2 km ³ (5.87 Maf)
Usable storage capacity	6.1 km ³ (4.98 Maf)

Dam, Concrete Gravity

Deck elevation	753.5 m (2472 ft)
Length	931.2 m (3055 ft)
Approximate height above riverbed	112.8 m (370 ft.)
Spillway – Maximum capacity	4110 m ³ /sec (145 kcfs)
Low-level outlets – Maximum capacity	1730 m ³ /sec (61 kcfs)

Power Facilities

Designed ultimate installation:

8 units at 105 MW	840 MW
-------------------	--------

Currently installed:

5 units at 120 MW	600 MW
Power commercially available	1975
Head at full pool	107 m (352 ft)
Maximum turbine discharge of 5 units at full pool	750 m ³ /sec (26.5 kcfs)