ANNUAL REPORT

to the

GOVERNMENTS

of

THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

30 September 2016

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COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A • U N I T E D S T A T E S

CANADIAN SECTION
N. O'DEA, Chair
T. Newton, Member

UNITED STATES SECTION
J. DALTON, Chair
E. Sienkiewicz, Member

8 February 2017

The Honorable Rex Tillerson
Secretary of State
Washington, D.C.

The Honourable James Carr
Minister of Natural Resources
Ottawa, Ontario

Dear Secretary Tillerson and Minister Carr:

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 52nd Annual Report of the Permanent Engineering Board, dated 30 September 2016. The report documents the results achieved under the Treaty for the period from 1 October 2015 to 30 September 2016.

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

In addition, we wish to draw your attention to the expiry of Article IV(2)(a) of the Treaty in September 2024. This Article outlines the principles by which Canada is required to operate to provide flood control for the initial sixty years of the Treaty's term (1964 to 2024), and for which the United States made payment to Canada of USD 64.4 million under Article VI. Absent agreement by the two countries to continue with this or some other arrangement, after September 30, 2024, flood risk management operations under the Treaty will be governed by the procedures described in Article 2(3), commonly referred to as the "called-upon" procedure. This represents a significant change to the regime by which flood risk is managed in the Columbia Basin.

As described in Annex B of the Treaty, the Treaty Entities are to agree to an "assured plan of operation" for Canadian Treaty storage five years in advance for the sixth succeeding year as the basis for determining downstream power benefits. This is known as the Assured Operating Plan or AOP. The AOP for the 2024-25 operating year would, therefore, be required to be finalized and agreed upon by the Entities no later than September 30, 2019 for the Treaty to remain in compliance. As this would be the first such AOP to incorporate the "called-upon" flood control procedure, it represents a significant change from the first sixty years of operations under the Treaty. In order to develop the 2024-25 AOP, the Entities need to develop, analyze and agree upon methodologies and procedures for the "called-upon" operations. Given these complexities, it will be important that the U.S. and Canadian Entities take action to dedicate the resources necessary to define the operations required.

Respectfully submitted:

For the United States	For Canada
James Dalton, Chair	Niall O'Dea, Chair
Ed Sienkiewicz	Tim Newton

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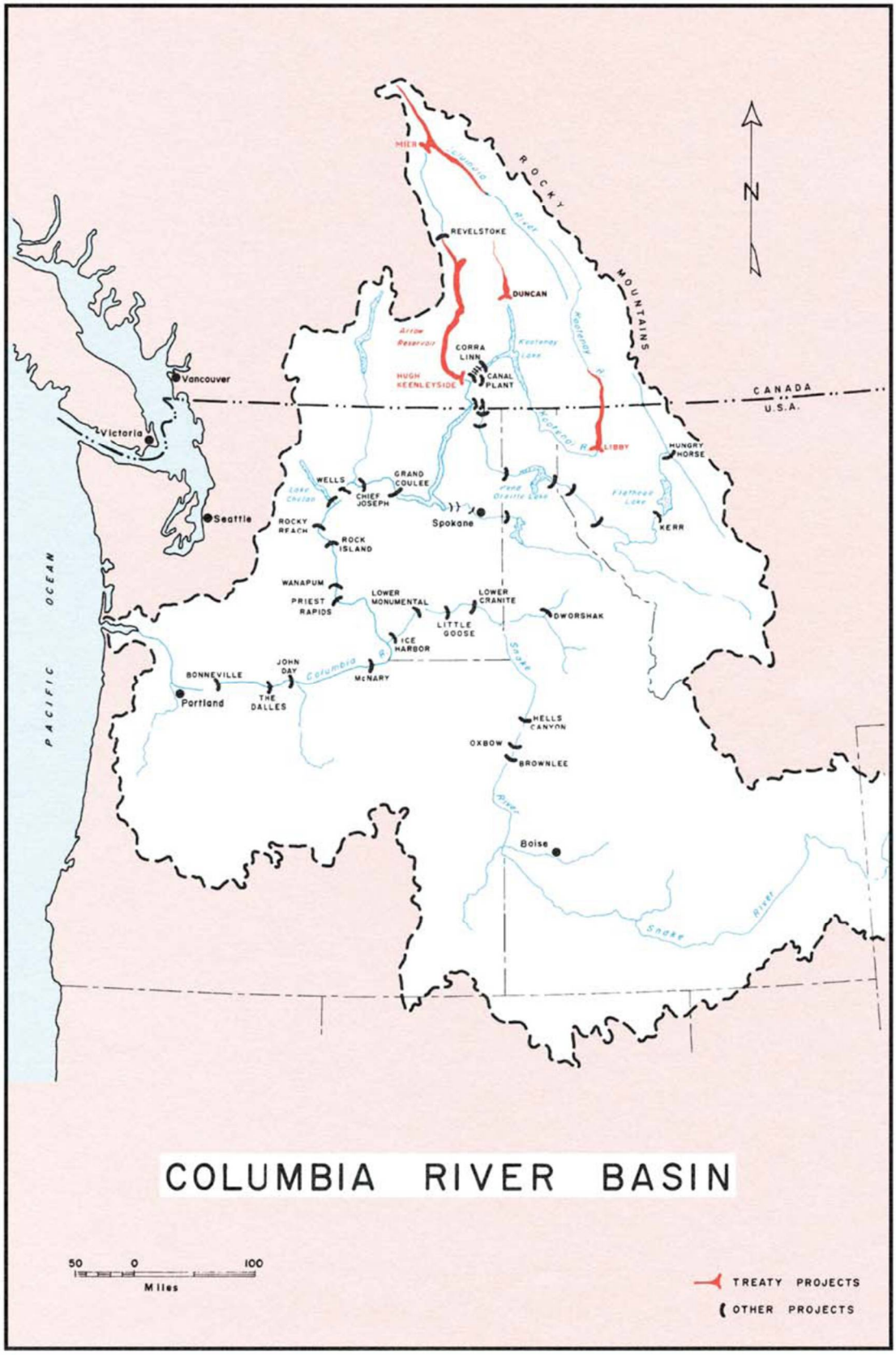

COLUMBIA RIVER BASIN

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ANNUAL REPORT

to the

GOVERNMENTS

of

THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 September 2016

EXECUTIVE SUMMARY

The fifty-second 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 (CRT) 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 2015 to 30 September 2016.

During the reporting period, the Canadian Treaty projects – Mica, Duncan, and Arrow – were operated according to the 2015-2016 and 2016-2017 Detailed Operating Plans (DOPs), the 2003 Flood Control Operating Plan (FCOP), and several supplemental operating agreements. 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 (USFWS) 2006 Biological Opinion (BiOp), as clarified, and NOAA Fisheries' 2010 and 2014 Supplemental BiOp for operation and maintenance of the Federal Columbia River Power System (FCRPS).

Canadian Treaty storage began the Operating Year on 1 August 2015 at 76.8 percent full, and ended the year on 31 July 2015 at 81.2 percent full. The actual January through July runoff for the Columbia River above The Dalles was 120.4 km^3 (97.6 Maf), or 96 percent of the 1981-2010 average. In contrast, the actual April through August runoff for the Columbia River above The Dalles was 96.7 km^3 (78.4 Maf), or 90 percent of the 1981-2010 average. Water Year 2016 resulted in a quiet flood risk management season due to the slightly below average seasonal volumes. Near normal snow pack, early runoff, and below average late season precipitation across the basin resulted in no significant system or local flood risk issues.

The Canadian Entitlement (CE) to the downstream power benefits for the reporting period was determined according to the procedures set out in the Treaty and Protocol. From 1 August 2015 through 31 July 2016, the U.S. Entity delivery of the Canadian Entitlement to downstream power benefits, before deducting transmission losses, was 488.7 megawatts of average energy at rates up to 1,332 megawatts of capacity. From 1 August 2016 to 30 September 2016, the U.S. Entity delivery of the Canadian Entitlement to downstream power benefits, before deducting transmission losses, was 484.0 megawatts of average energy at rates up to 1,333 megawatts of capacity. The Canadian Entitlement obligation was determined by the 2015-2016 and 2016-2017 Assured Operating Plans (AOP) and Determination of Downstream Power Benefits.

During the course of the 2015-2016 Operating Year, there was one CE delivery curtailment event. On 15 December 2015, there was a three MWh cut in one hour which was not due to the intertie system operating limit but due to a flow gate limit. The three MWh was successfully redelivered on 17 December 2015.

The Columbia River Treaty Hydrometeorological Committee (CRTHMC) implemented a new Libby seasonal inflow volume forecast procedure for WY2015. In order to better portray how seasonal water supply forecasts are used, the operating committee adopted the use of The Dalles ESP-generated water supply forecast for use in December water management decisions. The PoP documentation was updated to reflect this change and several others. In order to make water supply and flood risk management information available to the region and for use in treaty coordination sooner in each

month, the committee also recommended using ESP water supply forecasts with 5 days of short-term weather forecasts released on the third working day of each month. These forecasts are produced by the Northwest River Forecast Center. This is a change from previous years where the fifth working day information was used. These recommendations were approved for a one year trial.

BC Hydro completed their transition to secure FTP and all agencies are now receiving Canadian CROHMS data through this more secure channel. Now that B. C. Hydro and BPA are both on the same software modeling platform, the agencies are exploring ways to more efficiently exchange streamflow data for the bi-monthly AER coordination. Fernie BC precipitation gage which was automated last year has been reporting reliably since December 2015 and greatly improved the use of the information in the Libby forecast procedure. Precipitation gages at Porthill and Bonners Ferry ID are currently planned for automation to improve data reliability. CRTHC has determined that the station network is adequate for Treaty purposes.

The CRT Entities continue to work toward a long-term solution to address Flood Risk Management on Kootenay Lake. The Entities are expecting to extend the STLA through 31 August 2018, even though the STLA does not fully address the increase in Kootenay Lake flood risk due to VarQ. Joint studies are underway to examine flood risk management (FRM) operation at Libby.

The Long Term NTSA, executed in April 2012, was utilized by BPA and BC Hydro for power purposes through fall and winter of 2015-16. The NTSA includes a dry year release provision that guarantees to BPA the release of 0.62 km^3 (252 ksfd, 0.5 Maf) from Canadian storage projects during the driest 20 percent of runoff years as measured at The Dalles Dam in the U.S. The “dry year release” provision was not triggered in 2016. 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.

During the period of this Annual Report, the CRTOC completed three supplemental operating agreements. Throughout the operating year, composite Canadian Treaty 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 Nonpower Uses Agreement (NPU). As in past years, the CRTOC negotiated a Nonpower Uses Agreement in order 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 the end of January 2016. 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 flow augmentation water was subsequently released during July 2016 to help meet U.S. salmon flow objectives. From January until the end of July 2016, Canadian storage remained above TSR-specified levels. The CRTOC also negotiated the Arrow Summer Storage Agreements for the periods 1 July 2015 through 30 September 2015 signed on 17 July 2015 and 23 July 2016 through 31 August 2016 signed 21 July 2016 to help mitigate local concerns and operational issues at Arrow.

Regarding the review of the Columbia River Treaty, it was noted that on 13 December 2013 the U.S. Entity transmitted a document called “The U.S. Entity Regional Recommendation for the Future of the Columbia River Treaty after 2024,” to the U.S. Department of State. The U.S. Entity’s

Recommendation and the three-year process leading up to it marked the successful conclusion of the regional engagement chapter of the U.S. Entity's Treaty Review effort, and the beginning of the formal review by the U.S. Government. In the fall of 2015 the U.S. Department of State assigned a lead negotiator to the Columbia River Treaty, a key step in advancing the U.S. process towards formal negotiations. While awaiting the completion of the formal authorization for the U.S. to enter into negotiations with Canada, the lead negotiator conducted informal discussions with regional states, sovereigns, stakeholders, and federal agencies for further alignment and understanding of issues.

Led by the BC Treaty Review team, the Canadian Entity released the Government of British Columbia's decision to continue the Columbia River Treaty and seek improvements within its existing framework on 13 March 2014. BC's decision includes 14 principles that will guide BC in any future discussions with Canada and the U.S. on the future of the Treaty. The decision and principles follow more than two years of technical, social, economic and legal studies and an extensive consultation process with various levels of government, stakeholder groups, First Nations and the public. The principles include considerations around flood risk management, hydropower generation, ecosystems and climate change, while allowing for flexibility moving forward to adapt to evolving economic, social and environmental circumstances in each country.

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ABBREVIATIONS AND ACRONYMS

AER ……Actual Energy Regulation
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
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
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
mi ……Miles
MW ……Megawatts
MWh ……Megawatt hour
NMFS ……National Marine Fisheries Service
NOAA ……National Oceanic and Atmospheric Administration
NTSA ……Non-Treaty Storage Agreement
PEBCOM ……Permanent Engineering Board Engineering Committee
PNCA ……Pacific Northwest Coordination Agreement
PSANI ……Puget Sound Area / Northern Intertie
SRT ……Sovereign Review Team
TSR ……Treaty Storage Regulation
USACE ……US Army Corps of Engineers
USFWS ……US Fish and Wildlife Service
VarQ ……Variable discharge flood control

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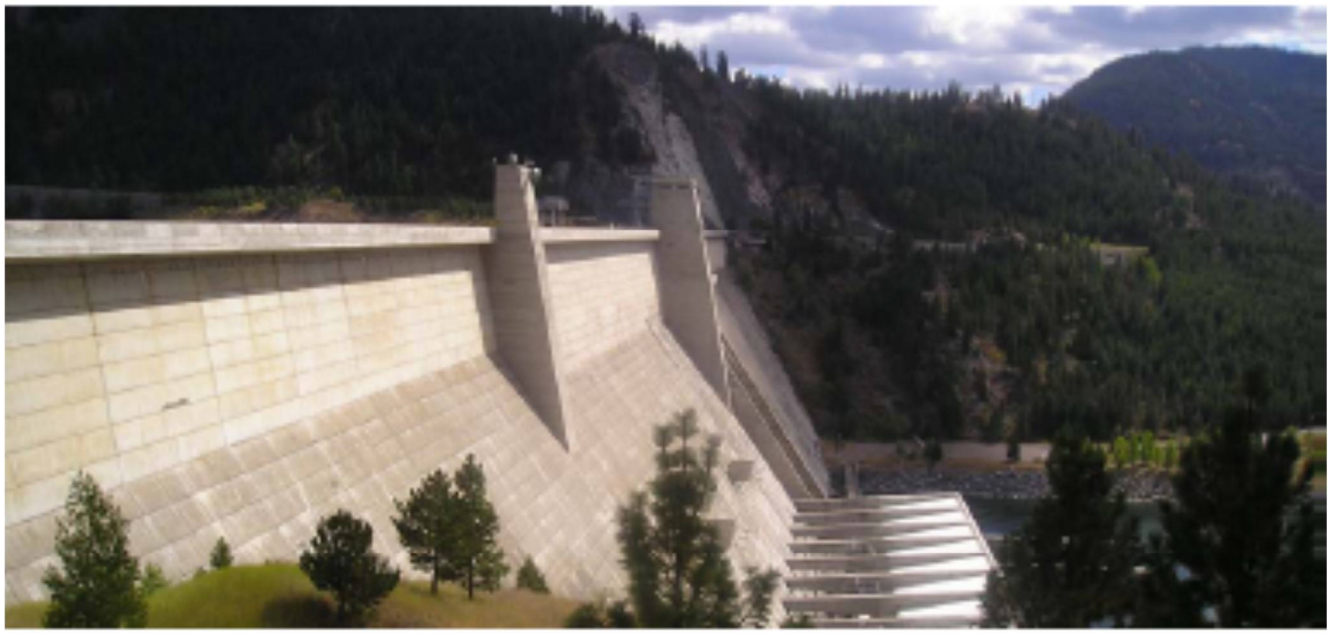
INTRODUCTION

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 2015 through 30 September 2016, describes the activities of the Board, Treaty projects, storage operations, and the resulting benefits achieved by each country. It also presents summaries of the essential features of the Treaty and of the responsibilities of the Board and the Entities.

The report refers to items currently under review by the Entities; provides details on calculating flood control and power benefits and on operation of Treaty reservoirs and flow discharges at the border; 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 (CEPA) 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 and Related Documents

The essential undertakings of the Treaty are as follows:

(a) Canada will provide 19.1 km^3 (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.

(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. 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 60 years (at the earliest) from its date of ratification (that is, on September 16, 2024), provided they have given at least ten years' written notice. Certain provisions of Treaty change automatically in 2024, while others 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. Appointments to the Board were to be made within three months of the date of ratification. 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 (PEBCOM).

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 83rd meeting on 3 February 2016 in Portland, OR. In conjunction with this meeting, the Board also held its 64th joint meeting with the Entities.

The following topics were discussed at the meeting: the current status of the 2016 CRT Review, the preparation and implementation of operating plans, the Short Term Libby Agreement and the delivery of the Canadian Entitlement as well as other Treaty implementation issues.

Reports 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 December 2015.

  This document is Amendment 2 to original agreement and provides for mutually agreeable storage and release of water and specified the associated financial payments through 31 August 2017.

- Columbia River Treaty Agreement on the Assured Operating Plan (AOP) and Determination of downstream Power Benefits (DDPB) For Operating Years 2019-2020, signed January 2016.

  This document is the agreement to implement the AOP and DDPB that provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2019 through 31 July 2020.

- Columbia River Treaty Agreement on the Assured Operating Plan (AOP) and Determination of downstream Power Benefits (DDPB) For Operating Years 2020-2021, signed January 2016.

  This document is the agreement to implement the AOP and DDPB that provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2020 through 31 July 2021.

- Columbia River Treaty Agreement on the Assured Operating Plan (AOP) and Determination of downstream Power Benefits (DDPB) For Operating Years 2021-2022, signed January 2016.

  This document is the agreement to implement the AOP and DDPB that provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2021 through 31 July 2022.

- Columbia River Treaty Agreement on the Assured Operating Plan (AOP) and Determination of downstream Power Benefits (DDPB) For Operating Years 2022-2023, signed January 2016.

  This document is the agreement to implement the AOP and DDPB that provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2022 through 31 July 2023.

- Columbia River Treaty Agreement on the Assured Operating Plan (AOP) and Determination of downstream Power Benefits (DDPB) For Operating Years 2023-2024, signed January 2016.

  This document is the agreement to implement the AOP and DDPB that provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2023 through 31 July 2024.

- Columbia River Treaty Agreement on the Detailed Operating Plan (DOP) for Canadian Storage, signed June 2016.

  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 2016 through 31 July 2017.

- Annual Report of the Columbia River Treaty, Canadian and United States Entities, for the period 1 August 2015 through 30 September 2016.

  This report summarizes the operation of Treaty projects and other activities of the Entities for the period of 1 August 2015 through 30 September 2016.

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 2015, 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, preparation of flood control operating plan, 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 a fifth in 2014, 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 5573 MW of generation capacity in British Columbia that might not have been installed without the Treaty. A sixth turbine with a capacity of 520 MW is being installed in the Mica Dam. 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 13, 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 7, and project data are provided in Appendix D, Table 2.

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) are committed under the Treaty.

Six Francis turbines and generators have been installed. The total capacity is limited to around 2750 MW due to constraints on maximum diversion in its water licence.

The project is shown on page 20, and project data are provided in Appendix D, Table 3.

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 km^3 (5. 9 Maf), of which 6.1 km^3 (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, of 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 (CRTHMC), formed by the Entities in 1968, makes recommendations on further development of the Treaty Hydrometeorological System.

The 2016 Annual Report of CRTHMC was completed in December 2016. In this reporting year, the CRTHMC continued to review and improve the reliability of meteorological stations and data transmission, data storage and exchange network, and forecasting procedures and results.

The newly automated precipitation gauge at Fernie, BC, has been providing data reliability since December 2015. The data is especially useful for Libby forecast. Automation equipment had also been installed in November 2016 in two precipitation stations in Idaho, at Porthill and Bonners Ferry, to improve data reliability and availability.

A more informational December water supply forecast was implemented and documented in the POP. The new forecast methodology uses ensemble streamflow predictions at The Dalles provided by the National Weather Service. It gives non-parametric statistics of monthly water supply forecast rather than single monthly mean values provided in previous forecasts.

Precipitation data input to forecast models are routinely reviewed for anomalies. Data at the Golden Airport used for December forecast was deemed unreliable and replaced by estimates which were later found to be more accurate.

To improve the timeliness of forecasts, CRTHMC proposed making the forecast available on the third working day of each month. The Operating Committee adopts the advanced schedule for a trial period of one calendar year, in 2017.

Efforts to enhance data sharing across multiple servers are ongoing. The effort balances security concerns with the needs to improve data availability and system compatibility.

Power Operating Plans and Calculation 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 calculation 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 2015 through 31 July 2016 dated June 2015, and the Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2016 through 31 July 2017, dated June 2016, as well as in accordance with the Columbia River Treaty Short-Term Libby Agreement on Coordination of Project Operations (STLA) signed in September 2013 and extended in December 2015 to 31 August, 2017, and CRTOC Agreements on Operation of Canadian Storage for Non-power Uses for 1 December 2015 through 31 July 2016, signed on 13 November 2015, and Arrow Summer Storage Agreements for the period 1 July 2015 through 30 September 2015 signed on 17 July 2015 and for the period 23 July 2016 through 31 August 2016 signed on 21 July 2016. These documents were based on the operating criteria and studies contained in the corresponding AOPs, together with any changes agreed to by the Entities.

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. 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 issues concerning salmon and white sturgeon fisheries operations of the Libby Project, and 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.

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.

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.

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.

Transmission Developments

During the course of the 2015-2016 Operating Year, there was one Canadian Entitlement delivery curtailment event. On 15 December 2015, there was a three MWh cut in one hour which was not due to the intertie system operating limit but due to a flow gate limit. The three MWh was successfully redelivered on 17 December 2015.

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 utilized by BPA and BC Hydro for power purposes through fall and winter of 2015-16. The NTSA includes a dry year release provision that guarantees to BPA the release of 0.5 Maf (252 ksfd) from Canadian storage projects during the driest 20 percent of runoff years as measured at The Dalles Dam in the U.S. The “dry year release” provision was not triggered in 2016. 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.

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.

Biological Opinion on the Federal Columbia River Power System

NOAA Fisheries issued a Supplemental Biological Opinion (BiOp) in January 2014. The supplemental BiOp analyzed research and monitoring results from the first five years of work under the original biological opinions, as well as the biological status of the species. The Federal Columbia River Power System (FCRPS) Supplemental 2014 BiOp addresses FCRPS project operations through 2018. Environmental plaintiffs have challenged the biological opinion resulting in a ruling (Opinion and Order) by Judge Simon (successor to Judge Redden) on 4 May 2016. The ruling noted that the Bureau of Reclamation and USACE had violated the National Environmental Policy Act (NEPA) by failing to prepare an Environmental Impact Statement (EIS) in connection with their records of decision adopting the reasonable and prudent alternatives described in the 2014 BiOP. A Court remand order, dated 6 July 2016, provides timelines for the Federal Defendants (Reclamation, USACE and NOAA Fisheries) to complete an EIS as well as for NOAA to correct certain deficiencies to the 2014 BiOP. Scoping of the EIS is to be complete on or before 30 September 2017 with a final Record of Decision by 24 September 2021.

FCRPS project operations until further notice, are under court order and continuing as before including:

- VARQ at Libby and Hungry Horse
- Continue Nonpower Users Agreement (NPU) for 1 Maf of Treaty storage
- Continue to implement Long-Term Non-Treaty Storage agreement with BC Hydro

U.S. Federal action agencies are beginning to prepare a Columbia Basin wide Bull Trout and Kootenai White Sturgeon Biological Assessment in concert with U.S. fish and Wildlife Service.

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 2015 to 30 September 2016, Treaty operations are based on the Treaty Operating Year of 1 August 2015 to 31 July 2016. Additional information for 1 August 2016 to 30 September 2016 is based on the Treaty Operating Year 1 August 2016 to 31 July 2017.

For the 1 August 2015 through 30 September 2016 reporting period, the Canadian Treaty Projects were operated according to the 2015-2016 and the 2016-2017 Detailed Operating Plans (DOPs), the 2003 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 NOAA Fisheries' 2010 and 2014 Supplemental BiOp for operation and maintenance of the Federal Columbia River Power System.

Treaty storage in Canada was operated by the Canadian Entity in accordance with the documents listed below. The Libby project was operated by the U.S. Entity according to the 2003 FCOP, the 2000 LCA, including the 13 January 2010 and 12 October 2010 updates to the Libby Operating Plan (LOP), U.S. requirements for power, guidelines set forth in the U.S. Fish and Wildlife Service (USFWS) 2008 Biological Opinion, and the U.S. National Marine Fisheries Service (NMFS) Biological Opinions and Action Agency Plans, as approved by Court order, and strict application of the eight-step VarQ operating procedures.

- *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 for1 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 2015-2016*, dated September 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 2015 through 31 July 2016.

- *Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2016–2017*, 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 2016 through 31 July 2017.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2015 through 31 July 2016*, dated June 2015

  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 2015 through 31 July 2016.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2016 through 31 July 2017*, dated June 2016

  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 2016 through 31 July 2017.

- *Columbia River Treaty Short-Term Libby Agreement on Coordination of Project Operations (STLA)*, signed 17 December 2015

This document addresses, until 31 August 2017, 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 three supplemental operating agreements during the reporting period:

- *Columbia River Treaty Operating Committee Arrow Summer Storage Agreement for the Period 1 July 2015 through 30 September 2015*, signed 7 July 2015

- *Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 1 December 2015 through 31 July 2016*, signed 13 November 2015

- *Columbia River Treaty Operating Committee Arrow Summer Storage Agreement for the Period 23 July 2016 through 31 August 2016*, signed 21 July 2016

These agreements are similar to previous agreements implemented to utilize Treaty storage for nonpower uses. These uses include: (1) providing flows for Canadian whitefish and trout spawning for the January through June period; (2) enhancing the capability in the U.S. of providing spring and summer flow augmentation for salmon and steelhead; (3) enhancing Arrow Lakes levels by ensuring progressive refill; and, (4) improving the U.S. capability to meet flow objectives for salmon at Vernita Bar below Priest Rapids Dam.

In addition to the agreements listed above, the Bonneville Power Administration and/or USACE and B.C Hydro developed the following bilateral agreements:

- Agreement between BPA and BC Hydro that allowed storage, and subsequent release, of Non-Treaty Storage Agreement (NTSA) water during the period 3 October 2015 through 25 March 2016, providing mutual power and nonpower benefits during the period.

- Agreement between Bonneville Power Administration and BC Hydro to allow BC Hydro to utilize space in BPA's Active NTSA account beginning October 2015. The purpose of the agreement was to provide operating flexibility to both parties.

System Storage

The 2015-16 operating year began on 1 August 2015 with the Canadian Treaty storage at 14.7 km3 (11.9 Maf), or 76.8 percent full. Canadian Treaty storage drafted to a minimum of 3.2 km3 (2.6 Maf), or 16.6 percent full on 4 March 2016, and refilled to 15.5 km3 (12.6 Maf), or 81.2 percent full, on 31 July 2016. Canadian Treaty reservoirs operated in proportional draft mode during August 2015 through January 2016, and again during June 2016 through the end of this reporting period, to meet Treaty firm loads. Throughout the operating year, composite Canadian Treaty 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 Nonpower Uses Agreement (NPU). Exceptions occurred 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 a Nonpower Uses Agreement in order 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 the end of January 2016. 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 flow augmentation water was subsequently released during July 2016 to help meet U.S. salmon flow objectives. From January until the end of July 2016, Canadian storage remained above TSR-specified levels.

The January 2016 water supply forecast for the Columbia River above The Dalles for January through July was 116.1 km^3 (94.1 Maf), or 93 percent of the 1981–2010 average. After the water supply forecast increased to 126.9 km^3 (102.9 Maf) in March, or 102 percent of the 1981-2010 average, the water supply forecasts at The Dalles then decreased going into late spring and early summer. By the June 2016 forecast, the (January-July) runoff forecast had decreased to 123.5 km^3 (100.1 Maf), or 99 percent of the 1981-2010 average. The actual January through July runoff for the Columbia River above The Dalles was 120.4 km^3 (97.6 Maf), or 96 percent of the 1981-2010 average. In contrast, the actual April through August runoff for the Columbia River above The Dalles was 96.7 km^3 (78.4 Maf), or 90 percent of the 1981-2010 average. This illustrates the relatively drier spring and early summer conditions and prior wetter conditions with strong, early runoff. The 2016 water year followed the 2015 drought year. While 2016 was not as low as 2015, it posed some operational challenges on refilling and retaining Canadian Storage due to two consecutive low flow summers.

Operations of the three Canadian projects— Mica, Keenleyside, and Duncan — and Libby in the United States are illustrated below for the 14-month period from 1 August 2015 to 30 September 2016. The hydrographs show actual reservoir levels (Storage Curve) and key rule curves that govern the operations of Treaty storage. The Flood Risk Management Rule Curve specifies maximum month-end reservoir levels which will permit timely evacuation of the reservoir to mitigate potentially high inflows from precipitation and snowmelt events. The First Critical Rule Curve (CRC1) shows the start of the proportional draft that ensures firm power demands can be met under adverse (low) water supply conditions. The Variable Refill Curve shows the reservoir elevations necessary to ensure refilling of the reservoir by the end of July with a reasonable degree of confidence. The Assured Refill Curve indicates the end-of-month storage content required to assure refill of the reservoir based on the 1931 historical volume of inflow during the refill period.

Mica (Kinbasket Reservoir)

Kinbasket reached a maximum elevation in 2015 of 750.97 m (2463.8 ft), 3.41 m (11.2 ft) below normal full pool on 15 July 2015. Similar to last year, the 2015/2016 fall and winter was warmer than normal. Despite relatively low loads, generation from Mica from September 2015 to January 2016 was 110% of normal, used to support Arrow reservoir levels during periods of deep proportional draft resulting from the 2015 drought conditions. The reservoir reached a minimum level of 729.39 m (2393.0 ft) on 1 April 2016, about 7.62 m (25.0 ft) lower than the 2015 minimum level and a maximum level of 752.03 m (2467.3 ft) on 4 September 2016, 2.35 m (7.7 ft) below normal full pool.

Hugh Keenleyside (Arrow Lakes Reservoir)

Arrow reached a maximum level of 435.47 m (1428.7 ft), 4.66 m (15.3 ft) below full pool, on 13 June 2015. Arrow reached a minimum level of 424.13 m (1391.5 ft) on 31 January 2016. By comparison, in the previous year, Arrow reached a minimum level of 423.82 m (1390.5 ft) on 30 March 2015.Snowpack in the Columbia depleted much earlier than normal due to unseasonably warm temperatures during April 2016. This resulted in above normal runoff at The Dalles in April which quickly declined through the rest of the season. By the 1 June water supply forecast, the forecast runoff at The Dalles (April-August period) had dropped about 7.4 km^3 (6 Maf) relative to the 1 March forecast. As a result, the Columbia reservoir system in the TSR study was in proportional draft beginning in June and continuing through the reporting period of September 2016. This operation resulted in high discharges from Keenleyside across the spring/summer and produced correspondingly low summer Arrow reservoir levels. The reservoir filled to a maximum of 437.24 m (1434.5 ft), 2.90 m (9.5 ft) below full pool, on 10 June 2016. Arrow drafted across July, August and September due to continuing proportional draft reaching 430.96 m and 427.88 m (1413.9 ft and 1403.8 ft) by 31 August and 30 September 2016, respectively.

Duncan (Duncan Reservoir)

Duncan refilled to 575.04 m (1886.6 ft), 1.65 m (5.4 ft) below full, on 3 August 2015.Duncan discharges were increased during August to support Arrow levels during proportional draft operations. To enable this operation, British Columbia Hydro and Power Authority (BC Hydro) requested and was granted a variance from the Water Comptroller. The variance allowed Duncan to deviate from the summer recreation target of 575.46 m (1888.0 ft) between 10 August and Labour Day, as per the Duncan Water Use Plan Order.From September 2015 through April 2016, Duncan was operated to supplement inflows into Kootenay Lake to provide spawning and incubation flows for fish downstream in the Duncan River and to meet Treaty Flood Risk Management requirements. As in most years, the reservoir was drafted to near empty in late April. Duncan reached its minimum level, 547.21 m (1795.3 ft) on 8 April 2016. By comparison, the reservoir reached a similar minimum level of 546.90 m (1794.3 ft) on 21 April 2015. The reservoir discharge was reduced to its minimum of 2.8 m^3/s (0.1 kcfs) in late-May to initiate reservoir refill. Releases from Duncan were held at minimum until late-July, when discharges were gradually increased to manage the rate of reservoir refill. In 2016, Duncan refilled to a maximum of 576.47 m (1891.3 ft), 0.21 m (0.7 ft) below full, on 8 August 2016. Duncan discharges were increased during August to facilitate drafting the reservoir to reach the summer recreation target of 575.46 m (1888.0 ft) between 10 August and Labour Day as per the Duncan Water Use Plan Order.

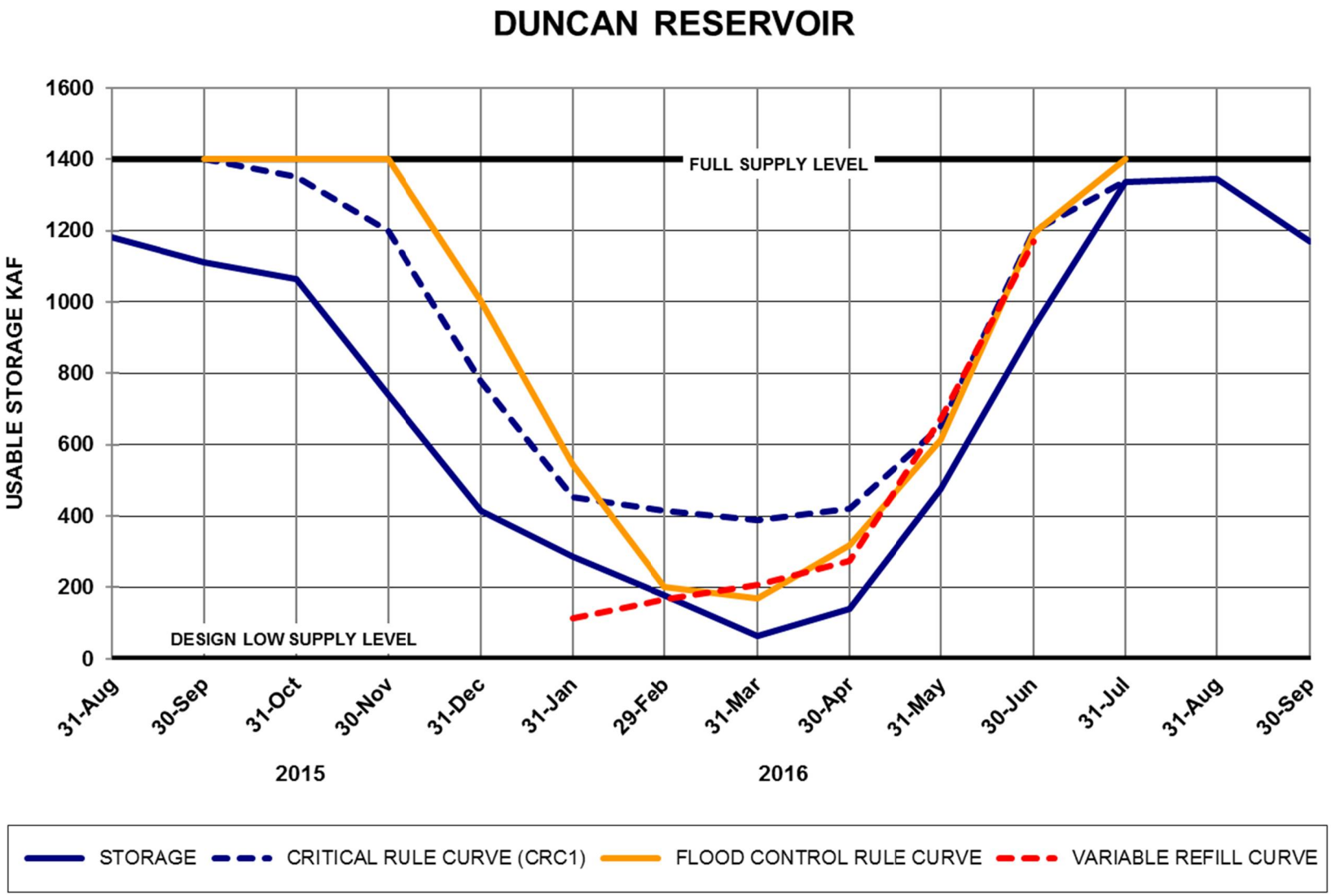
Libby (Lake Koocanusa)

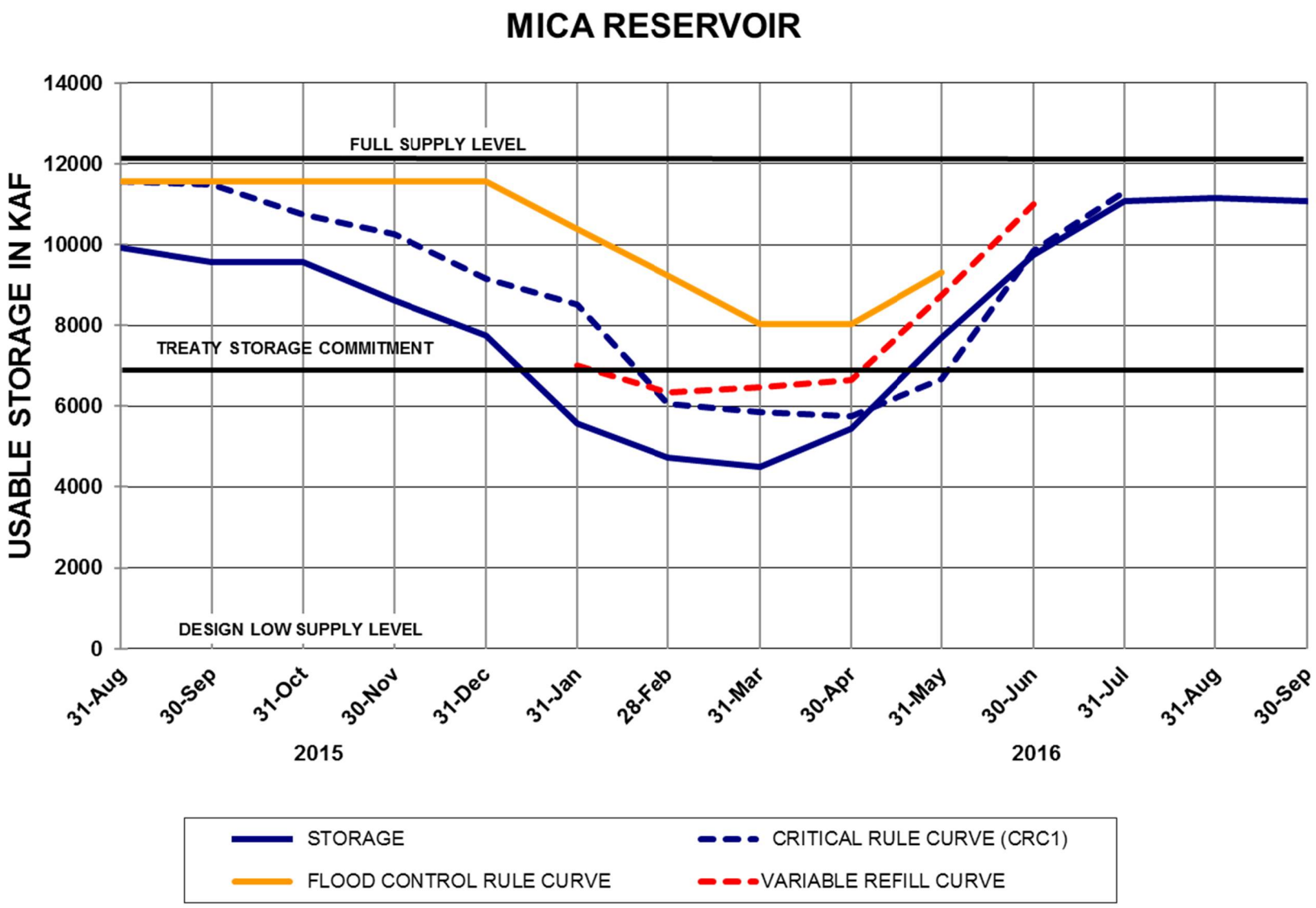
Lake Koocanusa ended July 2015 at elevation 744.69 m (2443.2 ft). The project was drafted to elevation 743.93 m (2440.7 ft) at the end of August 2015. From September through April, the project was operated to meet minimum bull trout flows, and Flood Risk Management (FRM) requirements. On 19 April 2016, Libby Dam reached its minimum elevation for the year of 730.70 m (2397.3 ft) and then operated to the Variable Flow (VarQ) flood risk management rules until the start of the sturgeon pulse. On 13 May 2016, Libby began to release the sturgeon volume 1.2 km3 (0.95 Maf) set by the May water supply forecast 7.2 km3 (5.8 Maf, or 99 percent of average), with releases increased to 566.3 m3/s (20.0

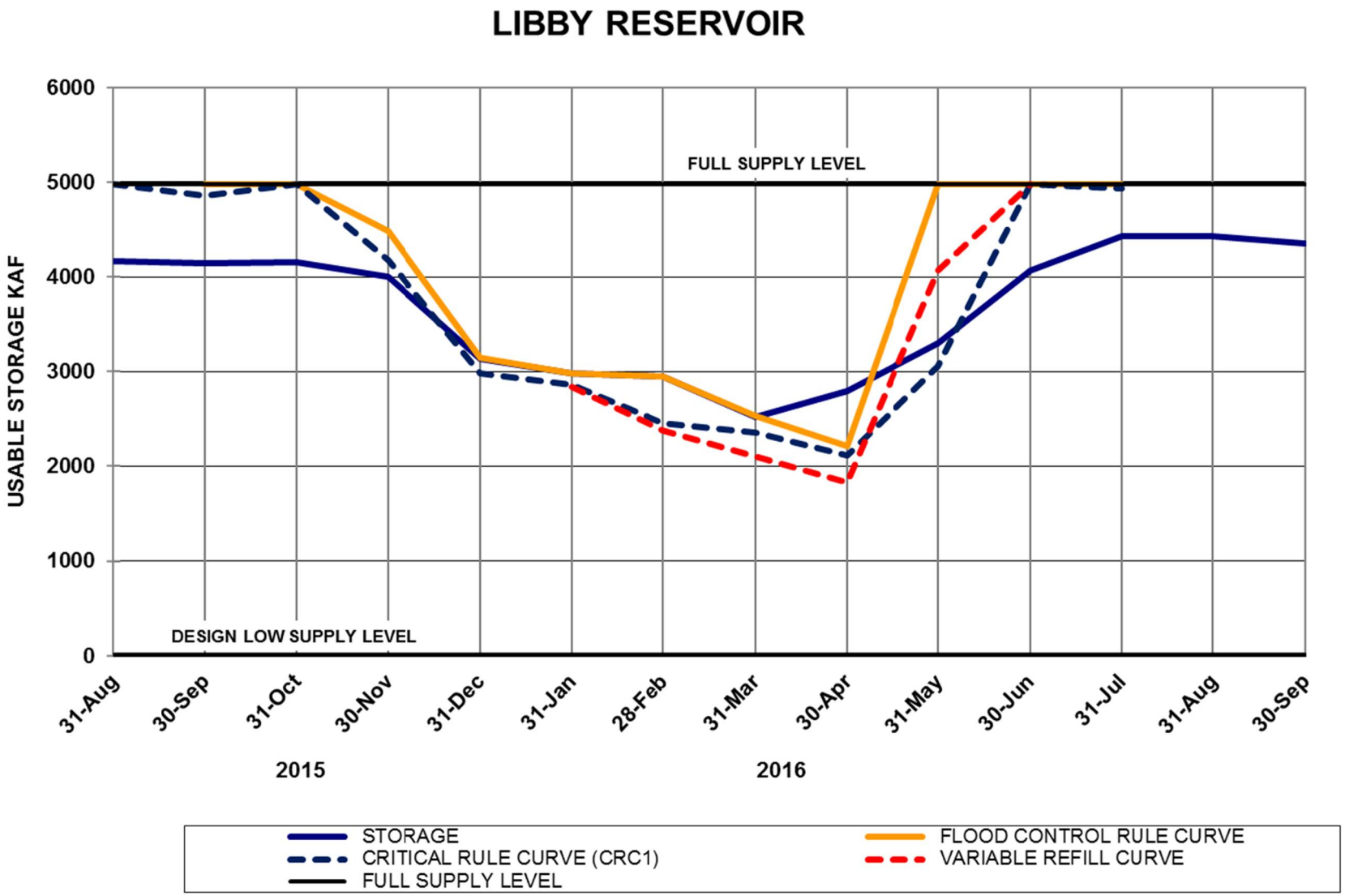
kcfs) for 2 days, followed by full powerhouse capacity of 750.4 m3/s (26.5 kcfs) for 11 days. Releases were ramped down to 198.2 m3/s (7.0 kcfs) on 14 June once the sturgeon volume was expended. Lake Koocanusa ended the month of June at elevation 743.50 m (2439.3 ft). The operation for the rest of the summer, July through August, was to try to refill Libby as best as possible and still meet the 746.46 m (2449.0 ft) target by the end of September, as required in the NOAA BiOp and coordinated through the Technical Management Team (TMT). Libby reached its peak elevation for the summer on 18 August, 746.03 m (2447.6 ft), which was 3.47 m (11.4 ft) below full pool. Due to low inflow conditions, the project kept releases to the minimum bull trout flow of 198.2 m3/s (7.0 kcfs) and then ramped down to 169.9 m3/s (6.0 kcfs), the minimum bull trout flow for September. Libby elevations were 745.72 m (2446.6 ft) and 745.3 m (2445.2 ft) at the end of August and September, respectively. The 169.9 m3/s (6.0 kcfs) in September was also the requested release from Libby to help with the ongoing in-stream habitat work for the Kootenai Tribe of Idaho (KTOI).

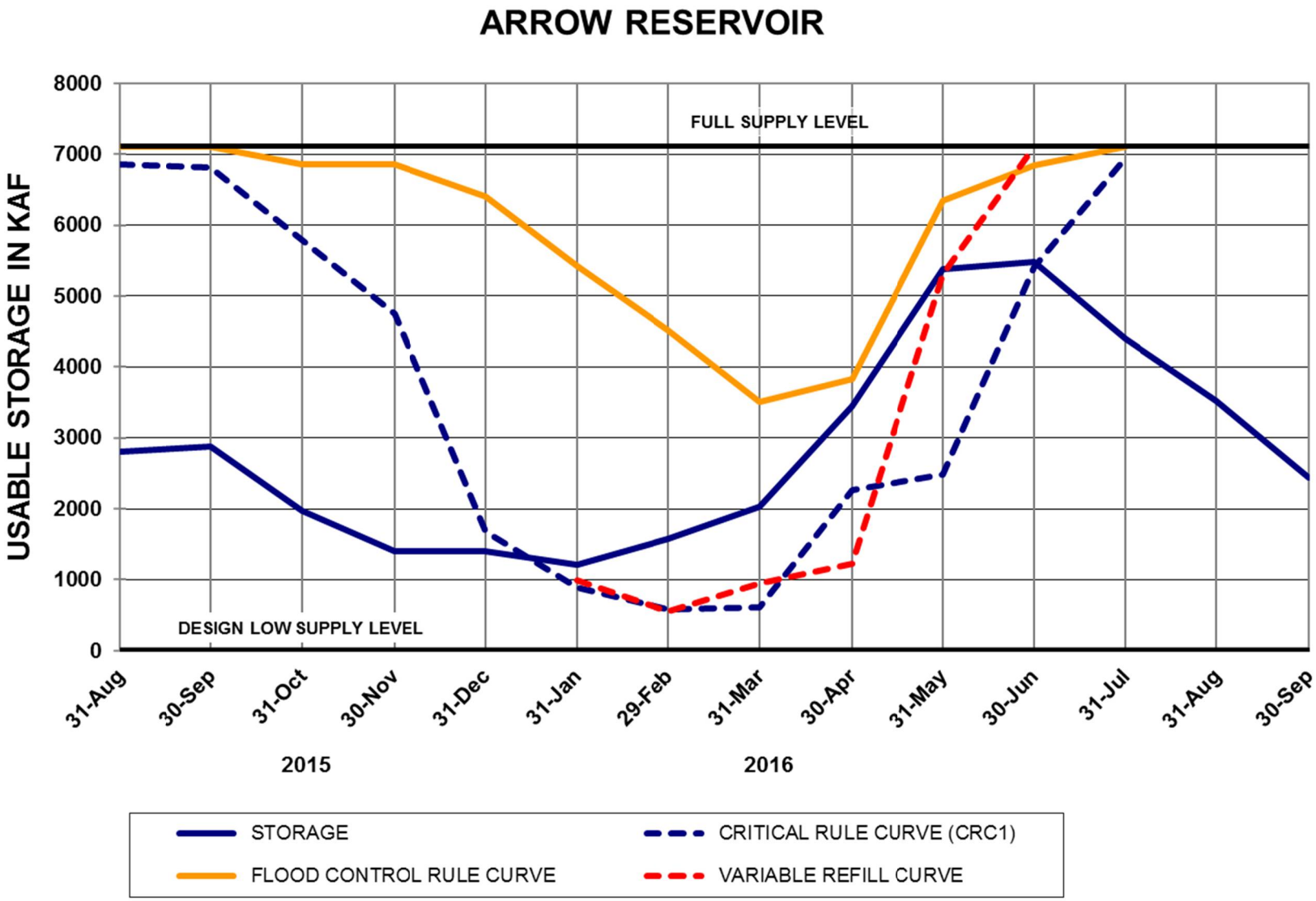
Flood Risk Management Operations

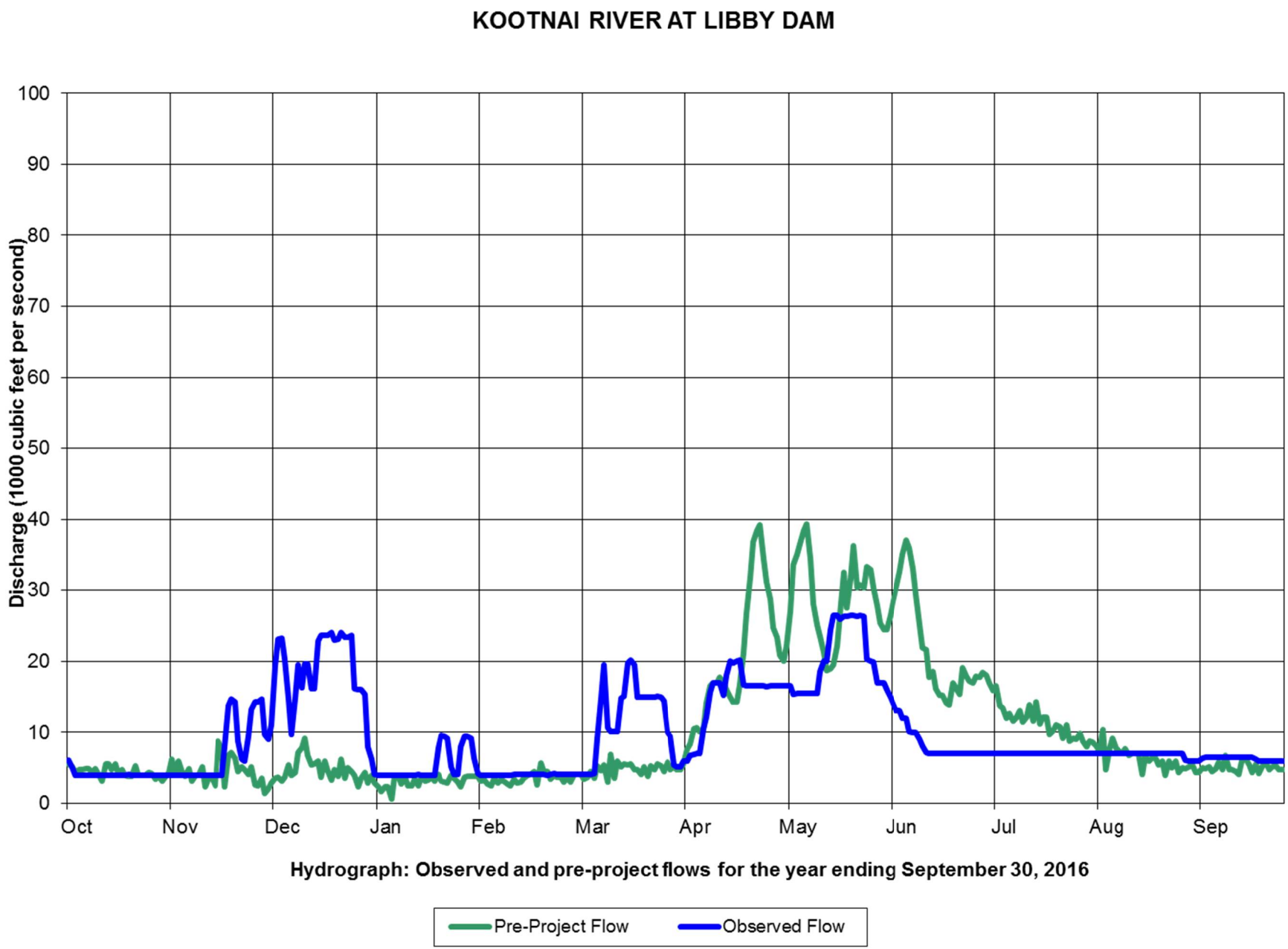
Columbia River Basin projects were operated according to the May 2003 Flood Control Operating Plan. The 2016 runoff volumes were below normal across the Columbia River Basin. The regulated peak flow during the freshet at The Dalles, Oregon, was 9,389.9 m3/s (331.6 kcfs) on 25 April 2016, and the unregulated peak flow was estimated at 13,204.1 m3/s (466.3 kcfs) on 10 May 2016. The regulated peak stage observed during the freshet at Vancouver, Washington, was 3.26 m (10.7 ft) on 25 April 2016, and the estimated peak unregulated stage was 5.00 m (16.4 ft) on11 May 2016, while the flood stage is 4.88 m (16.0 ft).

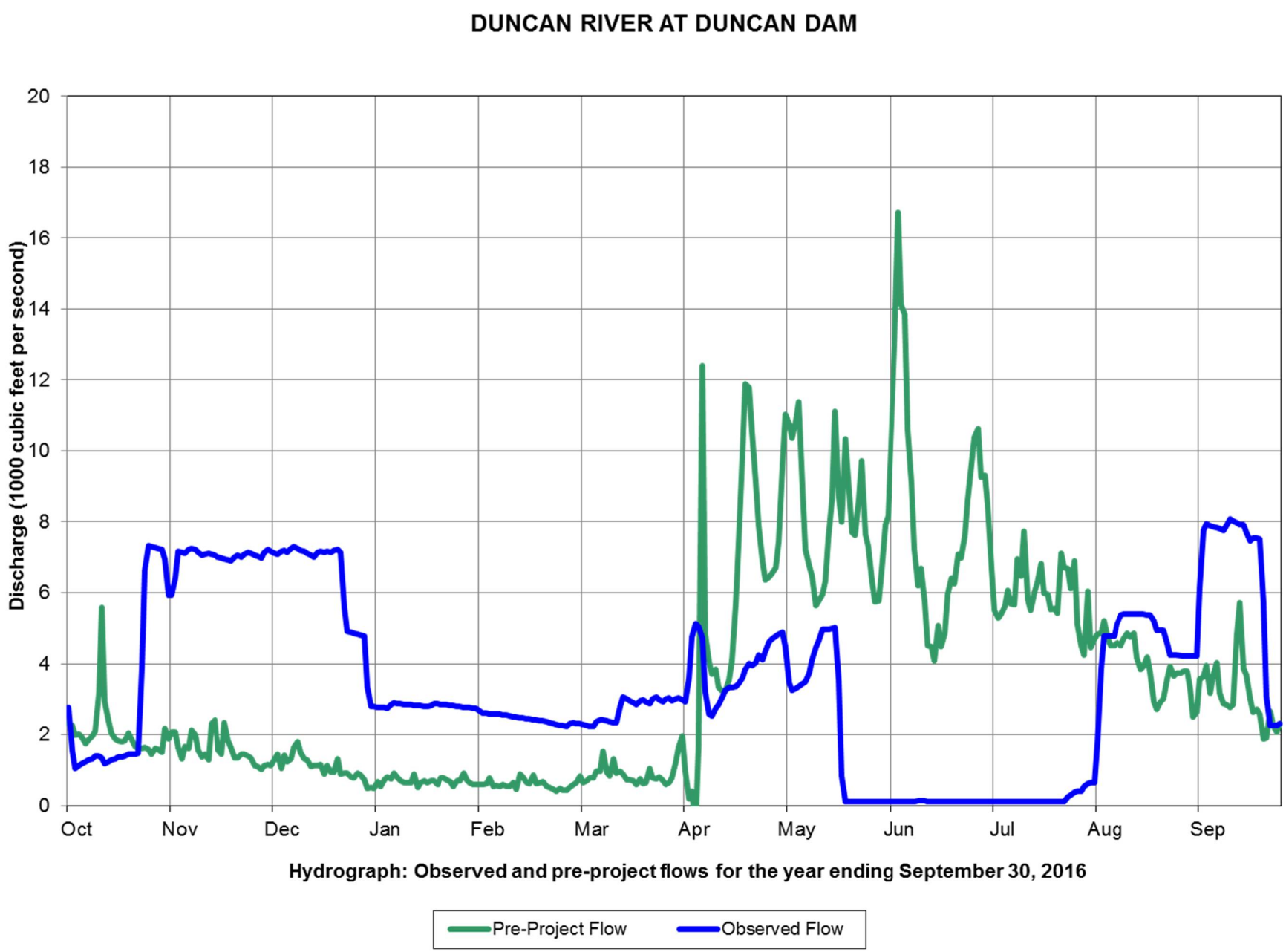

DUNCAN RESERVOIR
USABLE STORAGE KAF
1600
1400
1200
1000
800
600
400
200
0
FULL SUPPLY LEVEL
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
29-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2015
2016
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

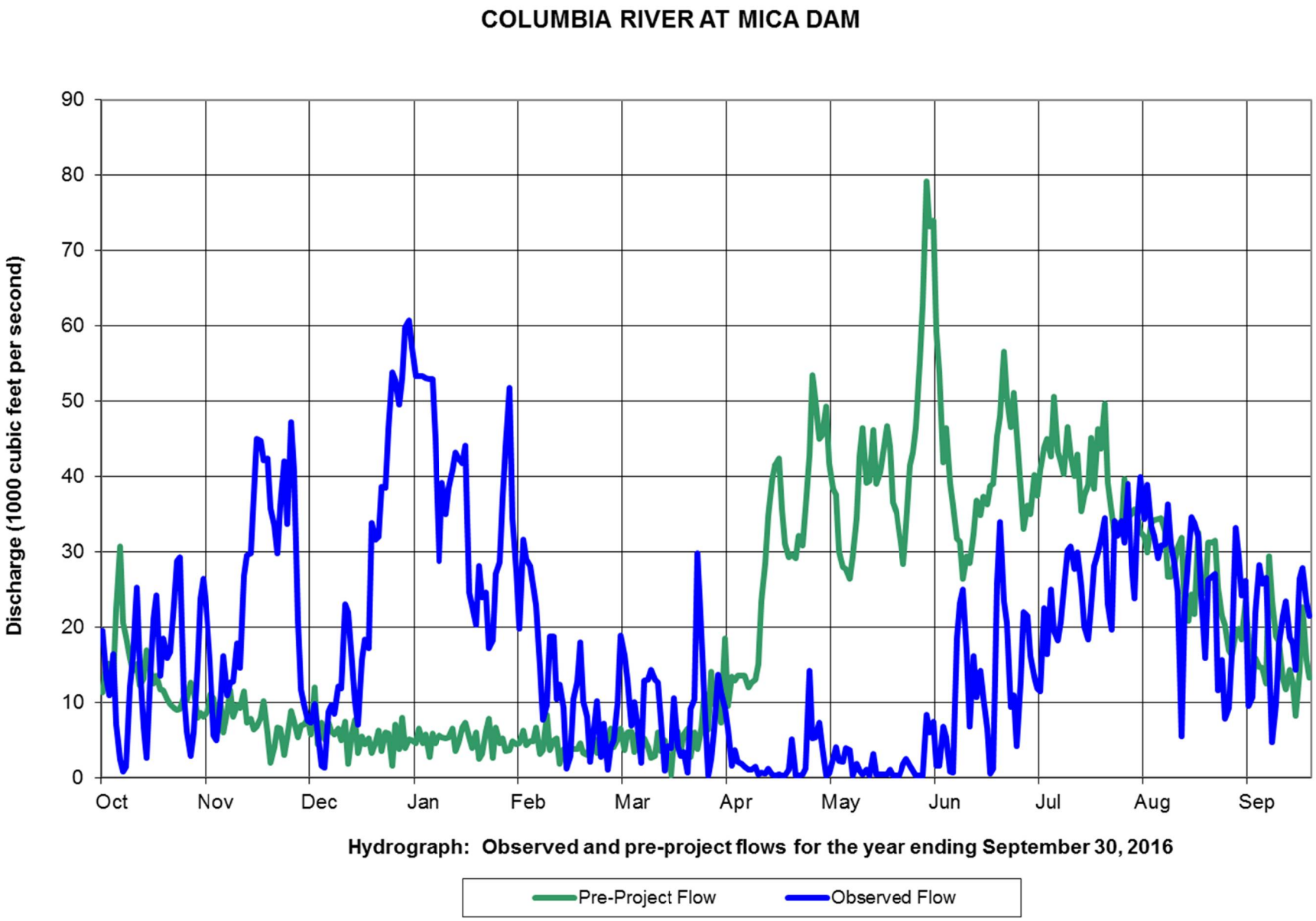

MICA RESERVOIR
USABLE STORAGE IN KAF
14000
12000
10000
8000
6000
4000
2000
0
FULL SUPPLY LEVEL
TREATY STORAGE COMMITMENT
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
28-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2015
2016
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

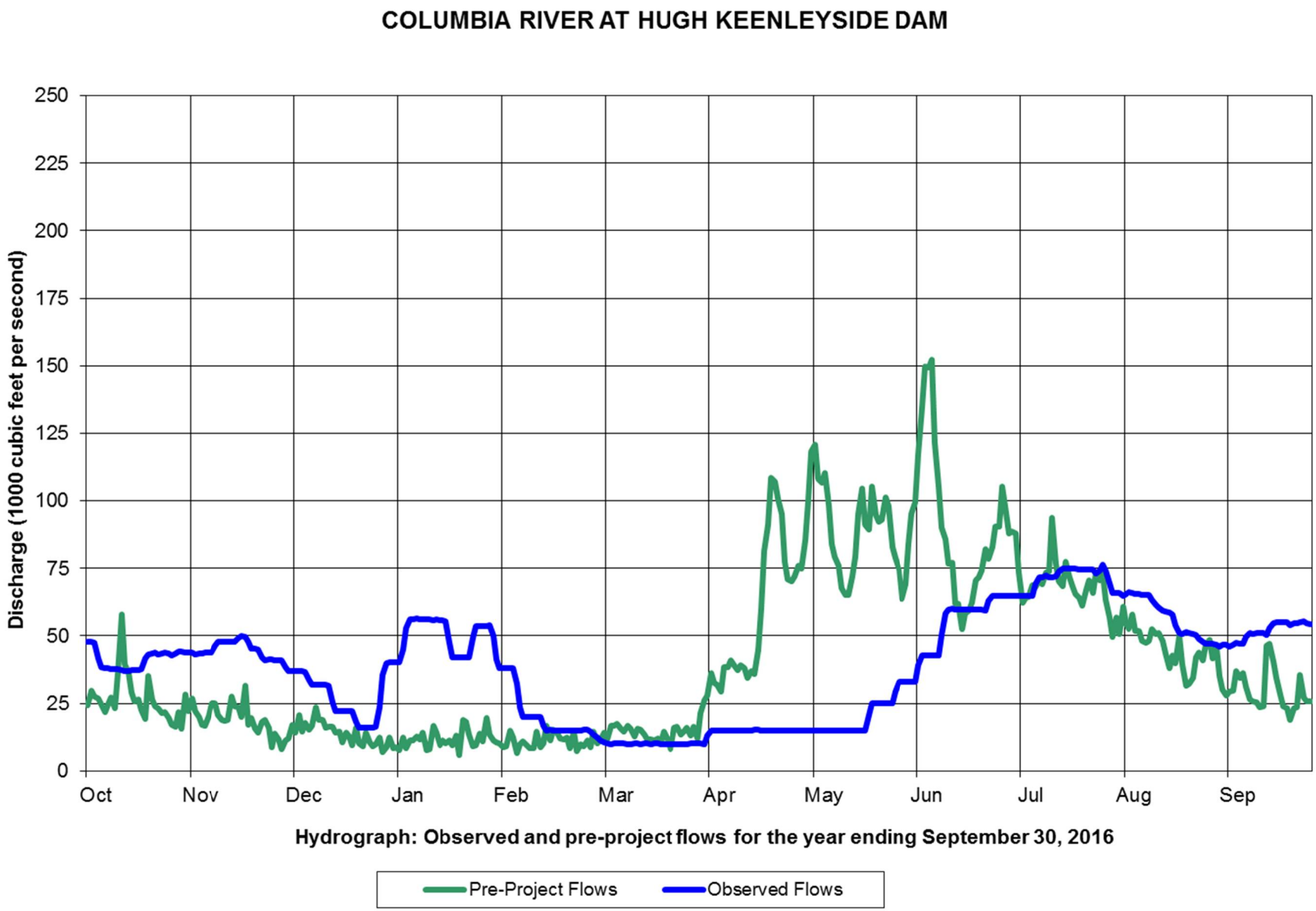

LIBBY RESERVOIR
USABLE STORAGE KAF
6000
5000
4000
3000
2000
1000
0
FULL SUPPLY LEVEL
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
28-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2015
2016
STORAGE
CRITICAL RULE CURVE (CRC1)
FULL SUPPLY LEVEL
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

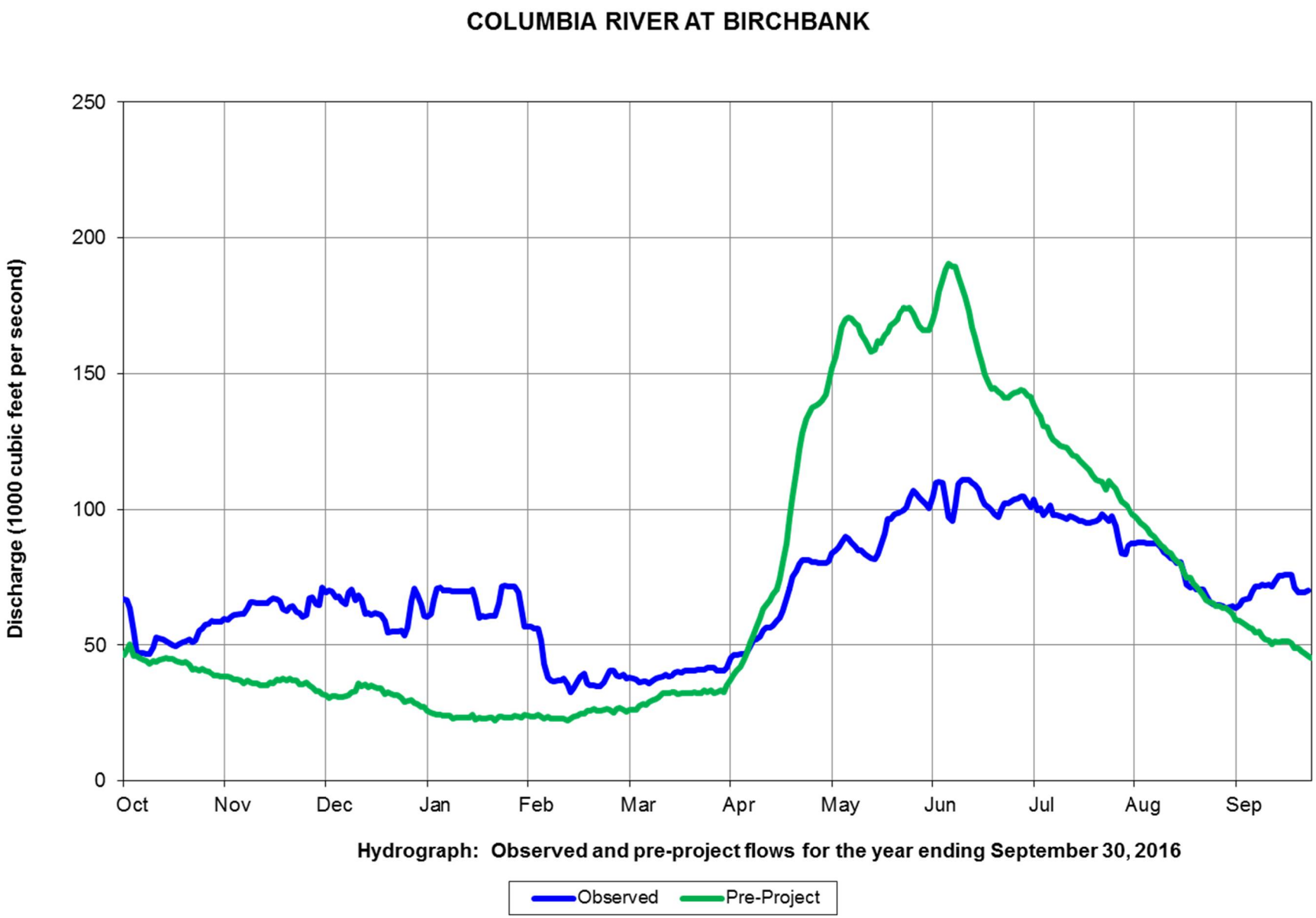

ARROW RESERVOIR
USABLE STORAGE IN KAF
8000
7000
6000
5000
4000
3000
2000
1000
0
FULL SUPPLY LEVEL
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
29-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2015
2016
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE


KOOTNAI RIVER AT LIBBY DAM
Discharge (1000 cubic feet per second)
100
90
80
70
60
50
40
30
20
10
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2016
Pre-Project Flow
Observed Flow


DUNCAN RIVER AT DUNCAN DAM
Discharge (1000 cubic feet per second)
20
18
16
14
12
10
8
6
4
2
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2016
Pre-Project Flow
Observed Flow


COLUMBIA RIVER AT MICA DAM
Discharge (1000 cubic feet per second)
90
80
70
60
50
40
30
20
10
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2016
Pre-Project Flow
Observed Flow


COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM
Discharge (1000 cubic feet per second)
250
225
200
175
150
125
100
75
50
25
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2016
Pre-Project Flows
Observed Flows


COLUMBIA RIVER AT BIRCHBANK
Discharge (1000 cubic feet per second)
250
200
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2016
Observed
Pre-Project

TREATY BENEFITS

Flood Risk Management Benefits

Water Year 2016 resulted in a quiet flood risk management season due to the slightly below average seasonal volumes. Near normal April snow pack, early runoff, and below average late season precipitation across the basin resulted in no significant system or local flood risk issues. Reservoirs throughout the Columbia River basin, including the Treaty projects, were drafted during the winter and spring in preparation for flood season. The actual unregulated runoff for the overall Columbia basin (U.S. and Canada combined) measured at The Dalles for January through July 2016 was 120.4 km3 (97.6 Maf), 96 percent of the 1981-2010 average. The peak regulated and estimated unregulated flows, and river stages are shown in the following tables:

Columbia River Steam flow at The Dalles, Oregon

Date	**Peak Unregulated Flow** m^3/s (cfs)	**Date**	**Peak Regulated Flow** m^3/s (cfs)
10 May 2016	13,204.1 m3/s (466.3 kcfs)	25 April 2016	9,389.9 m3/s (331.6 kcfs)

Columbia River Stage at Vancouver, Washington
Flood Stage is 4.9 meters (16.0 feet)

Date	**Peak Unregulated Stage** meters (feet)	**Date**	**Peak Regulated Stage** meters (feet)
11 May 2016	5.0 m (16.4 ft)	25 Apr 2016	3.26 m (10.7 ft)[1]

[1] The peak observed regulated stage at the Vancouver gage (VAPW) during the reporting period was 3.74 m (12.26 ft) which occurred on 10 December 2015 (during winter and outside the freshet).

Hydroregulation by Duncan and Libby projects limited the peak level of Kootenay Lake at Queen's Bay to 532.82 m (1748.1 ft) on 27 May 2016. Without regulation from those Treaty dams, the peak level would have been approximately 533.58 m (1750.6 ft). As documented in the 2003 Flood Control Operating Plan, flood damages commence at Nelson when the Kootenay Lake elevation reaches 534.92 m (1755.0 ft). Duncan, Keenleyside, Mica and Libby projects limited the peak flow of the Columbia River at Trail, just upstream of Birchbank, British Columbia, to 3,143.2 m3/s (111 kcfs) on 14 June 2016. Absent the dams, but with natural lake effects at Kootenay Lake, the flow would have been approximately 5,397.2 m3/s (190.6 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 represents one-half of the DDPB. For the period 1 August 2015 through 31 July 2016, the Canadian Entitlement amount, before deducting transmission losses, was 488.7 Average Megawatts (aMW) of energy, scheduled at rates up to 1332 MW. From 1 August 2016 through 30 September 2016, the amount, before deducting transmission losses, was 484.0 aMW of energy, scheduled at rates up to 1333MW.

During the course of the 2015-2016 Operating Year, there was one CE delivery curtailment event. On 15 December 2015, there was a three MWh cut in one hour which was not due to the intertie system operating limit but due to a flow gate limit. The three MWh was successfully redelivered on 17 December 2015. Actual U.S. power benefits from the operation of CRT storage are unknown and can only be roughly estimated. Treaty storage has such a large impact on the U.S. system operation 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 downstream U.S. power generation during the 2015-16 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 110 aMW. In addition to the increase in average annual U.S. power generation, the Treaty regulation also shifted the timing of generation from the freshet period into the winter months. No quantification of this benefit was reported by the Entities.

Other Benefits

During 2015-16, the CRTOC completed a supplemental operating agreement, the 2016 Non-power Uses Agreement, for the mutual benefit of both countries, signed 13 November 2015. 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 in December 2015 - January 2016 then was subsequently released in July 2016. The non-power benefits included changes to stream flows downstream of Keenleyside Dam from January through June that protected rainbow trout and mountain whitefish spawning in Canada and enhanced conditions for the downstream migration of salmon in the U.S.

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

United States

Members

Mr. James C. Dalton, P.E., Chair
Chief
Engineering and Construction
US Army Corps of Engineers
Washington, DC

Mr. Ed Sienkiewicz
Consultant
Newberg, Oregon

Alternates

Mr. Robert A. Pietrowsky
Director
Institute for Water Resources
US Army Corps of Engineers
Alexandria, Virginia

Mr. Stephen R. Oliver
Consultant
Lake Oswego, Oregon

Secretaries

Mr. Jerry W. Webb, P.E., D.WRE
Principal Hydrologic & Hydraulic Engineer
Engineering & Construction CoP
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

Canada

Dr. Niall O'Dea, Chair
Director General
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

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

Mr. Glen Davidson, P.Eng.
Comptroller of Water Rights
Water Management Division
BC Ministry of Natural Resource Operations
Victoria, British Columbia

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

Mr. Darcy Blais
Senior Policy Advisor
Renewable and Electrical Energy Division
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

RECORD OF MEMBERSHIP

United States

Members
Mr. Wendell Johnson* 1964–1970
Mr. Morgan Dubrow 1964–1970
Mr. John Neuberger 1970–1973
Mr. Joseph Caldwell* 1971–1973
Mr. Homer Willis* 1973–1979
Mr. King Mallory 1973–1975
Mr. Raymond Peck, Jr. 1976–1977
Mr. Emerson Harper 1978–1988
Mr. Lloyd Duscha* 1979–1990
Mr. Ronald Wilkerson 1988–2005
Mr. Herbert Kennon* 1990–1994
Mr. John Elmore* 1994–1996
Mr. Steven Stockton* 1996–2014
Mr. Ed Sienkiewicz 2005-
Mr. James Dalton* 2014-

Alternates
Mr. Fred Thrall 1964–1974
Mr. Emerson Harper 1964–1978
Mr. Alex Shwaiko 1974–1987
Mr. Herbert Kennon 1987–1990
Mr. Thomas Weaver 1979–1997
Mr. John Elmore 1990–1994
Mr. Paul Barber 1994–1995
Mr. Daniel Burns 1995–1997
Mr. George Bell 1997–2014
Mr. Earl Eiker 2000–2004
Mr. Robert Pietrowsky 2004-
Mr. Stephen Oliver 2015-

Secretaries
Mr. John Roche 1965–1969
Mr. Verle Farrow 1969–1972
Mr. Walter Duncan 1972–1978
Mr. Shapur Zanganeh 1978–1995
Mr. Richard DiBuono 1995–2000
Mr. Robert Bank 2000–2004
Mr. Jerry Webb 2004-

*Chair

Canada

Mr. Gordon McNabb* 1964–1991
Mr. Arthur Paget 1964–1973
Mr. Valter Raudsepp 1973–1974
Mr. Ben Marr 1974–1987
Mr. Tom Johnson 1987–1988
Mr. Douglas Horswill 1989–1991
Mr. John Allan 1991–1999
Mr. David Oulton* 1991–1996
Mr. Daniel Whelan* 1996–2002
Mr. Charles Kang 1999–2001
Mr. Jack Ebbels 2001–2003
Mr. Tim Newton 2003-
Mr. Tom Wallace* 2004–2012
Mr. Jonathan Will* 2012–2015
Dr. Niall O'Dea* 2015-

Mr. Mac Clark 1964–1992
Mr. Jim Rothwell 1964–1965
Mr. Hugh Hunt 1966–1988
Dr. Donald Kasianchuk 1988–1996
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-
Mr. Les MacLaren 2015-

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

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
ENGINEERING COMMITTEE

CURRENT MEMBERSHIP

United States

Members

Mr. Jerry W. Webb, P.E., D.WRE, Chair
Principal Hydrologic & Hydraulic Engineer
Engineering & Construction CoP
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

Mr. Kamau Sadiki
Manager
National Hydropower Program Business Line
Operations Community of Practice
US Army Corps of Engineers
Washington, DC

Mr. Thomas K. Patton, P.E.
Energy Management & Marketing Specialist
Power Marketing Division
Western Area Power Administration
Folsom, California

Mr. John Roache
Manager
River and Reservoir Operations Group
Pacific Northwest Regional Office
Bureau of Reclamation
Boise, Idaho

Canada

Mr. Darcy Blais, Chair
Senior Policy Advisor
Renewable and Electrical Energy Division
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

Mr. Chris Trumpy
Director
Generation and Regulatory
BC. Ministry of Energy and Mines
Victoria, British Columbia

Mr. KT Shum
Head, Licensing & Allocation
Water Management Division
BC Ministry of Natural Resource Operations
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

RECORD OF MEMBERSHIP

United States

Members

Mr. Shapur Zanganeh* 1990-1995
Mr. Gary Fuqua 1990-1996
Mr. Earl Eiker 1990-2000
Mr. Steve Wright 1990-1996
Mr. Larry Eilts 1991-1995
Mr. Richard Mittelstadt 1991-1996
Mr. Richard DiBuono* 1995-2000
Mr. James Barton 1996-2001
Mr. Robert Johnson 1996-1998
Mr. James Fodrea 1997-2009
Mr. Michael Cowan 1998-2014
Mr. Robert Bank* 2000-2004
Mr. Kamau Sadiki 2001-
Mr. Jerry Webb* 2003-
Mr. Patrick McGrane 2009-2014
Mr. Thomas Patton 2014-2016
Mr. John Roache 2014-

*Chair

Canada

Mr. Neill Lyons* 1990-1996
Mr. Dave McCauley 1990-1992
Mr. B. Stipdonk 1990-1991
Mr. Roger McLaughlin* 1991-2009
Mr. Robin Round 1991-1993
Mr. David Burpee* 1992-2000
Dr. Bala Balachandran 1993-2008
Mr. Bruno Gobeil 1995-1997
Mr. Larry Adamache 1996-2001
Ms. Myriam Boudreault 1997-2001
Ms. Donna Clarke 2001-2003
Mr. Ivan Harvie* 2002-2015
Ms. Eve Jasmin 2003-2007
Mr. Darcy Blais* 2007-
Mr. KT Shum 2008-
Mr. Chris Trumpy 2015-
Ms. Tracey Kutney 2016-

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

COLUMBIA RIVER TREATY ENTITIES

United States

Members

Mr. Elliot E. Mainzer, Acting Chair
Acting Administrator and CEO
Bonneville Power Administration
Department of Energy
Portland, Oregon

BG Scott Spellmon, Member
Division Engineer
US Army Engineer Division
Northwestern
Portland, Oregon

Coordinators

Mr. Richard Pendergrass, BPA Coordinator
Acting Vice President
Generation Supply
Bonneville Power Administration
Department of Energy
Portland, Oregon

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

Secretaries

Ms. Birgit Koehler, Secretary
Regional Coordination
Power Operations and Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Canada

Mr. Christopher K. O'Riley, Chair
Deputy CEO
Generation
British Columbia Hydro and Power Authority
Vancouver, British Columbia

Ms. Renata Kurschner, Coordinator
Director
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Douglas A. Robinson, Secretary
Principal Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

COLUMBIA RIVER TREATY ENTITIES OPERATING COMMITTEE

CURRENT MEMBERSHIP

United States

Members

Ms. Pamela A. Kingsbury, Alternating Chair
Manager
Power and Operations Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Ms. Birgit Koehler, Member
Regional Coordination
Power and Operations Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. Steven B. Barton, Alternating Chair
Chief
Columbia Basin Water Management Division
US Army Engineer Division
Northwestern
Portland, Oregon

Ms. Julie H. Amman, Member
Chief, Reservoir Control Center
US Army Engineer Division
Northwestern
Portland, Oregon

Canada

Mr. Darren Sherbot, Chair
Manager
System Optimization
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Doug Robinson, Member
Principal Engineer
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

CURRENT MEMBERSHIP

United States

Members

Ms. Ann McManamon, Co-chair
Hydrologist
Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. William Proctor, Co-chair
Chief
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 2016

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	6.96	6.40	12.77	6.38	6.96	8.51	10.89	10.89	24.30	10.18	8.26	7.78
2	5.45	6.28	20.57	5.94	6.71	8.57	11.36	11.36	24.10	10.27	8.03	6.96
3	4.98	5.43	23.67	5.83	6.54	8.58	13.37	13.37	22.68	10.07	7.58	7.03
4	4.77	5.06	24.17	6.08	6.36	8.57	15.45	15.45	21.87	9.36	7.88	7.25
5	4.73	4.72	20.87	6.08	6.41	8.58	17.24	17.24	20.76	9.38	8.12	7.00
6	4.77	4.66	16.07	6.01	6.43	9.51	17.19	17.19	19.84	9.65	7.65	7.11
7	4.87	4.79	11.78	5.94	6.59	11.85	16.91	16.91	19.51	9.51	7.75	7.46
8	4.79	4.66	17.39	5.93	6.41	17.10	17.34	17.34	18.37	9.42	8.25	7.34
9	4.74	4.62	29.44	5.65	6.40	21.98	22.07	22.07	17.64	9.33	8.46	7.55
10	5.17	4.73	40.58	5.71	6.30	24.59	26.16	26.16	15.74	9.32	8.20	7.54
11	4.37	4.59	34.75	5.75	6.26	19.60	30.20	30.20	15.35	9.26	7.80	7.37
12	4.58	4.78	27.51	5.67	6.45	18.72	31.37	31.37	14.74	9.18	8.24	7.90
13	4.62	5.13	23.09	5.65	7.02	19.54	31.14	31.14	13.60	9.01	8.19	7.47
14	4.57	8.13	22.27	5.78	7.25	20.62	30.04	30.04	12.69	9.18	7.78	7.47
15	4.61	9.52	26.64	5.80	7.77	23.40	28.27	28.27	11.69	8.98	7.97	7.74
16	4.47	7.21	26.74	5.83	9.42	23.78	29.14	29.14	11.67	8.90	8.00	7.49
17	4.51	10.48	26.82	5.78	10.83	26.27	29.55	29.55	11.18	8.72	7.96	7.61
18	4.14	18.18	26.84	5.73	11.46	26.46	29.75	29.75	11.26	8.56	7.93	7.83
19	4.12	18.56	26.93	5.78	12.17	24.86	30.89	30.89	10.88	8.85	7.97	7.97
20	4.31	17.10	26.03	9.75	11.95	21.35	32.05	32.05	10.85	8.61	8.00	7.58
21	4.45	11.19	25.52	11.06	11.33	20.77	32.39	32.39	10.94	8.73	8.27	7.47
22	4.31	8.34	26.32	10.96	10.32	20.88	33.44	33.44	10.93	8.81	7.64	7.45
23	4.49	8.04	25.91	10.47	9.68	20.78	35.74	35.74	10.52	8.75	7.76	7.12
24	4.47	11.18	25.50	7.29	9.21	20.78	35.84	35.84	10.73	8.42	7.98	6.64
25	4.48	14.56	24.80	6.43	8.78	21.08	34.18	34.18	10.53	8.45	7.72	6.79
26	4.65	15.45	19.19	6.38	8.49	21.07	31.43	31.43	10.52	8.16	7.99	7.32
27	4.47	15.38	18.28	9.99	8.32	20.87	29.47	29.47	10.21	8.05	7.63	7.04
28	4.26	15.27	17.98	11.07	8.40	19.46	28.72	28.72	10.05	8.71	7.92	7.23
29	4.21	10.77	16.47	11.67	8.25	16.16	27.47	27.47	10.29	8.46	7.86	7.31
30	4.34	10.17	10.46	11.27		14.76	26.43	26.43	10.68	8.44	7.93	7.05
31	4.96		8.20	8.99		11.37		25.01		8.06	8.19	
Mean	4.7	9.2	22.7	7.3	8.2	18.1	26.2	26.1	14.5	9.0	8.0	7.4

COLUMBIA RIVER AT BIRCHBANK, BC

Daily discharges in thousands of cubic feet per second for the year ending 30 September 2016

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	6.96	6.40	12.77	6.38	6.96	8.51	10.89	10.89	24.30	10.18	8.26	7.78
2	5.45	6.28	20.57	5.94	6.71	8.57	11.36	11.36	24.10	10.27	8.03	6.96
3	4.98	5.43	23.67	5.83	6.54	8.58	13.37	13.37	22.68	10.07	7.58	7.03
4	4.77	5.06	24.17	6.08	6.36	8.57	15.45	15.45	21.87	9.36	7.88	7.25
5	4.73	4.72	20.87	6.08	6.41	8.58	17.24	17.24	20.76	9.38	8.12	7.00
6	4.77	4.66	16.07	6.01	6.43	9.51	17.19	17.19	19.84	9.65	7.65	7.11
7	4.87	4.79	11.78	5.94	6.59	11.85	16.91	16.91	19.51	9.51	7.75	7.46
8	4.79	4.66	17.39	5.93	6.41	17.10	17.34	17.34	18.37	9.42	8.25	7.34
9	4.74	4.62	29.44	5.65	6.40	21.98	22.07	22.07	17.64	9.33	8.46	7.55
10	5.17	4.73	40.58	5.71	6.30	24.59	26.16	26.16	15.74	9.32	8.20	7.54
11	4.37	4.59	34.75	5.75	6.26	19.60	30.20	30.20	15.35	9.26	7.80	7.37
12	4.58	4.78	27.51	5.67	6.45	18.72	31.37	31.37	14.74	9.18	8.24	7.90
13	4.62	5.13	23.09	5.65	7.02	19.54	31.14	31.14	13.60	9.01	8.19	7.47
14	4.57	8.13	22.27	5.78	7.25	20.62	30.04	30.04	12.69	9.18	7.78	7.47
15	4.61	9.52	26.64	5.80	7.77	23.40	28.27	28.27	11.69	8.98	7.97	7.74
16	4.47	7.21	26.74	5.83	9.42	23.78	29.14	29.14	11.67	8.90	8.00	7.49
17	4.51	10.48	26.82	5.78	10.83	26.27	29.55	29.55	11.18	8.72	7.96	7.61
18	4.14	18.18	26.84	5.73	11.46	26.46	29.75	29.75	11.26	8.56	7.93	7.83
19	4.12	18.56	26.93	5.78	12.17	24.86	30.89	30.89	10.88	8.85	7.97	7.97
20	4.31	17.10	26.03	9.75	11.95	21.35	32.05	32.05	10.85	8.61	8.00	7.58
21	4.45	11.19	25.52	11.06	11.33	20.77	32.39	32.39	10.94	8.73	8.27	7.47
22	4.31	8.34	26.32	10.96	10.32	20.88	33.44	33.44	10.93	8.81	7.64	7.45
23	4.49	8.04	25.91	10.47	9.68	20.78	35.74	35.74	10.52	8.75	7.76	7.12
24	4.47	11.18	25.50	7.29	9.21	20.78	35.84	35.84	10.73	8.42	7.98	6.64
25	4.48	14.56	24.80	6.43	8.78	21.08	34.18	34.18	10.53	8.45	7.72	6.79
26	4.65	15.45	19.19	6.38	8.49	21.07	31.43	31.43	10.52	8.16	7.99	7.32
27	4.47	15.38	18.28	9.99	8.32	20.87	29.47	29.47	10.21	8.05	7.63	7.04
28	4.26	15.27	17.98	11.07	8.40	19.46	28.72	28.72	10.05	8.71	7.92	7.23
29	4.21	10.77	16.47	11.67	8.25	16.16	27.47	27.47	10.29	8.46	7.86	7.31
30	4.34	10.17	10.46	11.27		14.76	26.43	26.43	10.68	8.44	7.93	7.05
31	4.96		8.20	8.99		11.37		25.01		8.06	8.19	
Mean	4.7	9.2	22.7	7.3	8.2	18.1	26.2	26.1	14.5	9.0	8.0	7.4

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

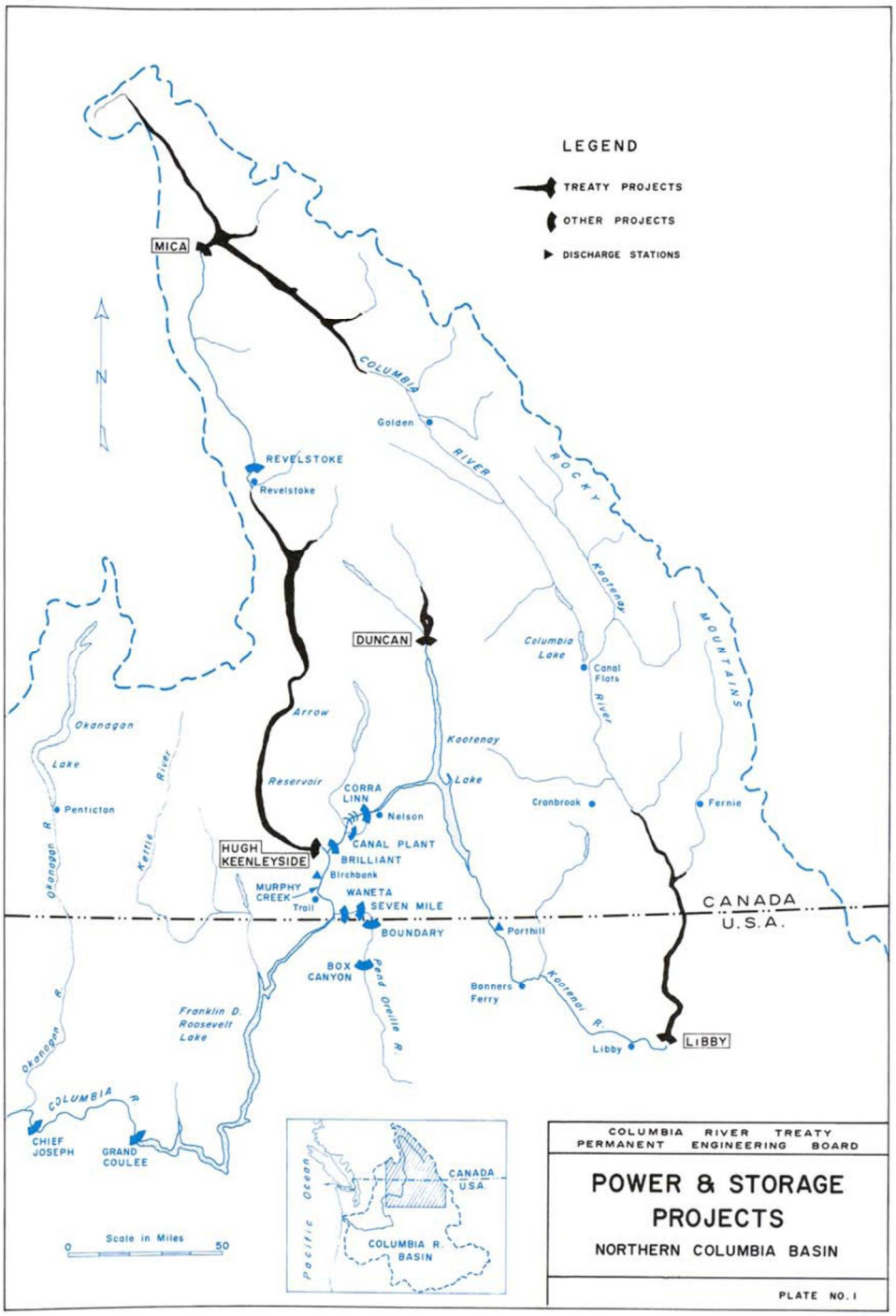

LEGEND
TREATY PROJECTS
OTHER PROJECTS
DISCHARGE STATIONS
MICA
N
COLUMBIA
RIVER
ROCKY
MOUNTAINS
Golden
REVELSTOKE
Revelstoke
DUNCAN
Columbia Lake
Canal Flats
Kootenay
River
Arrow
Reservoir
Okanagan
Lake
Penticton
Okanagan R.
Kettle River
Kootenay
Lake
CORRA LINN
Nelson
CANAL PLANT
BRILLIANT
Birchbank
HUGH KEENLEYSIDE
MURPHY CREEK
Trail
WANETA
SEVEN MILE
BOUNDARY
Cranbrook
Fernie
CANADA
U.S.A.
Porthill
BOX CANYON
Pend Oreille R.
Bonners Ferry
Kootenai R.
Libby
LIBBY
Franklin D. Roosevelt Lake
COLUMBIA
CHIEF JOSEPH
GRAND COULEE
Scale in Miles
0
50
Pacific Ocean
CANADA
U.S.A.
COLUMBIA R. BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
PLATE NO. 1

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)