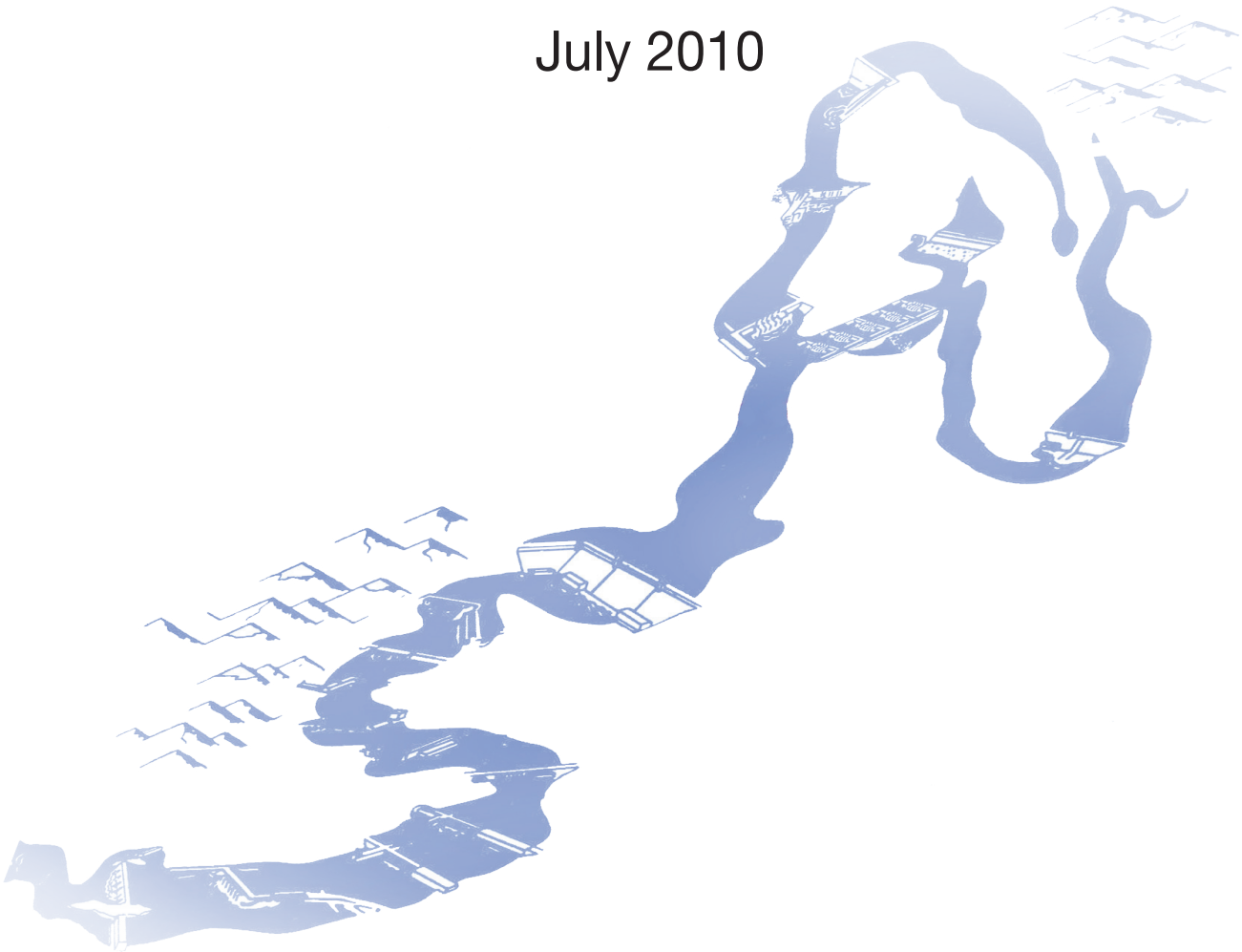
Columbia River Treaty

2014/2024 Review • Phase 1 Report

APPENDICES

July 2010



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The Treaty does not provide detailed procedures for Called Upon, and there are differences between the Entities with regard to interpretation of Called Upon rights and obligations, including flood control objectives (e.g. 600 kcfs or 450 kcfs). Thus, on a without prejudice basis, two different flow objectives were simulated to provide information regarding a potential range of future operations.

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APPENDIX A

CURRENT METHODOLOGY

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APPENDIX A. CURRENT METHODOLOGY

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APPENDIX A. CURRENT METHODOLOGY

A.1 INTRODUCTION

Appendix A describes how planning studies and real-time operations for flood control and power generation are currently conducted under the existing Treaty. The purpose of this appendix is to provide a basis on which the study methodologies applied in Phase 1 can be compared and understood. In most of the Phase 1 scenarios, the modeling either paralleled or modified how the current planning and real-time implementation occur.

The overall purpose of Treaty planning and implementation studies is to provide for an assured operation to meet flood control requirements and optimize power production for the Columbia River basin across a range of historical or forecast streamflow conditions. The Treaty directs the Entities to develop a flood control operating plan and hydroelectric operating plans for Treaty storage provided by Canada at Mica, Arrow, and Duncan reservoirs (Canadian storage). The Treaty is specific that these plans must be designed to achieve optimum power generation in both the U.S. and Canada and reflect only the requirements included in the Treaty, its Annexes and Protocol, and subsequent Entity Agreements. Characteristics of each hydroelectric study, planning and real-time, are explained below and summarized briefly in Table A.1.

It is important to note that in both planning and real-time operations, flood control requirements are examined first and applied as a limit to power operations planning and real-time studies. Although priority is always given to achieving minimum flood control objectives, the two objectives of flood control and power are often complementary, as the evacuation and refill of reservoirs provides benefits for both.

Table A.1. Characteristics of each hydroelectric study

Study	Type	Modeling Horizon	Mode	Water Supply/ Streamflow Input
Assured Operating Plan (AOP)	Planning	6 years	Observed	Historical
Detailed Operating Plan (DOP)	Planning	1 year	Observed	Historical
Treaty Storage Regulation (TSR)	Real-time	Within Year	Forecast	Observed and In-Season Forecast

A.1.1 FLOOD CONTROL OPERATING PLAN

The purpose of Columbia River system flood control is to achieve the desired local and system flood control objectives in the United States and Canada. Design of the system flood control is focused on reducing flows at the Columbia System reference point at The Dalles, Oregon. In

general, meeting system flood control objectives at The Dalles will most likely result in adequate control at other flood damage areas in Canada and the United States.

The Canadian storage is an integral part of the overall Columbia River reservoir system, and it is used in coordination with the U.S. storage to achieve system flood control objectives. The Treaty Flood Control Operating Plan[1] (FCOP) prescribes criteria and procedures for operation of Mica, Duncan, and Arrow reservoirs to achieve the flood control objectives. Libby reservoir is included in the FCOP to meet the Treaty requirement to coordinate Libby's operation for flood control protection in Canada and for the system. The U.S. Corps of Engineers ensures that the principles and operating criteria within the FCOP for Treaty storage are consistent with the overall system flood control for the Columbia River. Operations for flood control at Grand Coulee and other U.S. reservoirs are described in their respective Water Control Manuals and are not explicitly described in the FCOP. Charts 2, 3, and 6 of the FCOP do, however, refer to Grand Coulee and other U.S. reservoirs.

The FCOP provides guidance for both real time operations and flood control planning studies. Flood control requirements used in power planning studies are derived from observed mode (see section A.1.2) system flood control regulation studies. These flood control constraints are then transferred to the power operating plans.

A.1.2 POWER OPERATING PLANS

An Assured Operating Plan (AOP) is prepared annually for the sixth succeeding operating year. The AOP provides a guaranteed default operation that enables orderly planning of the power systems in Canada and the U.S., which are dependent on and coordinated with the operation of Treaty storage. The AOP is prepared in conjunction with the Determination of Downstream Power Benefits (DDPB). The Canadian Entitlement to downstream U.S. power benefits is one-half of the computed DDPBs.

Immediately prior to each August through July operating year, a Detailed Operating Plan (DOP) is developed from the AOP for that operating year. The DOP may reflect any changes mutually agreed upon by the Ent and may be updated with more recent project operating criteria or information. The DOP, together with the FCOP, serves as a guide and provides criteria for actual operation of Canadian storage. The DOP development process does not change the Canadian Entitlement amounts agreed to in the AOP/DDPB, regardless of any changes in the operating criteria.

Both the AOP and DOP studies for Treaty operation are conducted in *observed mode*. In observed mode, reservoir regulation decisions are made with assumed perfect foresight of all future runoff volumes and inflows across the entire Columbia Basin. Modelers are able to draft reservoirs to the proper elevation to refill the system at the correct rate and time to maximize

[1] The initial development of the FCOP for Canadian storage began in 1965, with a draft completed in 1968. In 1971 the FCOP was updated and modified to reflect changed conditions since 1968 while preserving the essence of the original draft. The revised version was reviewed in 1972 by the Columbia River Treaty Operating Committee. Revisions to the 1972 FCOP occurred in 1999 and 2003.

power production, avoid spill, and limit the peak flow at The Dalles. Observed mode studies are a relatively simple and fast way to perform regulation studies; however, forecast uncertainty is not addressed in these studies.

A.1.3 REAL-TIME OPERATIONS

During the operating year, the Entities perform a Treaty Storage Regulation (TSR) study at least twice per month. The TSR studies are conducted in *forecast mode* using existing reservoir conditions and forecasts of monthly and seasonal inflows. The TSR uses these forecasts, in conjunction with the rules governing Canadian storage operation outlined in the DOP and FCOP, to determine the end-of-month storage levels for Canadian storage. This information is then used by the Entities to determine the coordinated weekly Treaty storage operation.

The flood control component of TSR studies is the only type of Treaty study that incorporates the risk and uncertainty associated with forecasting future water supply, streamflows, and resultant operations. In forecast mode, the modelers apply the historical forecast errors to determine the drawdown of the reservoirs for flood control, thus incorporating uncertainty and error into the modeling of the system.

A.2 SYSTEM FLOOD CONTROL

A.2.1 FLOOD CONTROL OBJECTIVE

The basic objective in the 1972 FCOP for flood regulation is to operate reservoirs to reduce the river stages, at all potential flood damage areas in Canada and the United States, to non-damaging levels insofar as possible. Larger floods that cannot be controlled to non-damaging levels are reduced to the lowest possible level that the available storage space allows.

In the 1972 FCOP, major flood damage levels were identified at different locations within the Columbia Basin in both Canada and the United States. Elevations where damage commences were also identified and are used as the flood control objectives in the FCOP. The terms “Major Damage” and “Damage Commences” are relative descriptors that do not have standard definitions. Development has occurred throughout the Columbia Basin so that damage now commences at elevations lower than those identified in the FCOP. For example, flood damages are reported to occur in the lower Columbia River downstream of Vancouver at flows as low as 200 kcfs as measured at The Dalles.[2] Damages in Nelson, B.C., occur when Kootenay Lake reaches 1750 feet, and significant damage occurs at 1755 feet.[3] Flood damage levels will be confirmed as part of the Flood Risk Management Study.[4]

The flood control flows and stages of interest locations in the 2003 FCOP are provided in Tables A.2 and A.3 below. In the U.S., changes to a project’s authorized level of protection (as

[2] This result was reported in “Columbia River System Operation Review Final Environmental Impact Statement,” Appendix E, dated November 1995; however, this is a very low flow, and this reported damage level needs to be confirmed and re-evaluated.

[3] “Kootenay Lake West Arm: Stage-Damage Relationship Development,” dated 28 November 2005.

[4] See section 5.2.2 of the main report.

defined in the project's congressional authorization) cannot be made without congressional approval and completion of a comprehensive study addressing the impacts to local and system flood control and necessary operational changes.

In the United States, the National Weather Service has the authority (given to it by the U.S. Congress) to issue all flood warnings in the United States and to set the river stages at which these warnings will be issued. Flood warning levels are often the same as or slightly below an elevation considered to be zero damage levels. Flood control zero damage stages are determined by the National Weather Service local forecast office after consultation with the interested local community, the project owner, and the project regulator. In general, a flood warning level may be lowered in response to deterioration in the condition of a levee or if stream channel hydraulic characteristics have changed such that a stream is no longer able to convey the same amount of flow for a certain stage. For example, at Bonners Ferry, two flood warning changes were requested and made—first down to a stage of 1766.5 feet from 1770 feet and later to 1764 feet.

Table A.2. Flood Control Objectives in Canada (2003 FCOP)

	Major Damage	Damage Commences
Revelstoke[a]	1,450 ft (200 kcfs with Arrow @ El 1446 ft)	
Castlegar[b]	1405 ft	1400 ft
Trail[c]	1,352 ft 280 kcfs	1,347 ft @ old highway bridge 225 kcfs @ Birchbank
Creston[a,d]	1,763 ft	
Nelson[a]	1759 ft	1755 ft

a. Elevations based on Geodetic Survey of Canada (GSC) 1961 data.
b. It is assumed that if flood control requirements at Trail are met, flood protection is also achieved at Castlegar.
c. GSC 1951 data.
d. It is assumed that if the stage at Bonners Ferry is controlled to 1770 feet, flood protection at Creston will be achieved.

Table A.3. Flood Control Objectives in the United States (2003 FCOP)

	Major Damage	Flood Stage as defined by the National Weather Service
Vancouver, Washington[a]	24 ft NGVD 22.2 ft, Columbia River Datum 600 kcfs @ The Dalles	17.8 feet NGVD 16 feet, Columbia River Datum 450 kcfs @ The Dalles
Bonners Ferry, Idaho[b, c, d]	1774 feet NGVD	1764 ft NGVD (~50 kcfs when Kootenay Lake is at 1750 ft NGVD)
Hanford,[e] Washington (mid Columbia)		400 kcfs as measured at the Priest Rapids project

a. 1959 USGS adjustment.
b. The river stage at Bonners Ferry, Idaho, is influenced by the backwater effects of Kootenay Lake and the amount of flow in the Kootenai River.
c. Originally, flood damage began at 1770 feet NVGD (approximately 75,000 cfs when Kootenay Lake is at 1750 feet NGVD), and the authorization of Libby and its associated water control plans were designed to this stage.
d. In some years local inflow downstream from Libby Dam may cause the flood stage of 1764 feet to be exceeded so that control to this limit will not always be possible.
e. The regulation required for The Dalles normally will also achieve the desired protection in the mid-Columbia area.

A.2.1.1. Local Flood Control Objectives

Storage in upstream reservoirs to meet system flood control objectives at The Dalles generally will result in adequate control at other flood damage areas in Canada and the United States. If this is not the case, reservoir releases may be adjusted for local requirements. Columbia Falls below Hungry Horse (South Fork Flathead River), Spaulding below Dworshak (Clearwater River), Bonners Ferry below Libby (Kootenai River), and the area just downstream of Duncan all are operated for both local and system flood control. Brownlee, Grand Coulee, and Mica, in contrast, do not have local flood control requirements immediately downstream of the dams.

If the rate of filling vacated storage at Arrow required to control the flow at Trail, B.C., exceeds the rate of filling requirement for control of the lower Columbia, the requirement for Trail will take precedence, and to the extent possible appropriate evacuation of storage will be made at other Category IV (see section A.2.2) projects to compensate for the fill into Arrow Reservoir.

A.2.2 RESERVOIR CATEGORIZATION

The FCOP states that the rules and diagrams required to accomplish the refill of storage space divide the reservoirs in the Columbia River system into five major categories. Projects in each category are listed in Table A.4. Categories I and IV provide the majority of system flood control operation.

CATEGORY I - *Reservoirs operated under fixed releases primarily for flood control of the lower Columbia.* Reservoirs in this category cannot be operated on a day-to-day basis for flood control of the lower Columbia due mainly to the relatively long time it takes for a change in the outflow at these reservoirs to have a significant effect upon streamflow at The Dalles.

CATEGORY II - *Reservoirs operated for tributary flood protection with incidental flood regulation for the lower Columbia.*

CATEGORY III - *Major lakes with projects operated to control lake elevations during non-flood period.* The regulation of these lakes during the high-flow period is such that the natural storage effect of the lakes is preserved to the extent possible. However, local conditions are limiting factors that must be considered.

CATEGORY IV - *Reservoirs operated with variable releases primarily for flood control of the lower Columbia.* Reservoirs in this category are those in which outflows have a relatively brief time of travel (two days or less) to the lower Columbia flood area, and have sufficient flexibility to permit variable releases on a day-to-day forecast basis. These reservoirs provide the final major flow regulation of the flood control system and are used primarily to maintain the desired controlled flow in the lower Columbia and provide local flood protection. Although John Day Dam is a Category IV project, it does not operate to Storage Reservation Diagrams (SRDs) like Grand Coulee and Arrow. The John Day flood control space is used only occasionally during large flood events.

CATEGORY V - *Run-of-River Projects on the mainstem Columbia and major tributaries.* The effect of the run-of-river projects on the total regulation of the Columbia River flood flows is minor, but the operating requirements for these projects provide for establishment of specific outflows individually on a day-to-day basis for Columbia River flood regulation.

Table A.4. Reservoir Categories for Flood Control

I **Fixed minimum releases**	**II** **Tributary protection**	**III** **Major lakes**	**IV** **Variable releases**	**V** **Run-of-River Projects**[a]
Hungry Horse Dworshak Brownlee Libby Duncan Mica	River Basins: Upper Snake Boise River Payette River Yakima River	Kootenay Flathead Pend Oreille Spokane	John Day Grand Coulee Arrow	Revelstoke Chief Joseph Wells Rocky Reach Rock Island Wanapum Priest Rapids McNary The Dalles Bonneville

a. Only run-of river projects on the mainstem of the Columbia are listed.

A.2.3 OVERVIEW OF SEASONAL FLOOD CONTROL OPERATION

Flood control operation involves two seasonal periods—the storage reservoir evacuation period (normally the low-flow period from October through March), and the reservoir refill period (normally the high-flow period from May through July). Either evacuation or refill of reservoir storage may occur during April depending upon runoff conditions.

A.2.3.1. Flood Control Storage Evacuation Period

In the winter months, reservoirs are drafted in accordance with their Storage Reservation Diagrams to provide storage space for the spring runoff. Storage requirements are based on forecasts of spring/summer volume runoff. Early evacuation of reservoirs is required for the possibility of an early spring runoff that would preclude further reservoir draft. In order to ensure drawdown in an orderly manner with consideration of project operating limits, it is necessary to initiate evacuation of reservoirs by either December first or January first. The timing of required evacuation and the period used for forecasting varies by reservoir, as shown in Table A.5. Differences in timing are due to geographical location of watershed and contributing areas at different elevations in each watershed. Lower elevation watersheds, and those located farther south, typically have an earlier completion of spring runoff.

Table A.5. Reservoir Evacuation Requirements

Dam	Forecast used for Evacuation (Period, Location)	Date When Evacuation Is Required
Mica	Apr-Aug, The Dalles	March 31
Arrow	Apr-Aug, The Dalles	March 31
Duncan	Apr-Aug, Duncan	February 28
Libby	Apr-Aug, Libby	March 15
Grand Coulee	Apr-Aug, The Dalles	April 30
Hungry Horse	May-Sep, Hungry Horse	April 30
Dworshak	Apr-Jul, Dworshak	April 15
Brownlee	Apr-Aug, The Dalles Apr-Jul, Brownlee (regulated)	April 30

The end-of-evacuation date and/or forecast period are different from project to project for two main reasons: 1) to arrange orderly drawdown to avoid requiring all projects to release high outflows in the same short period, thereby potentially causing unintended regulated flood; and 2) to follow the natural runoff pattern; e.g., the highest-elevation project's runoff starts later (note Hungry Horse).

A.2.3.2. Flood Control Refill Period

Refill is initiated to 1) meet the system flood control objective represented by the controlled flow target for the lower Columbia River as measured at The Dalles, Oregon, 2) meet assured refill criteria as determined by flood control refill curves, and 3) meet other operational objectives that are not related to hydropower or flood control.

Day-to-day regulation in the Refill Period is accomplished by first establishing a controlled flow objective at The Dalles using the methodologies described in the FCOP and adjusting reservoir releases to try not to exceed that controlled flow. Reservoirs are divided into five categories according to the operating rules for accomplishing refill, as described in section A.2.2.

The Flood Control Refill Period is defined as commencing 10 days prior to the date the unregulated mean daily discharge is forecast to first exceed the controlled flow objective at The Dalles. The end of the Flood Control Refill Period will be when no further flood potential exists at any of the damage areas. It should be noted that a realistic forecast window of unregulated streamflow does not extend beyond 10 days; and in an effort to maintain a good likelihood of refill, refill may begin in moderate to low runoff volume years well before unregulated flows are forecasted to exceed controlled flow objectives at The Dalles.

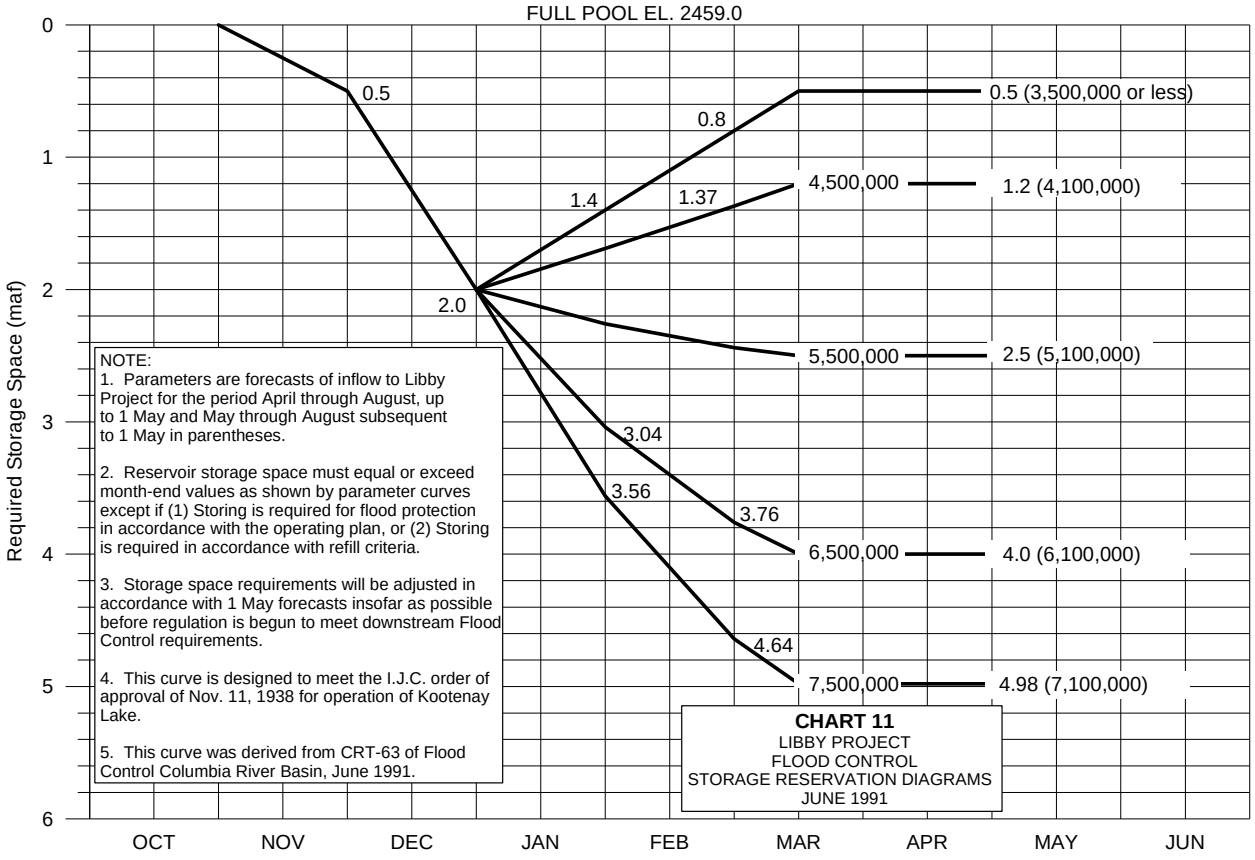
A.2.3.3. Fall and Winter Floods

Occasionally, heavy rains and rain-on-snow events can cause flood-level flows in the lower Columbia River and its tributaries during the fall and winter months. In the fall, from October through December, a small amount of storage space is required at Mica and Arrow to ensure that, to the extent possible, releases do not exceed natural streamflows if flooding is occurring in the lower Columbia River. No more than 0.71 Maf storage space in Arrow and 0.39 Maf storage in Mica are obligated for this operation. In the event of flooding in the Lower Columbia, the Mica and Arrow projects will be operated so that, insofar as possible, the outflow from Arrow will not exceed the natural streamflow.

A.2.4 Reservoir-Specific Flood Control Strategies Used in Development of Real-Time Flood Control Rule Curves

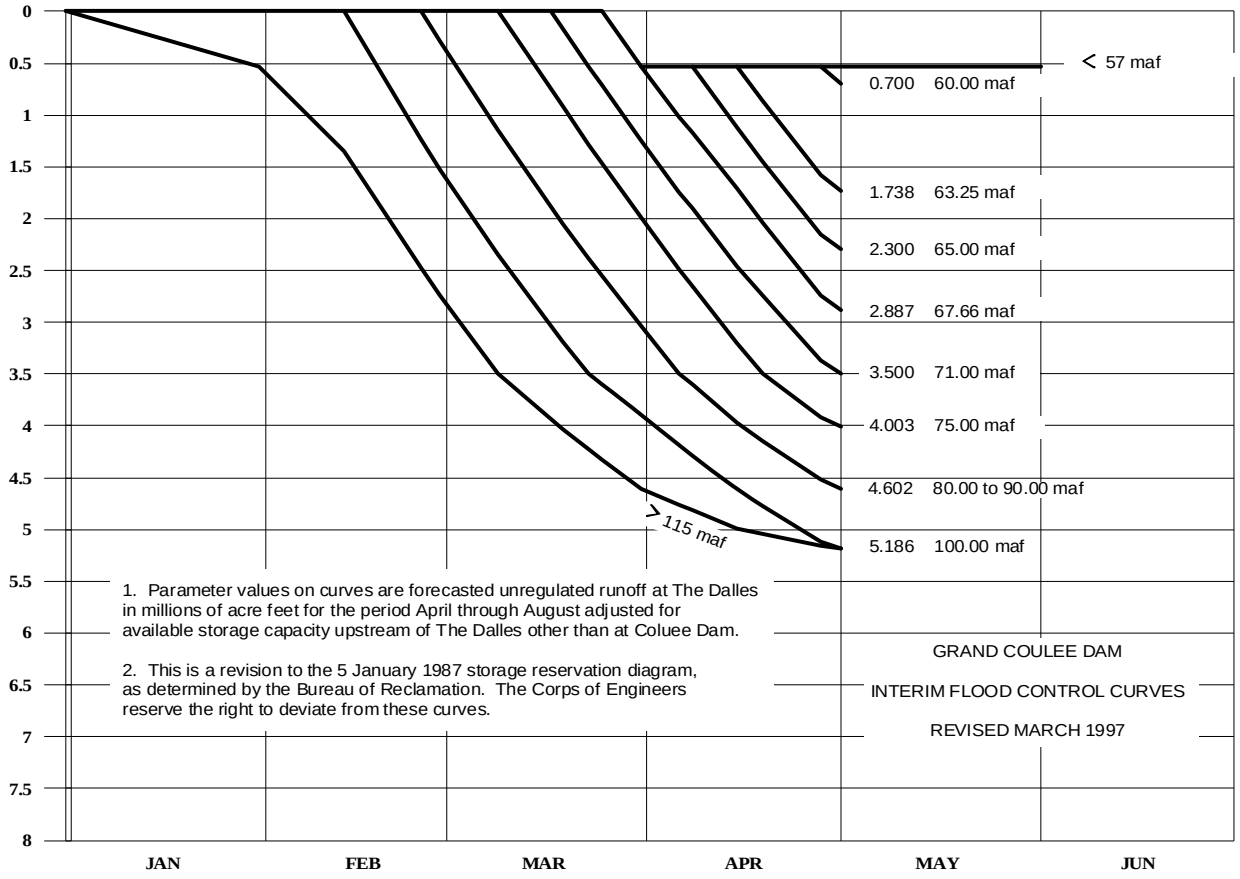
Figures A.1 and A.2 provide sample Storage Reservation Diagrams for two representative Category I and IV reservoirs, Libby and Grand Coulee. Each reservoir in the system is operated slightly differently from other reservoirs. The following discussions are intended to clarify some of the operating nuances that are unique to each reservoir. These real-time operations are used as a basis to determine how to characterize the operations of the reservoirs in planning studies such as the AOPs and DOPs, or the Phase 1 studies.

Figure A.1. Example Libby Storage Reservation Diagram[5]



[5] This diagram represents Libby Standard flood control operations used in Treaty studies. A different SRD for Libby VarQ is used in real-time operations.

Figure A.2. Example Grand Coulee Storage Reservation Diagram



A.2.4.1. Exchange of Storage between Mica and Arrow

As provided for under the Treaty, Canada may exchange flood control storage space between Mica and Arrow if the Entities agree that the exchange gives the same degree of flood protection at The Dalles. The original 8.45 Maf of primary storage space prescribed in the Treaty includes 7.1 Maf at Arrow, 0.08 Maf at Mica, and 1.27 Maf at Duncan. The 1972 FCOP adopted a 5.1/2.08 Maf Arrow/Mica allocation, which reflects an exchange of 2 Maf of flood control storage from Arrow to Mica.

The maximum limit of flood control space that can be exchanged from Arrow to Mica without adversely affecting flood control at The Dalles was confirmed in a Corps report[6] as 3.5 Maf, provided that 0.5 Maf of additional storage is provided in Mica. The Canadian Entity agreed with the Corps' assessment that a 3.6/4.08 and 5.1/2.08 Maf allocation of primary flood control space between Arrow and Mica provide an equivalent level of flood protection at The Dalles. During the operating year, but no later than November first, Canada may select a flood control storage space combination between Arrow and Mica consistent with the allocations described in

[6] Summary Report, Proposed Reallocation of Flood Control Space, Mica and Arrow Reservoirs, March 31, 1995.

this section. The Treaty FCOP SRDs that are used to determine required flood control draft have been modified to accommodate any Arrow/Mica storage exchange.

A.2.4.2. Grand Coulee Storage Reservation Diagram

Grand Coulee Dam's (GCL) primary flood control purpose is to reduce system flows measured at The Dalles, Oregon, although it does offer some incidental flood protection in the Hanford Reach. GCL has an SRD but does not use a seasonal volume forecast exclusively to determine its required flood control space. Instead, GCL uses an Upstream Storage Correction, which is the aggregation of all anticipated space upstream of The Dalles regardless of whether drafted for power or flood control needs available by April 30 (except space at GCL). The parameter necessary to make use of GCL's SRD is the unregulated seasonal volume forecast at The Dalles minus the Upstream Space Adjustment. The procedure for determining this parameter for use in GCL's SRD is outlined in Chart 2 of the FCOP. In some cases, a project may have more space drafted than can possibly be refilled. This can occur if the reservoir is evacuated deeply for power generation or if the water supply forecast during the evacuation period caused the reservoir to draft deeply and the water supply forecast does not materialize. In such a situation, the amount of space allowed for that project's upstream storage correction is limited to the expected seasonal volume of runoff minus that project's minimum flow requirement during the refill period.

A.2.4.3. Standard and Variable Discharge Flood Control

The flood control operation described in the FCOP is referred to as "Standard Flood Control." Standard Flood Control is used in all Treaty regulation studies including the AOP, DOP, and TSR. In 2003, real-time Libby and Hungry Horse operations initiated a modified flood control strategy called VarQ. Variable Discharge Flood Control, or "VarQ,"[7] is an alternative system flood control operation developed by the Corps for both Libby and Hungry Horse to improve the likelihood of refill and potentially provide more instream flow both during and after the refill season. Implementation of VarQ at Libby and Hungry Horse Dams permits lower volumes to be released (i.e., allows higher reservoir levels during the evacuation period) and increases the likelihood of providing more reliable spring flows for fish. Because Hungry Horse is not a Treaty project, subsequent VarQ discussion and description in this appendix will reference Libby only.

Since the flood control draft at Grand Coulee Dam is based, in part, on the available storage space upstream from The Dalles (see section A.2.4.2), VarQ flood control at Libby and Hungry Horse dams influences operations for system flood control at Grand Coulee Dam by causing Grand Coulee Dam to draft deeper to maintain system flood protection at The Dalles. In practice, Grand Coulee Dam drafts deeper for flood control only in years where the seasonal volume Water Supply Forecasts (WSF) prepared for Libby Dam in December through March are between 86 and 100 percent of average. The increase in flood control draft at Grand Coulee Dam is less than the net decrease in draft at Libby and Hungry Horse dams.

[7] Q is engineering shorthand for flow.

Standard Flood Control and VarQ also differ during reservoir refill. For example, standard flood control at Libby dam allows releases to its authorized project minimum flow of 4 kcfs during the refill period from May through July. Minimum releases during the refill period from Libby under VarQ operation can be as high as 25 kcfs.

Libby operations for VarQ and flow augmentation to protect sturgeon, bull trout, and salmon are embedded in all recent Biological Opinions developed by the U.S. Fish and Wildlife Service and NOAA-Fisheries. The Corps prepared an Environmental Impact Statement (EIS) on permanent implementation of Libby VarQ flood control in April 2006 and issued a related Record of Decision in June 2008. Those documents indicated that VarQ flood control procedures for Libby Dam would be implemented on a permanent basis starting with the 2008-09 operating year.

A.2.4.4. Libby Variable End-of-December Draft

The Protocol states, with regard to Libby Dam, that the Entities shall cooperate on a continuing basis to coordinate the operation of that dam with the operation of hydroelectric plants on the Kootenay River and elsewhere in Canada. Libby Reservoir is included in the FCOP to meet the Treaty requirement to coordinate its operation for flood control protection in Canada and for the system.

When the Treaty FCOP was first put into practice, the Libby SRD required a fixed flood control draft of two million acre-feet by the end of December, because seasonal volume forecasts were not prepared until January. Two million acre-feet was chosen because if the first seasonal volume forecast at Libby was relatively high, then a "head start" on the draft was appropriate to increase the likelihood of achieving Libby's full flood control draft by March 15th. During the flood control evacuation period, Libby's outflow (and subsequent ability to evacuate water pursuant to its SRD) is constrained by the Kootenay Lake Order. The Kootenay Lake Order requires Libby to reduce outflows so as not to force Kootenay Lake above fixed winter elevations. In relatively low-volume runoff years, a Libby draft of two million acre-feet is excessive and jeopardizes refill. Recent advances in volume forecasting technology and skill allow a seasonal volume forecast of inflow to Libby to be prepared by December first. The December forecast now enables the end-of-December Libby flood control elevation to be variable and less than two million acre feet. The total allowable "relaxation" of Libby end-of-December flood control draft is 600,000 acre-feet, thereby potentially reducing the maximum draft to 1.4 Maf. The amount of relaxation is determined as follows:

If 1 Dec forecast for Libby Dam $\geq$ 5900 kaf for the April through August period (94 percent of normal), no relaxation, and 2 Maf is evacuated by the end of December.

If 1 Dec forecast for Libby Dam $\leq$ 5500 kaf for the April through August period (88 percent of normal), relax draft by 600 kaf, and 1.4 Maf is evacuated by the end of December.

For 5500 kaf < 1 Dec forecast < 5900 kaf, relax draft by interpolating between 600 and 0 kaf.

The variable end of December draft procedure has been used in real-time operations since the 2005 Water Year.[8] This process is not used in Treaty studies such as the AOP, DOP, or TSR.

A.2.4.5. Other Projects

Duncan

Duncan is a Category I Treaty project. Its flood control effect is dedicated primarily to the system; however, there is an incidental local flood control benefit to the river reach starting immediately below the project and extending to Kootenay Lake. Duncan has 1.27 Maf of authorized primary flood control space. A detailed description of Duncan's flood control operation is found in Chapter VIII of the Treaty Flood Control Operating Plan.

Hungry Horse

Hungry Horse is not a Treaty project and is a Category I project. As a headwater project, its outflow can be reduced to project minimum to minimize downstream flooding, or to enhance refill probability. Hungry Horse has approximately 3 Maf of authorized flood control space. Hungry Horse provides a flood control benefit for the system and at the Columbia Falls, Montana, local control point on the South Fork Flathead River, a few river miles below Hungry Horse Dam. It has flow augmentation requirements and a VarQ flood control scheme. As with Libby, the effect of VarQ is to potentially facilitate a more-reliable supply of spring and summer flows for fish while simultaneously better ensuring higher reservoir elevations in the summer. Flow augmentation occurs in the summer months for salmon and year-round, in the form of a minimum flows, for bull trout.

Dworshak

Dworshak is not a Treaty project and is a Category I project. Dworshak is a headwater project, and its outflow is reduced to its project minimum at the start of the refill season. Dworshak has approximately 2 Maf of authorized flood control space. Dworshak provides a flood control benefit for the system and at the Spalding, Idaho, local control point on the Clearwater River, just upstream of the confluence of the Snake and Clearwater Rivers.

Brownlee

Brownlee Dam is not a Treaty project and is a Category I project. As a headwater project, its outflow is reduced to its project minimum at the start of the refill season. Brownlee is owned and operated by Idaho Power Company and is the only project on the Snake River with system flood control space dedicated for use in a coordinated fashion for system flood control. The 1 Maf of system flood control space authorized by Brownlee's FERC license is drafted for flood control according to its Storage Reservation Diagram, directed by the Corps.

[8] *Summary Report, 31 December Variable Flood Control Draft For Libby Reservoir*, Columbia Basin Water Management Division, US Army Corps of Engineers, January 2004

Kootenay Lake

On November 11, 1938, the International Joint Commission (IJC) granted an Order of Approval to the West Kootenay Power and Light Company to operate Corra Linn dam at Granite, B.C., to store six feet of water in Kootenay Lake and also to excavate the outlet of the lake at Grohman Narrows. The Order stipulated that the works be operated subject to a number of conditions and established the International Kootenay Lake Board of Control (KLBC) to oversee the operation of the works. The Board consists of four members, one each from the U.S. Army Corps of Engineers, U.S. Geological Survey, Environment Canada, and B.C. Ministry of the Environment. An annual report is submitted to the IJC in April of each year.

The 1938 Order requires an orderly drawdown of Kootenay Lake in preparation for the spring runoff such that the elevation does not exceed 1739.32 feet on or about April first as measured by the lake elevation gauge at Queens Bay. During the high summer water, the allowable lake elevation is calculated using a lowering formula from the natural lake elevation that would have occurred under original outlet conditions existing before the excavation of Grohman Narrows. At the end of the summer, for agricultural interests, the 1938 Order also specifies that once the lake elevation falls below 1743.32 feet, as measured at the Nelson gauge, it should be held below this elevation until August 31. Between September 1 and January 7, the maximum elevation is 1745.32 feet. The Treaty requires that the operation of Libby be consistent with the Kootenay Lake IJC Order. The current FCOP contains statements indicating that both Duncan and Libby must operate so as to avoid violating the IJC Order.

A.2.5 DETAILS OF REFILL PERIOD

A.2.5.1. Flood Control Refill Curves

Flood Control Refill Curves help guide the refill of reservoirs during the spring refill period and ensure that the flood control regulation does not adversely affect refill insofar as possible. Individual project refill can commence before regulation to meet the Initial Controlled Flow (ICF; see section A.2.5.3) at The Dalles if the reservoir is at or below its Flood Control Refill Curve. The refill curves define the upper reservoir elevation at any point during the refill period. Their derivation is based on the "95 percent confidence volume runoff forecast," reduced by the amount of water to be filled into reservoirs upstream and project outflows that are anticipated to occur during the remaining refill period.

The 95 percent forecast is computed by reducing the expected seasonal runoff volume by approximately 1.65 times the standard error of the forecast. The purpose of the reduction is to account for a situation where the volume is over forecast and refill cannot be achieved because the anticipated volume did not materialize, thus creating a refill volume shortage.

The refill curves are updated daily, if necessary, using the residual volume inflow forecast and hydrologic simulations of forecasted stream flows to as much as 10 days into the future during the refill period to determine when the ICF will be reached and refill can begin. Daily inflows into the reservoirs are accounted for, and deducted from, the 95 percent confidence volume runoff forecast to determine the residual volume inflow forecast. It is important to note that the

95 percent confidence volume runoff forecast is not probability-based. If actual seasonal runoff is more than the expected value, then the excess water is passed through the project throughout the entire refill period such that a "fill and spill" condition is avoided.

A.2.5.2. Arrow/Grand Coulee Coordinated Refill

During the refill period, Arrow and Grand Coulee reservoirs refill at proportional rates to control flow at The Dalles to the required ICF (see section A.2.5.3). The rate of refill of the reservoirs is computed based on how full each reservoir is on the date of the ICF. The proportional fill of each reservoir is guided by use of Charts 3 and 6 in the FCOP. The proportional fill quantities for each reservoir are revisited throughout the refill season and adjusted as each reservoir fills.

FCOP Chart 3 is used to determine the flow to be met at The Dalles during the refill period. The flow is a function of the ICF and the combined space available to fill at Arrow plus Grand Coulee. The space available at Arrow plus Grand Coulee is defined as the percent of space available on the date of ICF. This available space, combined with the expected volume of runoff yet to come on the date of the ICF, less the volume of other upstream storage to be filled, gives the user a flow objective at The Dalles.

FCOP Chart 6 is used to determine how to proportionally fill the reservoirs. Chart 6 uses the ratio of storage space available in Grand Coulee compared to Arrow and prorates the amount of storage to be filled at Grand Coulee. Chart 6 is used as guidance and can be revisited throughout the refill season.

A.2.5.3. Controlled Flow at The Dalles

During the refill period, the upstream reservoirs operate as a system to meet the controlled flow at The Dalles, Oregon. The controlled flow is the target flow for lower Columbia River flood control as measured at The Dalles. The controlled flow is a function of the projected volume of the Columbia River spring runoff as measured at The Dalles and the amount of upstream storage space that has been evacuated for system flood control. Refill of upstream reservoir storage is regulated in a manner that provides the desired controlled flow at The Dalles. While a discharge of 450 kcfs, as measured at The Dalles, may be considered a bank-full level, higher controlled flows will be used for high-magnitude floods, resulting in damaging flows in the lower Columbia, to prevent storage space from filling too soon.

The expected controlled flow for the runoff season, and the one-day annual peak flow objective at The Dalles, is called the Initial Controlled Flow. The ICF is used in conjunction with unregulated streamflow forecasts to guide the determination of when to begin refill of reservoirs. The ICF is fundamentally a water balance calculated using the available system storage volume on 30 April and the forecasted seasonal runoff volume. The resultant volume is then converted to a flow rate and labeled the ICF. The simplistic interpretation of ICF is that all unregulated flow above the ICF during the runoff season at The Dalles can be stored in upstream reservoirs, thereby refilling reservoirs. Therefore, when the calculated unregulated flow at The Dalles reaches the ICF, the system can begin refill and operate to a regulated flow that is equal to the ICF. The ICF thus is the trigger to initiate system refill. The ICF is used to ensure that the

projects refill while minimizing the peak runoff at The Dalles. Charts in the FCOP are used to establish the ICF. In FCOP Chart 1, the ICFs at The Dalles are shown as low as 200 kcfs.

As stated earlier, the one-day annual peak flow objective and the refill season flow objective at The Dalles are the ICF, and every effort is made to control flows down to the ICF by the regulation of upstream reservoirs until the end of the flood control period or until revised forecasts indicate the necessity for the controlled flow to be changed. Change in the controlled flow at The Dalles will be made based primarily upon day-to-day forecasts of streamflow and reservoir regulation by computer simulations, together with the latest volume forecasts of runoff.

A.2.6 ON-CALL FLOOD CONTROL (PRE-2024)

The Columbia River Treaty refers to two types of flood control storage space that is provided by Canadian storage. Storage space that is available on an annual basis is defined as Primary Storage. Under the Columbia River Treaty, the United States paid U.S. $64.4 million for use of 8.45 Maf[9] of Primary Storage through September 2024. The Treaty also requires Canada to operate any storage in addition to the Primary Storage in the Columbia River Basin in Canada as required to meet flood control needs in the United States that cannot adequately be met by flood control facilities in the United States and Primary Storage. The Protocol further defines this need as arising only in the case of potential floods that would result in a peak discharge in excess of 600,000 cfs at The Dalles after the use of all related United States storage capacity existing and under construction in January 1961, Libby storage, and the Primary Storage. This additional Canadian space beyond Primary Storage is labeled “On-Call” storage.

A request for On-Call storage space must be processed in accordance with the Treaty. A large part of this On-Call storage would normally be evacuated during the winter, but this is not assured. Under the Treaty, a delay of 20 days may be encountered before the request for On-Call storage use is honored. With consideration of the discharge limitations at each project, the time required to prepare forecasts, and the time to process a request, it will be necessary for consultations on the use of On-Call storage to commence early in order to be assured that the storage space at each project can be made available by April first.

When the forecast of unregulated April through August runoff for the Columbia River at The Dalles exceeds the values shown in Table A.6, the United States Entity may, at its discretion, initiate formal consultation with the Canadian Entity on the need for On-Call storage:

Table A. 6. Forecast of Unregulated April through August Runoff Volumes in Millions of Acre-feet at The Dalles

Date of Forecast	Millions of Acre-feet at The Dalles
1 January	105
1 February	108
1 March	110
1 April	111

[9] This amount of space was augmented in 1995 to 8.95 MAF as part of the flood control storage reallocation between Mica and Arrow reservoirs (see section A.2.4.1)

The Treaty requires that the United States pay Canada $1,875,000 for each of the first four calls for On-Call Storage. In addition, the United States will deliver electric power equal to the power lost by Canada as a result of operating the storage to meet the flood control need for which the call was made. To date, the U.S. has not requested On-Call storage in Canada.

A.3 ASSURED OPERATING PLAN AND DOWNSTREAM POWER BENEFIT COMPUTATION

A.3.1 OVERVIEW

The Treaty requires that the Entities prepare annually an Assured Operating Plan for Canadian Storage and calculate the resulting Determination of Downstream Power Benefits. These studies are prepared for the sixth succeeding operating year. The AOPs are designed to achieve an optimum power operation in both Canada and the U.S. The DDPB calculates the Canadian Entitlement of the improved and optimized generation from downstream U.S. projects due to a coordinated and optimized Canadian Treaty storage operation. It also determines the year-to-year limit of allowable decrease in Entitlement due to the operation of Canadian storage for optimum power in both Canada and the U.S.

The AOP operating criteria include a series of rule curves that guide reservoir operation for flood control, optimum power generation, and reservoir refill in average and better water years. Similarly, critical rule curves guide reservoir operation for firm power in low flow conditions. Also included are operating criteria for Mica and Arrow that optimize Canadian power generation. This includes minimum and maximum flows, procedures for target flows, storage contents at Mica, and storage upper limits for Arrow.

The objective of the DDPB studies is to compute the Canadian Entitlement associated with the AOP operation. To the extent possible, the same operating criteria and procedures have to be applied to both AOP and the DDPB. Therefore, the development of AOP and the computations of Downstream Power Benefits are interdependent and have to be accomplished concurrently. The Canadian Entitlement is one-half of the DDPB.

AOP studies and the DDPB are prepared in accordance with the Treaty, the Protocol,[10] and the following Entity Agreements:

- Principles for the Preparation of the AOP and DDPB Studies (28 July 1988)
- Changes to Procedures for the Preparation of the AOP and DDPB Studies (12 August 1988)
- Columbia River Treaty Entity Agreement on Resolving the Dispute on Critical Period Determination, the Capacity Entitlement, for the 1998-99, 1999-00, and 2000-01 AOP/DDPBs, and Operating Procedures for the 2001-02 and Future AOPs (29 August 1996)

[10] Protocol - Annex to Exchange of Notes, Dated January 22, 1964 Between the Governments of Canada and the United States Regarding the Columbia River Treaty (Protocol).

- Principles and Procedures for Preparation and use of Hydroelectric Operating Plans for Canadian Treaty Storage (October 2003)[11]

Any procedure changes from these agreements are noted in the annual AOP and DDPB report.

Five studies are generally performed to complete the AOP and DDPB studies. The basic assumptions for these studies and their general purpose are shown in Table A.7, and a process diagram is provided in Figure A.3. Steps I, II, and III U.S. optimum studies are completed first. In the Step I and II U.S. optimum studies, Canadian storage is operated to provide optimum power generation in the United States. The Step III study excludes Canadian storage and operates for optimum power in the U.S.

Once the three U.S. optimum studies are complete, the next stage in the process is to complete the "Canadian Re-operation," which involves developing project-specific operating criteria for Canadian storage projects to optimize generation in both countries. These criteria are then included in the Joint Optimum Step I and Step II systems. The Step I Joint Optimum study becomes the basis for the AOP. The Step II Joint Optimum study is then used for comparison with the Step III study to compute the Joint Optimum Downstream Power Benefits.

Within each of the five studies described above (U.S. Optimum Steps I, II, III and Joint Optimum Steps I and II) there are three different system regulation studies that may be simulated:

- Critical Period System Regulation Studies
- Power Refill studies
- System Regulation Studies

The system regulation studies are used to develop the rule curves, operating rules, and project operating criteria that, in conjunction with the FCOP, are used to guide operations.

Due to the interdependence of the AOP (Step I) and the DDPB (Steps II and III), and with the three types of system regulation studies, it is difficult to describe a linear process for conducting the AOP/DDPB studies. The various studies' components and approaches are organized in the following sections:

A.3.2 Step I, II, III Descriptions

A.3.3 System Regulation Studies and Associated Rule Curves

A.3.4 Input Data to the AOP Process

Descriptions and definitions of these system regulation studies, and their associated rule curves, are provided in the subsequent sections.

[11] This Entities' Agreement is referred to as POP. Appendices have been added and updated since 2003, including Appendix 6 - Streamline Procedures (2004), Appendix 7 - Table of Median Streamflows (2004), and Appendix 8 - Water Supply Forecasts (2007).

Table A. 7. Summary of Assured Operating Plan and Downstream Power Benefit System Regulation Studies

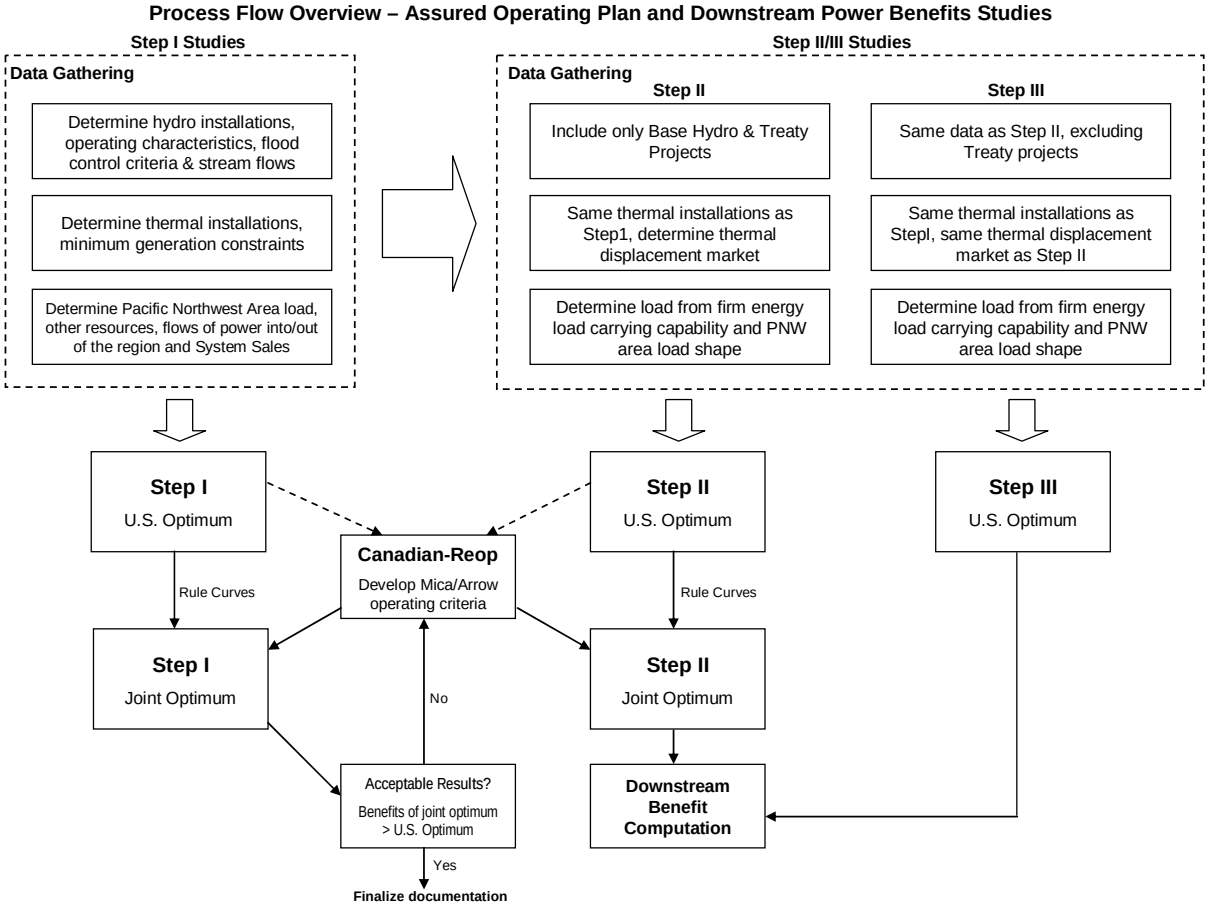
Study Name Annex B Step #	System Configuration	Study Purpose / Description
US Optimum		
Step I	15.5 Maf Canadian storage **All U.S. Columbia Basin hydro projects** **Coordinated Cdn projects**	1) Establishes the power installations required and U.S. Optimum generation that must be met or exceeded by the Joint Optimum Step I generation.
Step II	15.5 Maf Canadian storage **13.0 Maf Base System** PNWA Load Shape Step I Thermal Installations	1) Compared to Step III study [no Canadian storage] to establish U.S. optimum Downstream Power Benefits. 2) Compared to Joint Optimum Step II study to determine reduction, if any, in Downstream Power Benefits caused by Canadian re-operation.
Step III	**No Canadian storage** **13.0 Maf Base System** PNWA Load Shape Step I Thermal Installations	Base case for all Downstream Power Benefit computations. [Use of Base system, defined in Annex B, provides Canada with the next-added benefits agreed to in Article Vll(2)(b) of the Treaty.]
Joint Optimum (Re-regulation of U.S. Optimum Step I and II studies to include Canadian Generation)		
Step I	15.5 Maf Canadian storage **All U.S. Columbia Basin hydro projects** Step I Load Shape Step I Thermal Installations **Coordinated Cdn projects**	Establishes operating plan for Canadian storage, including Mica Operating Criteria, based on Joint Optimum generation, which must exceed U.S. Optimum Step I generation.
Step II	15.5 Maf Canadian storage **13.0 Maf Base System** Step I Load Shape Step I Thermal Installations	1) Compared to Step III U.S. Optimum to establish final Downstream Power Benefits, based on Joint Optimum with Canadian storage next-added to 13.0 Maf Base System Storage. 2) Compared to Step II U.S. Optimum to determine reduction, if any, in Downstream Power Benefits caused by Canadian re-regulation. Downstream Power Benefit reduction must not exceed limits specified in the Treaty (see section A.3.6.1.)

Notes:

1) 13 Maf (16.035 km^3) Base System defined in Annex B, includes 0.673 Maf (0.829 km^3) of usable storage at Kootenay Lake.

2) Two AOP studies used to limit the reduction in Downstream Power Benefits that may result from re-operation of Canadian storage are not included in this table.

Figure A.3. Process Diagram



A.3.2 STEP I, II, III DESCRIPTIONS

In accordance with Annex B, paragraph 7, of the Treaty, the increase in dependable hydroelectric capacity and the increase in average annual hydroelectric energy are determined from critical period and 30-year system regulation studies of the following systems:

Step I: The Step I study is used for two purposes:

1. To develop the Assured Operating Plan for Canadian storage to fulfill Treaty obligations. The study determines whether the proposed operating rules are optimum in both countries. The final "joint optimum" study forms the basis of the Assured Operating Plan. The Joint Optimum AOP Step I Study is the default required operation of Canadian Treaty Storage, unless otherwise agreed upon in the DOP.
2. To set the agreed-upon planning processes, joint optimum operating criteria, and thermal and hydropower installations that are used for the Step II and III studies.

Step II: These studies determine the critical period energy capability and the average annual usable hydro energy capability of a system that includes the same thermal installation as the

Step I studies, only the Base System projects with the same installed capacity as Step I, and the Canadian Treaty Storage.

Step III: These studies are the same as Step II studies except Canadian Treaty Storage is not included.

Information developed in the Step I studies that is carried over to and utilized in the Step II and Step III studies includes, but is not limited to, the following:

- Load shape of the Pacific Northwest Area (PNWA)
- Installed capacity of the Base System
- Project Operating Criteria
- Thermal Installations
- Flood Control rule curves
- Minimum generation of each Thermal Installation
- System Sales
- PNWA monthly load factors during the Step I critical period

The Step II and Step III studies are used to determine Downstream Power Benefits and are not based on real power systems. Analysis of these hypothetical systems is required because the Treaty provides that Canadian storage shall be considered as "next added" to the 13.0 Maf of usable storage in the Base System. Next-added refers to the concept that the first increments of storage will provide greater benefits than increments built later.

System configurations for the Step I, II and II studies are listed below.

Step I: Represents the actual physical system, including:

- 15.5 Maf Canadian storage
- All U.S. Columbia Basin hydro projects
- Coordinated Canadian projects[12]
- Thermal Installations operated in coordination with the PNWA
- PNWA firm loads, plus estimated imports, exports, and all other PNWA generation

Step II: Represents the "base system"[13] with the Canadian storage:

- 15.5 Maf Canadian storage
- 13.0 Maf "base system" (essentially the 1961 storage reservoirs upstream of Bonneville dam, as modeled in the 1961 Modified Flow Report,[14] plus all mainstem run-of-river projects)

[12] Recent AOPs have included projects on the Kootenay and Pend Oreille.
[13] The "base system" plants are defined in the Treaty.

- Step I Thermal Installations
- System power loads equal to critical period resources, but shaped the same as Step I PNWA load

Step III: Same as Step II except Canadian storage is not included.

A.3.3 SYSTEM REGULATION STUDIES AND ASSOCIATED RULE CURVES

There are three different system regulation studies that may be simulated in each of the Step I, II, and III studies.

1. **Critical Period Studies.** Determine the critical period,[15] the U.S. system firm energy load carrying capability (FELCC),[16] and Critical Rule Curves used to guide operations during low streamflow operations.
2. **Power Refill Studies.** Establish operating criteria for middle and high water years by looking at 30 water years to preserve the future FELCC (that is, not overdraft the reservoir while serving the secondary market).
3. **System Regulation Studies**. Simulate a continuous operation over 70 years (30 years for Steps II/III) with the operating criteria established from critical period and refill studies.

Further details on these system regulation studies and their associated rule curves are provided in the following sections. A description of how each system regulation study is used in the Step I process can be found in section A.3.5.

A.3.3.1. Flood Control Upper Rule Curves

The flood control Upper Rule Curve (URC) defines the maximum allowable end of month reservoir levels at each project during the evacuation and refill periods. The Upper Rule Curves used in the AOP are determined from observed mode flood control regulation studies conducted by the U.S. Entity. During the evacuation period (the low flow period from October to March), the URCs are based on Storage Reservation Diagram contained in the FCOP. The URC for the refill period is derived from a daily analysis of system flood control simulations to control flows at the lower Columbia River as measured at The Dalles, Oregon. URCs are used as a constraint in the AOP hydroregulation studies. More information on flood control is provided in section A.2.

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[14] The Modified Flow report is referred to in Protocol VIII. It includes a large amount of regulation at projects not modeled, and irrigation depletion, especially the Upper Snake, Priest Lake, Upper Deschutes, and Yakima, which otherwise would not appear to be part of the Base System.

[15] The critical period is defined as the period, beginning with the initial release of stored water from full reservoir conditions and ending with the reservoirs empty, when the water available from reservoir releases plus the natural streamflow is capable of producing the least amount of hydroelectric power in meeting system load requirements.

[16] The system generation during the critical period is the firm energy load carrying capability.

A.3.3.2. Critical Period Studies and Rule Curves

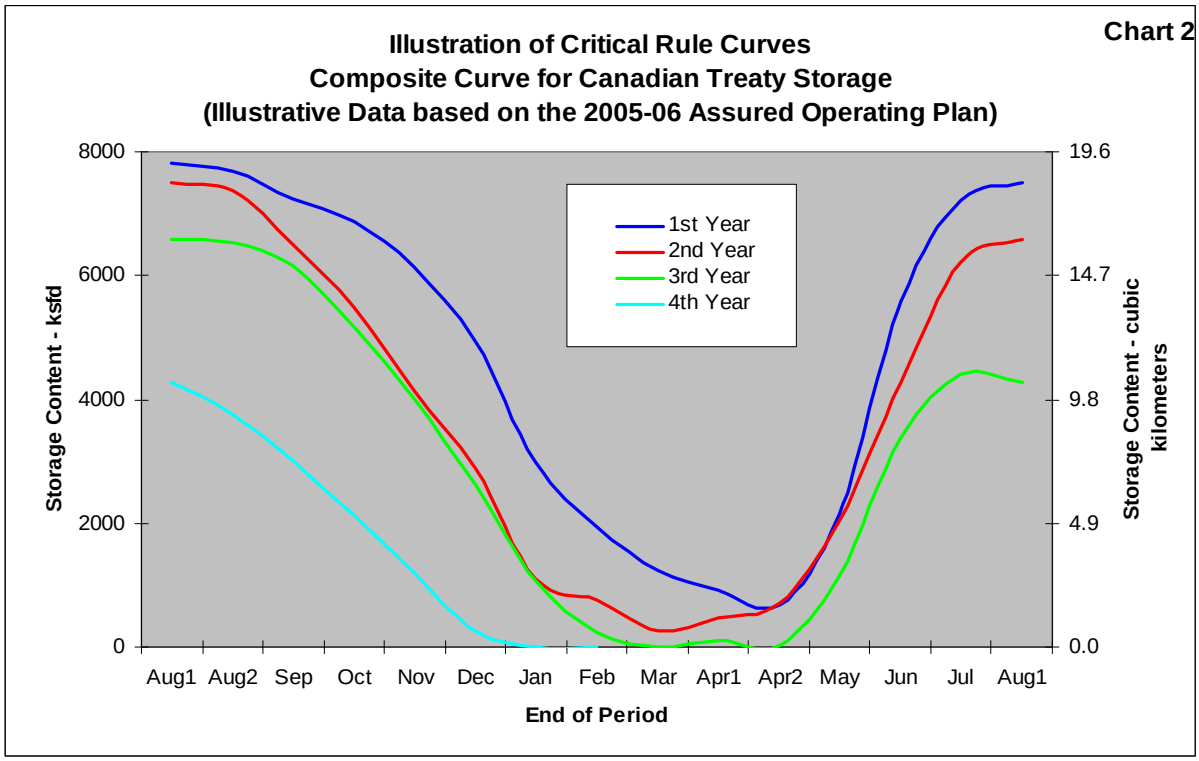
The purpose of the critical period study is to determine the FELCC of the hydroelectric system and the operating criteria that guide each project's operation during the critical period. FELCC is the maximum amount of annual firm energy (shaped load) that the system can continuously support while drafting the active storage of the system from full to empty under the most adverse sequence of streamflows occurring within the adopted historical record (the critical period). In critical period studies, the system is regulated to maximize critical period energy, shaped to the load of the Pacific Northwest Area, within the operating constraints applied to the study. The study is conducted in observed mode, which assumes complete foreknowledge of all stream flows during the critical period.

Critical Rule Curves (CRC) are developed for each storage reservoir by the Critical Period Study. The end-of-month storages are the CRC. This study also determines the length of the critical period. A CRC provides a monthly guide to reservoir storage drafts and fills to provide an optimum power operation to meet system FELCC during periods of low inflows.

In multiple-year critical periods, there will be a CRC for each year of the critical period. The first Critical Rule Curve (CRC1) is used in the development of the Operating Rule Curve. Any additional rule curves define proportional drafting[17] points below the Operating Rule Curve, which guide reservoir operation while generating system FELCC during low water conditions. Figure A.4 below provides an illustration of the Critical Rule Curves for Canadian Treaty Storage.

[17] Proportional draft equitably distributes draft of storage among the reservoirs in the system during poor water years to ensure that FELCC will be met when reservoirs must be drafted below Energy Content Curves. See section A.3.3.7.

Figure A.4. Illustration of Critical Rule Curves



A.3.3.3. Power Refill Studies and Associated Curves

The refill studies develop guidelines for generation to produce secondary energy while protecting future FELCC and ensuring a high probability of refill. A reservoir shall not be drafted below its refill curve (ARC; see next paragraph) to serve any secondary energy loads, unless required by established operating procedures at the project.

Two refill curves are developed to guide reservoir operations. The Variable Refill Curve (VRC) is based on a 95 percent refill probability. The Assured Refill Curve (ARC) is developed using the second-lowest January to July volume inflow of historical stream flows (1931). In essence, the ARC provides a check on the VRC and allows a deeper draft if the VRC is found to be overly conservative.

ARCs are developed for all reservoirs. VRCs are developed only for reservoirs with multi-year storage (i.e., reservoirs that do not normally draft from full to minimum levels every year, e.g., Mica, Arrow, Duncan, Libby, and Grand Coulee).

Power refill studies are used to develop the ARCs and VRCs. The studies incorporate the CRCs and FELCC developed in the Critical Period System Regulation Study.

Monthly Power Discharge Requirements are parameters used in computing the ARCs and VRCs. They define the “amount of water to hold back for filling the reservoir.” The Power Discharge

Requirements vary as a function of the unregulated January through July runoff volume at The Dalles, Oregon, and are defined for forecast volumes of 80 Maf, 95 Maf, and 110 Maf. Between these runoff volumes, the Power Discharge Requirements are linearly interpolated. In years when the runoff volume is less than 80 Maf or greater than 110 Maf, the Power Discharge Requirement at 80 and 110 Maf, respectively, is used.

A.3.3.4. Operating Rule Curve Lower Limit

The Operating Rule Curve Lower Limit (ORCLL) defines the minimum month-end storage content that provides a high probability that the system will be capable of meeting its FELCC during the period 1 January through 30 April in the event that the VRCs permit storage to be emptied prior to the start of the freshet. For multi-year critical periods, the ORCLLs are determined from special 1937 hydroregulation studies. If the critical period is one year or less, the ORCLL and the first-year CRC are identical during the period 1 January through 30 April.

A.3.3.5. Operating Rule Curves

The Operating Rule Curve (ORC) for each reservoir is a synthesis of all of the preceding curves, as follows:

1 Aug - 31 Dec:	ORC = Higher of CRC1 and ARC
1 Jan - 31 Jul:	ORC = Lower of VRC and Higher of CRC1 and ARC
1 Jan - 15 Apr:	ORC is limited to no lower than ORCLL
At all times:	ORC is limited to no higher than the URC

The Operating Rule Curve allows, but limits, reservoir operation for the purpose of producing secondary energy. Reservoirs are drafted below Operating Rule Curves only if required to maintain the FELCC of the system or meet non-power requirements.

A.3.3.6. Non-Power Requirements

In Treaty studies, project operations[18] are subject to agreed (established) non-power requirements at each of the hydro projects, such as the following:

1. Maximum rate of storage draft and refill
2. Maximum and minimum flows
3. Maximum ramping rates
4. Maximum and minimum reservoir elevations
5. Flood control criteria
6. Other agreed at-site non-power requirements

[18] Actual operations may be subject to additional non-power requirements that are not included in Treaty studies.

Non-power requirements for AOP and DDPB studies for Base System projects and Canadian storage are established in the 29 August 1996 Entity Agreement. Non-power requirements for Libby are established in the Libby Coordination Agreement. The non-power requirements at Base system and Canadian storage projects can be changed only by mutual agreement.

A.3.3.7. Additional Operating Criteria

In general, the whole of Canadian storage is operated to follow the Operating Rule Curve. However, there are situations where this does not occur.

Operating Above the Operating Rule Curve. Draft to the Operating Rule Curve is typically limited at Mica and all U.S. storage reservoirs to maximum powerhouse discharge (i.e., projects do not need to spill water to meet ORC draft levels). Operating above the Operating Rule Curve also can occur if the U.S. project secondary energy generation amounts exceed the secondary market limit.

Proportional Draft Below the Operating Rule Curve. Under low water conditions, proportional draft below the Operating Rule Curves is required to produce the hydro FELCC of the U.S. system. When proportional draft conditions are met, the whole of the Canadian storage and all reservoirs in the U.S. system are initially drafted proportionally between their respective Operating Rule Curves and their first Critical Rule Curves. If it is necessary to draft additional storage after system reservoirs reach their first Critical Rule Curves, the proportional draft shall be made between their first and second Critical Rule Curves, their second and third Critical Rule Curves, and so on.

Proportional draft is limited by 1) maximum powerhouse discharge at Mica and all U.S. reservoirs, 2) Mica/Arrow operating criteria, and 3) non-power requirements and project operating criteria.

Composite Operation of Canadian Storage. While the operating plans and rule curves are developed for each Canadian reservoir, the obligation of Canada to provide storage regulation is measured by the composite storage in all three Treaty reservoirs. To accomplish this, Canadian storage operation is guided by the composite Operating Rule Curve and composite Critical Rule Curves for the whole of Canadian storage. A composite rule curve for the whole of Canadian storage is the summation, by month, of the storage corresponding to the rule curves for Mica, Arrow, and Duncan. In addition, the individual operation of Mica and Arrow is guided by Upper Rule Curves and project operating criteria, which may cause a deviation from the rule curves.

In actual operation, the Canadian Entity may vary the individual project operation in any manner consistent with the composite operation for Canadian storage in the hydroelectric operating plan and the individual Upper Rule Curves at each project.

A.3.3.8. System Regulation Studies

These studies cycle through each of the historical streamflow conditions sequentially to test the system operating criteria developed in the critical period and refill studies over a wide range of

inflows. For joint optimum studies, operating criteria for Mica and Arrow are also included. The studies are used to determine the average annual usable energy and dependable peaking capacity produced by the Canadian and U.S. systems.

A.3.4 INPUT DATA TO THE AOP PROCESS

Input data must be gathered prior to conducting the system regulation studies. Required information includes loads and resources, streamflows, flood control criteria, and non-power requirements.

A.3.4.1. Loads and Resources

Load and resource forecasts provide basic but critical information required to simulate the operation of the PNWA coordinated hydroelectric system and, as a result, affect the design of reservoir operating criteria and the calculation of the Canadian Entitlement to downstream power benefits.

Loads are quantified by three main forecasts:

1. PNWA Firm Loads
2. Flow of power at points of interconnection (i.e., imports and exports)
3. Miscellaneous resources including some small hydro and other renewables (Step I firm load is reduced by these resources)

Resources are quantified by known and forecast:

1. Base System Hydro
2. Other Step I Coordinated Hydro
3. Thermal installations operated in coordination with the Base System
4. Maintenance, transmission loss, and reserves

The assumptions behind load and resource forecasts significantly influence the outcomes of the Phase 1 studies.

A.3.4.2. Streamflow Record

All system regulation studies are currently based on the 2000-level Modified Flow study data set (August 1928 through July 1998). Modified flow data includes updates for current best estimates of 2000 level irrigation depletions, return flows, and evaporation, and adjustments for errors and omitted projects.

In accordance with Protocol VIII, the AOP Step I, II, and III system regulation studies are based on only the 30-year streamflow period from 1928 through 1958. However, the Step I studies do use the total streamflow period (currently 70 years) from the 2000-level Modified Streamflows (1928-1978) to develop and test the AOP operating rules and rule curves to provide an indication

of actual Treaty operation over a wider range of streamflow conditions. The additional 40 years (currently) are not included in the determination of optimum power or the calculation of downstream power benefits.

The Entities have agreed to use a 1 August through 31 July operating year with 14 periods (August and April are split into two periods).

A.3.5 STEP I AOP PROCESS

Figure A.3 describes how each system regulation, described in section A.3.3, is used in the Step I studies. Links with the Step II and III studies are also shown in the figure.

A.3.5.1. Step I U.S. Optimum Study

The first study conducted is the Critical Period Study. An iterative process is required so that the Firm Load Carrying Capability (FLCC) determined from the Critical Period Study matches the Residual Hydro Load defined by the loads and resources. The critical rule curves defined in the Critical Period Study are then used in the power refill study, which develops the variable and assured refill curves and the power discharge requirements. Finally the system regulation studies are conducted to test operation criteria under a range of conditions and calculate the power produced.

A.3.5.2. Canadian Re-operation and Joint Optimum Study

After the U.S. Entity has completed the U.S. Optimum study, the information is provided to the Canadian Entity to adjust operation of Canadian Storage to optimize generation in both countries. The objective is to:

1. Increase the firm energy, secondary energy, and/or dependable capacity of Mica and the Canadian downstream projects
2. Improve the monthly distribution of energy production on the Canadian system
3. Maintain sufficient outflow to allow peaking during all periods

The Canadian re-operation can modify the rule curves that were developed in the U.S. Optimum studies and develop operating criteria for Mica and Arrow projects.

Under the Mica Project Operating Criteria, the Mica operation in each period is to a target flow or content as determined by Arrow's storage content at the end of the previous period. In the event that Mica's operation results in more or less than Mica's share of draft from the Operating Rule Curve or proportional draft point, compensating changes will be made from Arrow to the extent possible. In general, Arrow reservoir is operated to provide the balance of the required total Canadian Treaty Storage to compensate for Mica operation, subject to physical and

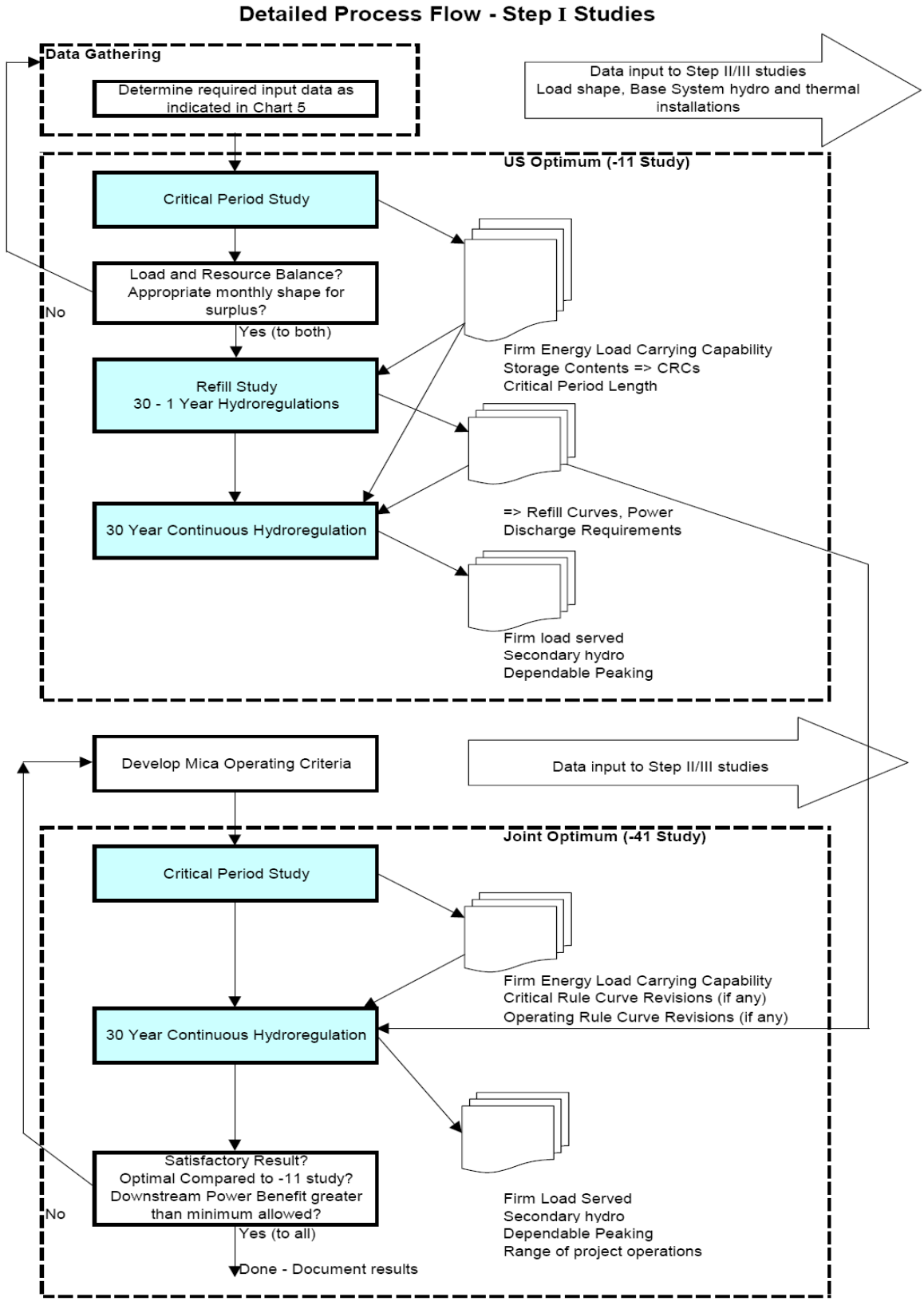
operating requirements.[19] The operation of Mica to specific project operating criteria, together with compensating changes to Arrow's operation, is commonly called "Mica/Arrow Balancing."

Other Canadian projects such as Revelstoke, Upper Bonnington, Lower Bonnington, South Slocan, Brilliant, Seven Mile, and Waneta are included in the study as run-of-river projects. Corra Linn and Kootenay Canal are included and operated in accordance with criteria that closely approximate an optimum power operation as limited by International Joint Commission requirements for Kootenay Lake.

The Canadian Treaty operating criteria are applied to both Step I and II joint optimum studies. As a result, the Canadian re-operation is conducted in parallel to the Step I and II joint optimum studies.

[19] Requirements include but are not limited to the flood control upper rule curve, rate-of-draft and minimum flow limits, and the Arrow Project Operating Criteria.

Figure A.5. How each system regulation study is used in the Step I process



A.3.5.3. Optimum Power Generation

The Treaty requires that the AOP be based on joint optimum power generation in Canada and the U.S. To evaluate the power gains and losses to the United States and Canada in the Step I U.S. Optimum and Step I Joint Optimum studies and ensure the joint optimum power operation, the Entities have agreed to a common measure, which is the weighted sum of each system's firm energy capability, dependable peaking capacity, and average annual usable secondary energy capability. The relative weights assigned to each quantity are provided in the table below:

Quantity	Relative Value
Annual firm energy capability (average megawatts (aMW))	3
Dependable peaking capability (MW)	1
Average annual usable secondary energy (aMW)	2

A.3.6 CALCULATION OF DOWNSTREAM POWER BENEFITS AND CANADIAN ENTITLEMENT

The Canadian Entitlement to Downstream Power Benefits for any operating year is one-half of the estimated increase in dependable hydroelectric capacity and one-half of the estimated increase in average annual usable hydroelectric energy.

Dependable Hydroelectric Capacity Benefit. Subject to the Capacity Credit Limit (section A.3.7), the capacity benefit from Canadian storage is the difference between the Step II and Step III systems' average rates of U.S. hydro generation during the critical periods, divided by the average of the monthly load factors during the critical period of the Pacific Northwest Area, as determined from the Step I study.

Average Annual Usable Hydroelectric Energy Benefits. The energy benefit from Canadian storage is the difference in the average annual usable energy of the Step II and Step III systems. Usable energy includes firm hydro energy plus a portion of secondary energy.

Usable energy has been defined as the sum of these three factors:

- The annual firm hydro energy determined from critical period studies
- The secondary hydro energy (generation in excess of firm energy) that can be used for thermal displacement
- The estimated amount of the remaining secondary generation that is agreed by the Entities to be usable, provided this amount does not exceed 40 percent of the remainder (in practice, the Entities have agreed that the 40 percent limit was applicable to all Downstream Power Benefit determinations to date)

A.3.6.1. Minimum Permitted Downstream Power Benefits

The Treaty provides certain restrictions on the reduction in Downstream Power Benefits resulting from re-operation of Canadian storage for optimal operation in both countries. As a

result of these limitations, the actual Downstream Power Benefits must be not less than the higher of the two following values:

The Downstream Power Benefits associated with 12.5 million acre-feet (15.5 cubic kilometers) of Canadian storage

The Downstream Power Benefits associated with the preceding year's benefits reduced by the effect of withdrawing 0.5 million acre-feet (0.6 cubic kilometers) of Canadian storage

This procedure has not limited the Canadian Entitlement for many years and so was not investigated as part of the Phase 1 technical studies. Therefore, the methodology for limiting the reduction in Downstream Power Benefits is not included in this appendix.

A.3.7 CAPACITY CREDIT LIMIT

The Treaty specifies that the Dependable Hydroelectric Capacity Benefit shall not exceed the difference between the capability of the base system without Canadian storage and the maximum feasible capability of the base system with Canadian storage to supply firm load during the critical streamflow periods.

The following example demonstrates how the capacity credit limit is computed for the Determination of Downstream Power Benefits. The information for this example is taken from AOP06.

The firm load carrying capacity of Step II is the lesser of:

Step II capacity load	28,608 MW
Step II resources minus reserves	32,323 MW

Similarly, the firm load carrying capacity of Step III is the lesser of:

Step III capacity load	23,394 MW
Step III resources minus reserves	32,174 MW

Therefore, the capacity credit limit is 28,608 minus 23,394, or 5,214 MW.

The actual dependable capacity gain for this year (from AOP06) was 2,436 MW, well within the Capacity Credit Limit. The Capacity Credit Limit has not limited capacity entitlements in any DDPB carried out to date.

A.3.8 SIMULATION MODEL

HYDSIM is the hydroregulation model that is used in AOP, DOP, and TSR studies. It simulates the month-to-month operation of the Pacific Northwest hydropower system in accordance with operating criteria and constraints based on the Columbia River Treaty. HYDSIM is used to determine the hydro system generation and resulting project outflows and ending storage contents under varying inputs of inflows, power loads, operating procedures and constraints, and physical plant data.

HYDSIM is not an optimizer; instead, it is a deterministic model that uses rule curves and flow or storage constraints to achieve operating objectives for power, flood control, and various constraints or requirements on the system. HYDSIM simulates one period at a time without looking forward. Each period is equivalent to one month, except for April and August, which are split into two periods each due to significant natural flow variation in those months, resulting in a 14-period operating year. HYDSIM is typically run using historical water year sequences—the 30-year or 70-year record of Modified Streamflows (1929-1998), or critical period studies looking at 1929-1932, 1937, or 1944-1945.

HYDSIM is run in either a continuous mode or a non-continuous (refill) mode. In continuous mode, the projects' storage contents start each year where the previous year ended. In non-continuous mode, the projects' initial storage contents are set to the same storage content in each operating year. Typically, mid-term studies (6 to 18 months out) are run in refill mode, and long-term studies (greater than 18 months out) are run in continuous mode.

Projects modeled in HYDSIM include both storage and run-of-river projects. Storage projects regulate inflows to adjust the river's natural flow patterns and reshape water on a seasonal basis (i.e., month to month) to conform more closely to desired water uses. For the PNWA, most storage projects capture the spring runoff for release during summer, fall, and winter, when natural streamflows are low. Run-of-river projects have limited storage capability and pass inflow on either a daily or weekly basis. Treaty studies typically include 29 storage projects (6 without generation) and 45 run-of-river projects, for a total of 74 projects. Most projects are upstream of Bonneville Dam, including 10 in British Columbia. There are 22 projects west of the Cascades that are coordinated with the Columbia system and are included in HYDSIM. The Federal Willamette projects, Yakima projects, and projects upstream of Brownlee are not included in HYDSIM and are treated as hydro independents.

For each period, HYDSIM reads input files containing forecasts of the residual power load to be met by the modeled hydro system, Modified Streamflows, flood control curves, energy content curves, critical rule curves, and other project-specific operating requirements.

A.4 DETAILED OPERATING PLAN

A.4.1 OVERVIEW

A Detailed Operating Plan is developed prior to each operating year and includes changes to the AOP that would be mutually advantageous to the Entities. The DOP is developed from the AOP previously agreed to for that operating year and provides information needed to operate Treaty storage within the operating year. Such information includes operating rule curves for the composite Canadian Storage and constraints and operating criteria that may apply to individual reservoirs. This information defines operations in the Treaty Storage Regulation Study, which is used to implement DOP operations throughout the operation year.

The process for development of the DOP has evolved over time and is designed to identify and evaluate proposed changes to the AOP that would be mutually advantageous to the Entities. This

process provides the opportunity to address non-power issues that are not included in the AOP. The DOP usually allows for further refinement of the operating plan throughout the operating year as more information becomes available about the current streamflow and water supply conditions.

A.4.2 DOP 70-YEAR STUDIES

A number of system regulation studies are used to test the default operating criteria in the AOP and to develop potential new operating criteria. The process is outlined below.

1. Start with the AOP Step I Joint Optimum 70-year study.
2. Update Flood Control rule curves for historical water years.
3. Update forecast information, typically including:
    - Forecast errors, distribution factors, and streamflow forecast procedures
    - Streamflow record increases corresponding to Coulee pumping and other irrigation depletions, if available
    - Estimate of hydro independents
4. Consider plant and reservoir updates that do not significantly affect operation of Canadian Storage, including:
    - Plant data
    - Operating criteria and non-power constraints for non-Base System projects
5. Explore modifications to Canadian operating criteria for mutual benefit.
6. Compare study results to AOP Step I Joint Optimum 70-year study.

A.4.3 SYSTEM REGULATION STUDY

A System Regulation Study is the primary tool used to evaluate current and proposed operating criteria. By agreement, additional water years from the 2000-level Modified Flow data set may be included. The studies can include the full 70 years of historical data. These studies cycle through all years in continuous mode, where the ending elevations for each historical year become the starting elevations for the next water year. Several other studies may also be required to test and evaluate proposed changes to the operating criteria. Any changes from the original AOP study must be agreed to by the Entities.

A.4.4 IMPLEMENTATION OF THE DETAILED OPERATING PLAN

Treaty Storage Regulation studies are prepared within the operating year to implement the DOP. The HYDSIM hydroregulation model (see section A.3.8) simulates the Columbia River system operation for power, flood control, and agreed non-power purposes. End-of-month storage contents for Canadian Treaty Storage are determined from the results of the model simulation for the current operating year. Input data to the TSR is either pre-defined in the AOP/DOP or variable based on conditions in the given operating year. Pre-defined inputs to the TSR are:

- Firm and secondary loads
- Thermal and miscellaneous resources
- Agreed non-power requirements
- Other plant and operating data
- Assured Refill Curves
- Critical Rule Curves
- Operating Rule Curve Lower Limits
- Upper Rule Curves (July through November)

Inputs that may vary each year based on hydrological conditions include:

- Unregulated observed and forecast streamflow
- Variable Refill Curves
- Upper Rule Curves (December through June)
- Hydro-independent generation

The TSR provides the Entities with the required composite operation of Canadian Treaty Storage for the current end of month and information on the subsequent two months. This information is used to plan the near-term operation of the Composite Treaty Storage, which is implemented through weekly agreements. Unless otherwise agreed, the weekly agreements are based on operating Canadian Treaty Storage to the end-of-month elevations determined in the current Treaty Storage Regulation study as modified by any Supplemental Operating Agreement. The one exception to this process is during the refill period, when the reservoirs are actively being managed for flood control requirements.

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APPENDIX B

COLUMBIA RIVER TREATY AND PROTOCOL

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APPENDIX B. COLUMBIA RIVER TREATY AND PROTOCOL

The Columbia Treaty

Treaty between Canada and the United States of America relating to Cooperative Development of the Water Resources of The Columbia River Basin

The Governments of Canada and the United States of America

Recognizing that their peoples have, for many generations, lived together and cooperated with one another in many aspects of their national enterprises, for the greater wealth and happiness of their respective nations, and

Recognizing that the Columbia River Basin, as a part of the territory of both countries, contains water resources that are capable of contributing greatly to the economic growth and strength and to the general welfare of the two nations, and

Being desirous of achieving the development of those resources in a manner that will make the largest contribution to the economic progress of both countries and to the welfare of their peoples of which those resources are capable, and

Recognizing that the greatest benefit to each country can be secured by cooperative measures for hydroelectric power generation and flood control, which will make possible other benefits as well.

Have agreed as follows:

ARTICLE I
Interpretation

1. In the Treaty, the expression

(a) “average critical period load factor” means the average of the monthly load factors during the critical stream flow period;

(b) “base system” means the plants, works and facilities listed in the table in Annex B as enlarged from time to time by the installation of additional generating facilities, together with any plants, works or facilities which may be constructed on the main stem of the Columbia River in the United States of America;

(c) “Canadian storage” means the storage provided by Canada under Article II;

(d) “critical stream flow period” means the period, beginning with the initial release of stored water from full reservoir conditions and ending with the reservoirs empty, when the water available from reservoir releases plus the natural stream flow is capable of producing the least amount of hydroelectric power in meeting system load requirements;

(e) “consumptive use” means use of water for domestic, municipal, stock-water, irrigation, mining or industrial purposes but does not include use for the generation of hydroelectric power;

(f) “dam” means a structure to impound water, including facilities for controlling the release of the impounded water;

(g) “entity” means an entity designated by either Canada or the United States of America under Article XIV and includes its lawful successor;

(h) “International Joint Commission” means the Commission established under Article VII of the Boundary Waters Treaty, 1909, or any body designated by the United States of America and Canada to succeed to the functions of the Commission under this Treaty;

(i) “maintenance curtailment” means an interruption or curtailment which the entity responsible therefor considers necessary for purposes of repairs, replacements, installations of equipment, performance of other maintenance work, investigations and inspections;

(j) “monthly load factor” means the ratio of the average load for a month to the integrated maximum load over one hour during that month;

(k) “normal full pool elevation” means the elevation to which water is stored in a reservoir by deliberate impoundment every year, subject to the availability of sufficient flow;

(l) “ratification date” means the day on which the instruments of ratification of the Treaty are exchanged;

(m) “storage” means the space in a reservoir which is usable for impounding water for flood control or for regulating stream flows for hydroelectric power generation;

(n) “Treaty” means this Treaty and its Annexes A and B;

(o) “useful life” means the time between the date of commencement of operation of a dam or facility and the date of its permanent retirement from service by reason of obsolescence or wear and tear which occurs notwithstanding good maintenance practices.

2. The exercise of any power, or the performance of any duty, under the Treaty does not preclude a subsequent exercise of performance of the power or duty.

ARTICLE II
Development by Canada

1. Canada shall provide in the Columbia River basin in Canada 15,500,000 acre-feet of storage usable for improving the flow of the Columbia River.

2. In order to provide this storage, which in the Treaty is referred to as the Canadian storage, Canada shall construct dams:

(a) on the Columbia River near Mica Creek, British Columbia, with approximately 7,000,000 acre-feet of storage;

(b) near the outlet of Arrow Lakes, British Columbia, with approximately 7,100,000 acre-feet of storage; and

(c) on one or more tributaries of the Kootenay River in British Columbia downstream from the Canada-United States of America boundary with storage equivalent in effect to approximately 1,400,000 acre-feet of storage near Duncan Lake, British Columbia.

3. Canada shall commence construction of the dams as soon as possible after the ratification date.

ARTICLE III
Development by the United States of America Respecting Power

1. The United States of America shall maintain and operate the hydro electric facilities included in the base system and any additional hydroelectric facilities constructed on the main stem of the Columbia River in the United States of America in a manner that makes the most effective use of the improvement in stream flow resulting from operation of the Canadian storage for hydro-electric power generation in the United States of America power system.

2. The obligation in paragraph (1) is discharged by reflecting in the determination of downstream power benefits to which Canada is entitled the assumption that the facilities referred to in paragraph (1) were maintained and operated in accordance therewith.

ARTICLE IV
Operation by Canada

1. For the purpose of increasing hydroelectric power generation in Canada and in the United States of America, Canada shall operate the Canadian storage in accordance with Annex A and pursuant to hydroelectric operating plans made thereunder. For the purpose of this obligation an operating plan if it is either the first operating plan or if in the view of either Canada or the United States of America it departs substantially from the immediately preceding operating plan must, in order to be effective, be confirmed by an exchange of notes between Canada and the United States of America.

2. For the purpose of flood control until the expiration of sixty years from the ratification date, Canada shall

(a) operate in accordance with Annex A and pursuant to flood control operating plans made thereunder

(i) 80,000 acre-feet of the Canadian storage described in Article II(2)(a),
(ii) 7,100,000 acre-feet of the Canadian storage described in Article II(2)(b),
(iii) 1,270,000 acre-feet of the Canadian storage described in Article II(2)(c),

provided that the Canadian entity may exchange flood control storage under subparagraph (ii) for flood control storage additional to that under subparagraph (I), at the location described in Article II(2)(a), if the entities agree that the exchange would provide the same effectiveness for control of floods on the Columbia River at the Dalles, Oregon;

(b) operate any additional storage in the Columbia River basin in Canada, when called upon by an entity designated by the United States of America for that purpose, within the limits of existing facilities and as the entity requires to meet flood control needs for the duration of the flood period for which the call is made.

3. For the purpose of flood control after the expiration of sixty years from the ratification date, and for so long as the flows in the Columbia River in Canada continue to contribute to potential flood hazard in the United States of America, Canada shall, when called upon by an entity designated by the United States of America for that purpose, operate within the limits of existing facilities any storage in the Columbia River basin in Canada as the entity requires to meet flood control needs for the duration of the flood control period for which the call is made.

4. The return to Canada for hydroelectric operation and the compensation to Canada for flood control operation shall be as set out in Articles V and VI.

5. Any water resource development, in addition to the Canadian storage, constructed in Canada after the ratification date shall not be operated in a way that adversely affect the stream flow control in the Columbia River within Canada so as to reduce the flood control and hydroelectric power benefits which the operation of the Canadian storage in accordance with the operating plans in force from time to time would otherwise produce.

6. As soon as any Canadian storage becomes operable Canada shall commence operation thereof in accordance with this Article and in any event shall commence full operation of the Canadian storage described in Article II(2)(b) and Article II(2)(c) within five years of the ratification date and shall commence full operation of the balance of the Canadian storage within nine years of the ratification date.

ARTICLE V
Entitlement to Downstream Power Benefits

1. Canada is entitled to one half the downstream power benefits determined under Article VII.

2. The United States of America shall deliver to Canada at a point on the Canada-United States of America boundary near Oliver, British Columbia, or such other place as the entities may agree upon, the downstream power benefits to which Canada is entitled, less

(a) transmission loss,

(b) the portion of the entitlement disposed of under Article VIII(1), and

(c) the energy component described in Article VIII(4).

3. The entitlement of Canada to downstream power benefits begins for any portion of Canadian storage upon commencement of its operation in accordance with Annex A and pursuant to a hydroelectric operating plan made thereunder.

ARTICLE VI
Payment for Flood Control

1. For the flood control provided by Canada under Article IV(2)(a) the United States of America shall pay Canada in United States funds:

(a) 1,200,000 dollars upon the commencement of operation of the storage referred to in subparagraph (a)(i) thereof,

(b) 52,100,000 dollars upon the commencement of operation of the storage referred to in subparagraph (a)(ii) thereof, and

(c) 11,100,000 dollars upon the commencement of operation of the storage referred to in subparagraph (a)(iii) thereof.

2. If full operation of any storage is not commenced within the time specified in Article IV, the amount set forth in paragraph (1) of this Article with respect to that storage shall be reduced as follows:

(a) under paragraph (1)(a), 4,500 dollars for each month beyond the required time,

(b) under paragraph (1)(b), 192, 100 dollars for each month beyond the required time, and

(c) under paragraph (1)(c), 40,800 dollars for each month beyond the required time.

3. For the flood control provided by Canada under Article IV(2)(b) the United States of America shall pay Canada in United States funds in respect only of each of the first four flood periods for which a call is made 1,875,000 dollars and shall deliver to Canada in respect of each and every call made, electric power equal to the hydroelectric power lost by Canada as a result of operating the storage to meet the flood control need for which the call was made, delivery to be made when the loss of hydroelectric power occurs.

4. For each flood period for which flood control is provided by Canada under Article IV(3), the United States of America shall pay Canada in United States funds:

(a) the operating cost incurred by Canada in providing the flood control, and

(b) compensation for the economic loss to Canada arising directly from Canada foregoing alternative uses of the storage used to provide the flood control.

5. Canada may elect to receive in electric power, the whole or any portion of the compensation under paragraph 4(b) representing loss of hydroelectric power to Canada.

ARTICLE VII
Determination of Downstream Power Benefits

1. The downstream power benefits shall be the difference in the hydroelectric power capable of being generated in the United States of America with and without the use of Canadian storage, determined in advance, and is referred to in the Treaty as the downstream power benefits.

2. For the purpose of determining the downstream power benefits:

(a) the principles and procedures set out in Annex B shall be used and followed;

(b) the Canadian storage shall be considered as next added to 13,000,000 acre-feet of the usable storage listed in Column 4 of the table in Annex B;

(c) the hydroelectric facilities included in the base system shall be considered as being operated to make the most effective use for hydroelectric power generation of the improvement in stream flow resulting from operation of the Canadian storage.

3. The downstream power benefits to which Canada is entitled shall be delivered as follows:

(a) dependable hydroelectric capacity as scheduled by the Canadian entity, and

(b) average annual usable hydroelectric energy in equal amounts each month, or in accordance with a modification agreed upon under paragraph (4).

4. Modification of the obligation in paragraph (3)(b) may be agreed upon by the entities.

ARTICLE VIII
Disposal of Entitlement to Downstream Power Benefits

1. With the authorization of Canada and the United States of America evidenced by exchange of notes, portions of the downstream power benefits to which Canada is entitled may be disposed of within the United States of America. The respective general conditions and limits within which the entities may arrange initial disposals shall be set out in an exchange of notes to be made as soon as possible after the ratification date.

2. The entities may arrange and carry out exchanges of dependable hydroelectric capacity and average annual usable hydroelectric energy to which Canada is entitled for average annual usable hydroelectric energy and dependable hydroelectric capacity respectively.

3. Energy to which Canada is entitled may not be used in the United States of America except in accordance with paragraphs (1) and (2).

4. The bypassing at dams on the main stem of the Columbia River in the United States of America of an amount of water which could produce usable energy equal to the energy component of the downstream power benefits to which Canada is entitled but not delivered to Canada under Article V or disposed of in accordance with paragraphs (1) and (2) at the time the energy component was not so delivered or disposed of, is conclusive evidence that such energy component was not used in the United States of America and that the entitlement of Canada to such energy component is satisfied.

ARTICLE IX
Variation of Entitlement to Downstream Power Benefits

1. If the United States of America considers with respect to any hydroelectric power project planned on the main stem of the Columbia River between Priest Rapids Dam and McNary Dam that the increase in entitlement of Canada to downstream power benefits resulting from the operation of the project would produce a result which would not justify the United States of America in incurring the costs of construction and operation of the project, Canada and the United States of America at the request of the United States of America shall consider modification of the increase in entitlement.

2. An agreement reached for the purposes of this Article shall be evidenced by an exchange of notes.

ARTICLE X
East-West Standby Transmission

1. The United States of America shall provide in accordance with good engineering practice east-west standby transmission service adequate to safeguard the transmission from Oliver, British Columbia, to Vancouver, British Columbia, of the downstream power benefits to which Canada is entitled and to improve system stability of the east-west circuits in British Columbia.

2. In consideration of the standby transmission service, Canada shall pay the United States of America in Canadian funds the equivalent of 1.50 United States dollars a year for each kilowatt of dependable hydroelectric capacity included in the downstream power benefits to which Canada is entitled.

3. When a mutually satisfactory electric coordination arrangement is entered into between the entities and confirmed by an exchange of notes between Canada and the United States of America the obligation of Canada in paragraph (2) ceases.

ARTICLE XI
Use of Improved Stream Flow

1. Improvement in stream flow in one country brought about by operation of storage constructed under the Treaty in the other country shall not be used directly or indirectly for hydroelectric power purposes except:

(a) in the case of use within the United States of America with the prior approval of the United States entity, and

(b) in the case of use within Canada with the prior approval of the authority in Canada having jurisdiction.

2. The approval required by this Article shall not be given except upon such conditions, consistent with the Treaty, as the entity or authority considers appropriate.

ARTICLE XII
Kootenai River Development

1. The United States of America for a period of five years from the ratification date, has the option to commence construction of a dam on the Kootenai River near Libby, Montana, to provide storage to meet flood control and other purposes in the United States of America. The storage reservoir of the dam shall not raise the level of the Kootenai River at the Canada-United States of America boundary above an elevation consistent with a normal full pool elevation at the dam of 2,459 feet, United States Coast and Geodetic Survey datum, 1929 General Adjustment, 1947 International Supplemental Adjustment.

2. All benefits which occur in either country from the construction and operation of the storage accrue to the country in which the benefits occur.

3. The United States of America shall exercise its option by written notice to Canada and shall submit with the notice a schedule of construction which shall include provision for commencement of construction, whether by way of railroad relocation work or otherwise, within five years of the ratification date.

4. If the United States of America exercises its option, Canada in consideration of the benefits accruing to it under paragraph (2) shall prepare and make available for flooding the land in Canada necessary for the storage reservoir of the dam within a period consistent with the construction schedule.

5. If a variation in the operation of the storage is considered by Canada to be of advantage to it the United States of America shall, upon request, consult with Canada. If the United States of America determines that the variation would not be to its disadvantage it shall vary the operation accordingly.

6. The operation of the storage by the United States of America shall be consistent with any order of approval which may be in force from time to time relating to the levels of Kootenay Lake made by the International Joint Commission under the Boundary Waters Treaty, 1909.

7. Any obligation of Canada under this Article ceases if the United States of America, having exercised the option, does not commence construction of the dam in accordance with the construction schedule.

8. If the United States of America exercises the option it shall commence full operation of the storage within seven years of the date fixed in the construction schedule for commencement of construction.

9. If Canada considers that any portion of the land referred to in paragraph (4) is no longer needed for the purpose of this Article Canada and the United States of America, at the request of Canada, shall consider modification of the obligation of Canada in paragraph (4).

10. If the Treaty is terminated before the end of the useful life of the dam Canada shall for the remainder of the useful life of the dam continue to make available for the storage reservoir of the dam any portion of the land made available under paragraph (4) that is not required by Canada for purposes of diversion of the Kootenay River under Article XIII.

ARTICLE XIII
Diversions

1. Except as provided in this Article neither Canada nor the United States of America shall, without the consent of the other evidenced by an exchange of notes, divert for any use, other than consumptive use, any water from its natural channel in a way that alters the flow of any water as it crosses the Canada-United States of America boundary within the Columbia River Basin.

2. Canada has the right, after the expiration of twenty years from the ratification date, to divert not more than 1,500,000 acre-feet of water a year from the Kootenay River in the vicinity of Canal Flats, British Columbia, to the headwaters of the Columbia River, provided that the diversion does not reduce the flow of the Kootenay River immediately downstream from the point of diversion below the lesser of 200 cubic feet per second or the natural flow.

3. Canada has the right, exercisable at any time during the period commencing sixty years after the ratification date and expiring one hundred years after the ratification date, to divert to the head-waters of the Columbia River any water which, in its natural channel, would flow in the Kootenay River across the Canada-United States of America boundary, provided that the diversion does not reduce the flow of the Kootenay River at the Canada-United States of America boundary near Newgate, British Columbia, below the lesser of 2500 cubic feet per second or the natural flow.

4. During the last twenty years of the period within which Canada may exercise the right to divert described in paragraph (3) the limitation on diversion is the lesser of 1000 cubic feet per second or the natural flow.

5. Canada has the right:

(a) if the United States of America does not exercise the option in Article XII(1), or

(b) if it is determined that the United States of America, having exercised the option, did not commence construction of the dam referred to in Article XII in accordance therewith or that the United States of America is in breach of the obligation in that Article to commence full operation of the storage,

to divert to the headwaters of the Columbia River any water which, in its natural channel, would flow in the Kootenay River across the Canada-United States of America boundary, provided that the diversion does not reduce the flow of the Kootenay River at the Canada-United States of America boundary near Newgate, British Columbia, below the lesser of 1000 cubic feet per second or the natural flow.

6. If a variation in the use of the water diverted under paragraph (2) is considered by the United States of America to be of advantage to it Canada shall, upon request, consult with the United States of America. If Canada determines that the variation would not be to its disadvantage it shall vary the use accordingly.

ARTICLE XIV
Arrangements for Implementation

1. Canada and the United States of America shall each, as soon as possible after the ratification date, designate entities and when so designated the entities are empowered and charged with the duty to formulate and carry out the operating arrangements necessary to implement the Treaty. Either Canada or the United States of America may designate one or more entities. If more than one is designated the powers and duties conferred upon the entities by the Treaty shall be allocated among them in the designation.

2. In addition to the powers and duties dealt with specifically elsewhere in the Treaty the powers and duties of the entities include:

(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) the 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 the 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 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,

(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.

3. The entities are authorized to make maintenance curtailments. Except in case of emergency, the entity responsible for a maintenance curtailment shall give notice to the corresponding Canadian or United States entity of the curtailment, including the reason therefor and the probable duration thereof and shall both schedule the curtailment with a view to minimizing its impact and exercise due diligence to resume full operations.

4. Canada and the United States of America may by an exchange of notes empower or charge the entities with any other matter coming within the scope of the Treaty.

ARTICLE XV
Permanent Engineering Board

1. A permanent Engineering Board is established consisting of four members, two to be appointed by Canada and two by the United States of America. The initial appointments shall be made within three months of the ratification date.

2. The Permanent Engineering Board shall:

(a) assemble records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) report to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate include in the report recommendations for remedial action and compensatory adjustments;

(c) assist in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) make periodic inspections and require reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and make special reports concerning any matter which it considers should be brought to their attention;

(f) investigate and report 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.

3. Reports of the Permanent Engineering Board made in the course of the performance of its functions under this Article shall be prima facie evidence of the facts therein contained and shall be accepted unless rebutted by other evidence.

4. The Permanent Engineering Board shall comply with directions, relating to its administration and procedures, agreed upon by Canada and the United States of America as evidenced by an exchange of notes.

ARTICLE XVI
Settlement of Differences

1. Differences arising under the Treaty which Canada and the United States of America cannot resolve may be referred by either to the International Joint Commission for decision.

2. If the International Joint Commission does not render a decision within three months of the referral or within such other period as may be agreed upon by Canada and the United States of America, either may then submit the difference to arbitration by written notice to the other.

3. Arbitration shall be a tribunal composed of a member appointed by Canada, a member appointed by the United States of America and a member appointed jointly by Canada and the United States of Am-erica who shall be Chairman. If within six weeks of the delivery of a notice under paragraph (2) either Canada or the United States of America has failed to appoint its member, or they are unable to agree upon the member who is to be Chairman, either Canada or the United States of America may request the President of the International Court of Justice to appoint the member or members. The decision of a majority of the members of an arbitration tribunal shall be the decision of the tribunal.

4. Canada and the United States of America shall accept as definitive and binding and shall carry out any decision of the International Joint Commission or an arbitration tribunal.

5. Provision for the administrative support of a tribunal and for remuneration and expenses of its members shall be as agreed in an exchange of notes between Canada and the United States of America.

6. Canada and the United States of America may agree by an exchange of notes on alternative procedures for settling differences arising under the Treaty, including reference of any difference to the International Court of Justice for decision.

ARTICLE XVII
Restoration of Pre-Treaty Legal Status

1. Nothing in this Treaty and no action taken or foregone pursuant to its provisions shall be deemed, after its termination or expiration, to have abrogated or modified any of the rights or obligations of Canada or the United States of America under then existing international law, with respect to the uses of the water resources of the Columbia River basin.

2. Upon termination of this Treaty, the Boundary Waters Treaty, 1909, shall, if it has not been terminated, apply to the Columbia River basin, except insofar as the provisions of that Treaty may be inconsistent with any provision of this Treaty which continues in effect.

3. Upon termination of this Treaty, if the Boundary Waters Treaty, 1909, has been terminated in accordance with Article XIV of that Treaty, the provisions of Article II of that Treaty shall continue to apply to the waters of the Columbia River basin.

4. If upon the termination of this Treaty Article II of the Boundary Waters Treaty, 1909, continues in force by virtue of paragraph (2) of this Article the effect of Article II of that Treaty with respect to the Columbia River basin may be terminated by either Canada or the United States of America delivering to the other one year's written notice to that effect; provided however that the notice may be given only after the termination of this Treaty.

5. If, prior to the termination of this Treaty, Canada undertakes works usable for and relating to a diversion of water from the Columbia River basin, other than works authorized by or under-taken for the purpose of exercising a right under Article XIII or any other provision of this Treaty, paragraph (3) of this Article shall cease to apply one year after delivery by either Canada or the United States of America to the other of written notice to that effect.

ARTICLE XVIII
Liability for Damage

1. Canada and the United States of America shall be liable to the other and shall make appropriate compensation to the other in respect of any act, failure to act, omission or delay amounting to a breach of the Treaty or any of its provisions other that an act, failure to act, omission or delay occurring by reason of war, strike, major calamity, act of God, uncontrollable force or maintenance curtailment.

2. Except as provided in paragraph (1) neither Canada nor the United States of America shall be liable to the other or to any person in respect of any injury, damage or loss occurring in the territory of the other caused by any act, failure to act, omission or delay under the Treaty whether the injury, dam-age or loss results from negligence or otherwise.

3. Canada and the United States of America, each to the extent possible within its territory, shall exercise due diligence to remove the cause of and to mitigate the effect of any injury, damage or loss occurring in the territory of the other as a result of any act, failure to act, omission or delay under the Treaty.

4. Failure to commence operation as required by Articles IV and XII is not a breach of the Treaty and does not result in the loss of rights under the Treaty if the failure results from a delay that is not wilful or reasonably avoidable.

5. The compensation payable under paragraph (1):

(a) in respect of a breach by Canada of the obligation to commence full operation of a storage, shall be forfeiture of entitlement to downstream power benefits resulting from the operation of that storage, after operation commences, for a period equal to the period between the day of commencement of operation and the day when commencement should have occurred;

(b) in respect of any other breach by either Canada or the United States of America, causing loss of power benefits, shall not exceed the actual loss in revenue from the sale of hydroelectric power.

ARTICLE XIX
Period of Treaty

1. The Treaty shall come into force on the ratification date.

2. Either Canada or the United States of America may terminate the Treaty other than Article XIII (Except paragraph (1) thereof), Article XVII and this Article at any time after the Treaty has been in force for sixty years if it has delivered at least ten years written notice to the other of its intention to terminate the Treaty.

3. If the Treaty is terminated before the end of the useful life of a dam built under Article XII then, notwithstanding termination, Article XII remains in force until the end of the useful life of the dam.

4. If the Treaty is terminated before the end of the useful life of the facilities providing the storage described in Article IV(3) and if the conditions described therein exist then, notwithstanding termination, Articles IV(3) and VI(4) and (5) remain in force until either the end of the useful life of those facilities or until those conditions cease to exist, whichever is the first to occur.

ARTICLE XX
Ratification

The instruments of ratification of the Treaty shall be exchanged by Canada and the United States of America at Ottawa, Canada.

ARTICLE XXI
Registration with the United Nations

In conformity with Article 102 of the Charter of the United Nations, the Treaty shall be registered by Canada with the Secretariat of the United Nations.

This Treaty has been done in duplicate copies in the English language.

IN WITNESS WHEREOF the undersigned, duly authorized by their respective Governments, have signed this Treaty at Washington, District of Columbia, United States of America, this seventeenth day of January, 1961.

For Canada

John G. Diefenbaker
Prime Minister of Canada
E.D. Fulton
Minister of Justice
A.D.P. Heeney
Ambassador Extraordinary and Plenipotentiary of Canada to the United States of America

For the United States of America

Dwight D. Eisenhower
President of the United States of America
Christian A. Herter
Secretary of State
Elmer F. Bennett
Under Secretary of the Interior

ANNEX A
Principles of Operation

General:

1. The Canadian storage provided under Article II will be operated in accordance with the procedures described herein.

2. A hydrometeorological system, including snow courses, precipitation stations and stream flow gauges will be established and operated, as mutually agreed by the entities and in consultation with the Permanent Engineering Board, for use in establishing data for detailed programming of flood control and power operations. Hydrometeorological information will be made available to the entities in both countries for immediate and continuing use in flood control and power operations.

3. Sufficient discharge capacity at each dam to afford the desired regulation for power and flood control will be provided through outlet works and turbine installations as mutually agreed by the entities. The discharge capacity provided for flood control operations will be large enough to pass inflow plus sufficient storage releases during the evacuation period to provide the storage space required. The discharge capacity will be evaluated on the basis of full use of any conduits provide for that purpose plus one half the hydraulic capacity of the turbine installation at the time of commencement of the operation of storage under the Treaty.

4. The outflows will be in accordance with storage reservation diagrams and associated criteria established for flood control purposes and with reservoir-balance relationships established for power operations. Unless otherwise agreed by the entities the average weekly outflows shall not be less than 3000 cubic feet per second at the dam described in Article II(2)(a), not less than 5000 cubic feet per second at the dam described in Article II(2)(b), and not less than 1000 cubic feet per second at the dam described in Article II(2)(c). These minimum average weekly releases may be scheduled by the Canadian entity as required for power or other purposes.

Flood Control:

5. For flood control operation, the United States entity will submit flood control operating plans which may consist of or include flood control storage reservation diagrams and associated criteria for each of the dams. The Canadian entity will operate in accordance with these diagrams or any variation which the entities agree will not derogate from the desired aim of the flood control plan. The use of these diagrams will be based on data obtained in accordance with paragraph 2. The diagrams will consist of relationships specifying the flood control storage reservations required at indicated times of the year for volumes of forecast runoff. After consultation with the Canadian entity the United States entity may from time to time as conditions warrant adjust these storage reservation diagrams within the general limitations of flood control operation. Evacuation of the storages listed hereunder will be guided by the flood control storage reservation diagrams and refill will be as requested by the United States entity after consultation with the Canadian entity. The general limitations of flood control operation are as follows:

(a) The Dam described in Article II(2)(a) - The reservoir will be evacuated to provide up to 80,000 acre-feet of storage, if required, for flood control use by May 1 of each year.

(b) The Dam described in Article II(2)(b) - The reservoir will be evacuated to provide up to 7,100,000 acre-feet of storage, if required, for flood control use by May 1 of each year.

(c) The Dam described in Article II(2)(c) - The reservoir will be evacuated to provide up to 700,000 acre-feet of storage, if required, for flood control use by April 1 of each year and up to 1,270,000 acre-feet of storage, if required, for flood control use by May 1 of each year.

(d) The Canadian entity may exchange flood control storage provided in the reservoir referred to in subparagraph (b) for additional storage provided in the reservoir referred to in sub-paragraph (a) if the entities agree that the exchange would provide the same effectiveness for control of floods on the Columbia River at The Dalles, Oregon.

Power:

6. For power generating purposes the 15,500,000 acre-feet of Canadian storage will be operated in accordance with operating plans designed to achieve optimum power generation downstream in the United States of America until such time as power generating facilities are installed at the site referred to in paragraph 5(a) or at sites in Canada downstream therefrom.

7. After at-site power is developed at the site referred to in paragraph 5(a) or power generating facilities are placed in operation in Canada downstream from that site, the storage operation will be changed so as to be operated in accordance with operating plans designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States of America, including consideration of any agreed electrical coordination between the two countries. Any reduction in the downstream power benefits in the United States of America resulting from that change in operation of the Canadian storage shall not exceed in any one year the reduction in downstream power benefits in the United States of America which would result from reducing by 500,000 acre-feet the Canadian storage operated to achieve optimum power generation in the United States of America and shall not exceed at any time during the period of the Treaty the reduction in downstream power benefits in the United States of America which would result from similarly reducing the Canadian storage by 3,000,000 acre-feet.

8. After at-site power is developed at the site referred to in paragraph 5(a) or power generating facilities are placed in operation in Canada downstream from that site, storage may be operated to achieve optimum generation of power in the United States of America alone if mutually agreed by the entities in which event the United States of America shall supply power to Canada to offset any reduction in Canadian generation which would be created as a result of such operation as compared to operation to achieve optimum power generation at-site in Canada and downstream in Canada and the United States of America. Similarly, the storage may be operated to achieve optimum generation of power in Canada alone if mutually agreed by the entities in which event Canada shall supply power to the United States of America to offset any reduction in United States generation which would be created as a result of such operation as compared to operation to achieve optimum power generation at-site in Canada and downstream in Canada and the United States of America.

9. Before the first storage becomes operative, the entities will agree on operating plans and the resulting downstream power benefits for each year until the total of 15,500,000 acre-feet of storage in Canada becomes operative. In addition, commencing five years before the total of 15,500,000 acre-feet of storage is expected to become operative, the entities will agree annually on operating plans and the result-ing downstream power benefits for the sixth succeeding year of operation thereafter. This procedure will continue during the life of the Treaty, providing to both the entities, in advance, an assured plan of opera-tion of the Canadian storage and a determination of the resulting downstream power benefits for the next succeeding five years.

ANNEX B
Determination of Downstream Power Benefits

1. The downstream power benefits in the United States of America attributable to operation in accordance with Annex A of the storage provided by Canada under Article II will be determined in advance and will be the estimated increase in dependable hydroelectric capacity in kilowatts for agreed critical stream flow periods and the increase in average annual usable hydroelectric energy output in kilowatt hours on the basis of an agreed period of stream flow record.

2. The dependable hydroelectric capacity to be credited to Canadian storage will be the difference between the average rates of generation in kilowatts during the appropriate critical stream flow periods for the United States of America base system, consisting of the projects listed in the table, with and without the addition of the Canadian storage, divided by the estimated average critical period load factor. The capacity credit shall not exceed the difference between the capability of the base system without Canadian storage and the maximum feasible capability of the base system with Canadian storage, to supply firm load during the critical stream flow periods.

3. The increase in the average annual usable hydroelectric energy will be determined by first computing the difference between the available hydroelectric energy at the United States base system with and without Canadian storage. The entities will then agree upon the part of available energy which is usable with and without Canadian storage, and the difference thus agreed will be the increase in average annual usable hydroelectric energy. Determination of the part of the energy which is usable will include consideration of existing and scheduled transmission facilities and the existence of markets capable of using the energy on a contractual basis similar to the then existing contracts. The part of the available energy which is considered usable shall be the sum of:

(a) the firm energy,

(b) the energy which can be used for thermal power displacement in the Pacific Northwest Area as defined in Paragraph 7, and

(c) the amount of the remaining portion of the available energy which is agreed by the entities to be usable and which shall not exceed in any event 40% of that remainder.

4. An initial determination of the estimated downstream power benefits in the United States of America from Canadian storage added to the United States base system will be made before any of the Canadian storage becomes operative. This determination will include estimates of the downstream power benefits for each year until the total of 15,500,000 acre-feet of Canadian storage becomes operative.

5. Commencing five years before the total of 15,500,000 acre-feet of storage is expected to become operative, estimates of downstream power benefits will be calculated annually for the sixth succeeding year on the basis of the assured plan of operation for that year.

6. The critical stream flow period and the details of the assured plan of operation will be agreed upon by the entities at each determination. Unless otherwise agreed upon by the entities, the determination of the downstream power benefits shall be based upon stream flows for the twenty year period beginning with July 1928 as contained in the report entitled Modified Flows at Selected Power Sites - Columbia River Basin, dated June 1957. No retroactive adjustment in downstream power benefits will be made at any time during the period of the Treaty. No reduction in the downstream power benefits credited to Canadian storage will be made as a result of the load estimate in the United States of America, for the year for which the determination is made, being less than the load estimate for the preceding year.

7. In computing the increase in dependable hydroelectric capacity and the increase in average annual hydroelectric energy, the procedure shall be in accordance with the three steps described below and shall encompass the loads of the Pacific Northwest Area. The Pacific Northwest Area for purposes of these determinations shall be Oregon, Washington, Idaho, and Montana west of the Continental Divide but shall exclude areas served on the ratification date by the California Oregon Power Company and the Utah Power and Light Company.

Step I - The system for the period covered by the estimate will consist of the Canadian storage, the United States base system, any thermal installation operated in coordination with the base system, and additional hydroelectric projects which will provide storage releases usable by the base system or which will use storage releases that are usable by the base system. The installations included in this system will be those required, with allowance for adequate reserves, to meet the forecast power load to be served by this system in the United States of America, including the estimated flow of power at points of inter-connection with adjacent areas, subject to paragraph 3, plus the portion of the entitlement of Canada that is expected to be used in Canada. The capability of this system to supply this load will be determined on the basis that the system will be operated in accordance with the established operating procedures of each of the projects involved.

Step II - A determination of the energy capability will be made using the same thermal installation as in Step I, the United States base system with the same installed capacity as in Step I and Canadian storage.

Step III - A similar determination of the energy capability will be made using the same thermal installation as in Step I and the United States base system with the same installed capacity as in Step I.

8. The downstream power benefits to be credited to Canadian storage will be the differences between the determinations in Step II and Step III in dependable hydroelectric capacity and in average annual usable hydroelectric energy, made in accordance with paragraphs 2 and 3.

ANNEX B - TABLE - BASE SYSTEM

Project	Stream	Stream Mile Above Mouth	Usable Storage Acre-Feet	Normal Pool Feet	Elev. Tailwater Feet	Gross Head Feet	Initial Install. # of Units	Initial Install. Plant Kilowatts (Nameplate)	Estimated Ultimate Install. # of Units	Estimated Ultimate Install. Plant Kilowatts (Nameplate)
Hungry Horse	SFk Flathead	5	3,161,000(4)	3560	3083	477	4	285,000	4	285,000
Kerr	Flathead	73	1,219,000	2893	2706	187	3	168,000	3	168,000
Thompson Falls	Clark Fork	279	Pondage	2396	2336	60	6	30,000	8	65,000
Noxon Rapids	Clark Fork	170	Pondage	2331	2179	152	4	336,000	5	420,000
Cabinet Gorge	Clark Fork	150	Pondage	2175	2078	97	4	200,000	6	300,000
Albeni Falls	Pend Oreille	90	1,155,000	2062	2034	28	3	42,600	3	42,600
Box Canyon	Pend Oreille	34	Pondage	2031	1989	42	4	60,000	4	60,000
Grand Coulee	Columbia	597	5,232,000(4)	1290(3,4)	947	343	18	1,944,000	34	3,672,000
Chief Joseph	Columbia	546	Pondage	946	775	171	16	1,024,000	27	1,728,000
Wells (1)	Columbia	516	Pondage	775	707	68	6	400,000	10	666,700
Rocky Reach	Columbia	474	Pondage	707	614	93	7	711,550	11	1,118,150
Rock Island	Columbia	453	Pondage	608	570	38	10	212,100	10	212,100
Wanapum	Columbia	415	Pondage	570	486	84	10	831,250	16	1,330,000
Priest Rapids	Columbia	397	Pondage	486	406	80	10	788,500	16	1,261,600
Brownlee	Snake	285	974,000	2077	1805	272	4	360,400	6	540,600
Oxbow	Snake	273	Pondage	1805	1683	122	4	190,000	5	237,500
Ice Harbor	Snake	10	Pondage	440	343	97	3	270,000	6	540,000
McNary	Columbia	292	Pondage	340	265	75	14	980,000	20	1,400,000
John Day	Columbia	216	Pondage	265	161	104	8	1,080,000	20	2,700,000
The Dalles	Columbia	192	Pondage	160	74	86	16(2)	1,119,000	24(2)	1,743,000
Bonneville	Columbia	145	Pondage	74	15	59	10	518,400	16	890,400
Kootenay Lk	Kootenay	16	673,000	1745	--	--	--	--	--	--
Chelan	Chelan	0	676,000	1100	707	393	2	48,000	4	96,600
Couer d'Alene L.	Couer d'Alene	102	223,000	2128	--	--	--	--	--	--
TOTAL 24 PROJECTS			13,313,000(4)			3128		11,598,800	258	19,476,600

(1) The Wells project is not presently under construction; when this project or any other project on the main stem of the Columbia River is completed, they will be integral components of the base system.

(2) Includes two 13,500 kilowatt units for fish attraction water.

(3) With flashboards.

(4) In determining the base system capabilities with and without Canadian storage the Hungry Horse reservoir storage will be limited to 3,008,000 acre-feet (normal full pool elevation of 3560 feet) and the Grand Coulee project will not include the effect of adding flashboards, limiting the storage to 5,072 acre-feet (normal full pool elevation of 1288 feet). The total usable storage of the base system as so adjusted will be 13,000,000 acre-feet.

Protocol

ANNEX TO EXCHANGE OF NOTES

Dated January 22, 1964 Between the Governments of Canada And The United States Regarding the Columbia River Treaty

I. If the United States entity should call upon Canada to operate storage in the Columbia River Basin to meet flood control needs of the United States of America pursuant to Article IV(2)(b) or Article IV(3) of the Treaty, such call shall be made only to the extent necessary to meet forecast flood control needs in the territory of the United States of America that cannot adequately be met by flood control facilities in the United States of America in accordance with the following conditions:

(1) Unless otherwise agreed by the Permanent Engineering Board, the need to use Canadian flood control facilities under Article IV(2)(b) of the Treaty shall be considered to have arisen only in the case of potential floods which could result in a peak discharge in excess of 600,000 cubic feet per second at The Dalles, Oregon, assuming the use of all related storage in the United States of America existing and under construction in January 1961, storage provided by any dam constructed pursuant to Article XII of the Treaty and the Canadian storage described in Article IV(2)(a) of the Treaty.

(2) The United States entity will call upon Canada to operate storage under Article IV(3) of the Treaty only to control potential floods in the United States of America that could not be adequately controlled by all the related storage facilities in the United States of America existing at the expiration of 60 years from the ratification date but in no event shall Canada be required to provide any greater degree of flood control under Article IV(3) of the Treaty than that provided for under Article IV(2) of the Treaty.

(3)A call shall be made only if the Canadian entity has been consulted whether the need for flood control is, or is likely to be, such that it cannot be met by the use of flood control facilities in the United States of America in accordance with subparagraphs (1) or (2) of this paragraph. Within ten days of receipt of a call, the Canadian entity will communicate its acceptance, or its rejection or proposals for modification of the call, together with supporting considerations. When the communication indicates rejection or modification of the call the United States entity will review the situation in the light of the communication and subsequent developments and will then withdraw or modify the call if practicable. In the absence of agreement on the call or its terms the United States entity will submit the matter to the Permanent Engineering Board provided for under Article XV of the Treaty for assistance as contemplated in Article XV(2)(c) of the Treaty. The entities will be guided by any instructions issued by the Permanent Engineering Board. If the Permanent Engineering Board does not issue instructions within ten days of receipt of a submission the United States entity may renew the call for any part or all of the storage covered in the original call and the Canadian entity shall forthwith honor the request.

II. In preparing the flood control operating plans in accordance with paragraph 5 of Annex A of the Treaty, and in making calls to operate for flood control pursuant to Articles IV(2)(b) and IV(3) of the Treaty, every effort will be made to minimize flood damage in both Canada and the United States of America.

III. The exchange of Notes provided for in Article VIII(1) of the Treaty shall take place contemporaneously with the exchange of the Instruments of Ratification of the Treaty provided for in Article XX of the Treaty.

IV. (1) During the period and to the extent that the sale of Canada's entitlement to downstream power benefits within the United States of America as a result of an exchange of Notes pursuant to Article

VIII(1) of the Treaty relieves the United States of America of its obligation to provide east-west standby transmission service as called for by Article X(1) of the Treaty, Canada is not required to make payment for the east-west standby transmission service with regard to Canada's entitlement to downstream power benefits sold in the United States of America.

(2) The United States of America is not entitled to any payments of the character set out in subparagraph (1) of this paragraph in respect of that portion of Canada's entitlement to down-stream power benefits delivered by the United States of America to Canada at any point on the Canada-United States of America boundary other than at a point near Oliver, British Columbia, and the United States of America is not required to provide the east-west standby transmission service referred to in subparagraph (1) of this paragraph in respect of the portion of Canada's entitlement to downstream power benefits which is so delivered.

V. Inasmuch as control of historic streamflows of the Kootenay River by the dam provided for in Article XII(1) of the Treaty would result in more than 200,000 kilowatt years per annum of energy benefit downstream in Canada, as well as important flood control protection to Canada, and the operation of that dam is therefore of concern to Canada, the entities shall, pursuant to Article XIV(2)(a) of the Treaty, cooperate on a continuing basis to coordinate the operation of that dam with the operation of hydroelectric plants on the Kootenay River and elsewhere in Canada in accordance with the provisions of Article XII(5) and Article XII(6) of the Treaty.

VI. (1) Canada and the United States of America are in agreement that Article XIII(1) of the Treaty provides to each of them a right to divert water for a consumptive use.

(2) Any diversion of water from the Kootenay River when once instituted under the provisions of Article XIII of the Treaty is not subject to any limitation as to time.

VII. As contemplated by Article IV(1) of the Treaty, Canada shall operate the Canadian storage in accordance with Annex A and hydroelectric operating plans made thereunder. Also, as contemplated by Annexes A and B of the Treaty and Article XIV(2)(k) of the Treaty, these operating plans before they are agreed to by the entities will be conditioned as follows:

(1) As the downstream power benefits credited to Canadian storage decrease with time, the storage required to be operated by Canada pursuant to paragraphs 6 and 9 of Annex A of the Treaty, will be that required to produce those benefits.

(2) The hydroelectric operating plans, which will be based on Step I of the studies referred to in paragraph 7 of Annex B of the Treaty, will provide a reservoir-balance relationship for each month of the whole of the Canadian storage committed rather than a separate relationship for each of the three Canadian storages. Subject to compliance with any detailed operating plan agreed to by the entities as permitted by Article XIV(2)(k) of the Treaty, the manner of operation which will achieve the specific storage or release of storage called for in a hydroelectric operating plan consistent with optimum storage use will be at the discretion of the Canadian entity.

(3) Optimum power generation at-site in Canada and downstream in Canada and the United States of America referred to in paragraph 7 of Annex A of the Treaty will include power generation at-site and downstream in Canada of the Canadian storages referred to in Article II(2) of the Treaty, power generation in Canada which is coordinated therewith, downstream power benefits from the Canadian storage which are produced in the United States of America and measured under the terms of Annex B of the Treaty, power generation in the Pacific Northwest Area of the United States of America and power generation coordinated therewith.

VIII. The determination of downstream power benefits pursuant to Annex B of the Treaty, in respect of each year until the expiration of thirty years from the commencement of full operation in accordance with Article IV of the Treaty of that portion of the Canadian storage described in Article II of the Treaty which is last placed in full operation, and thereafter until otherwise agreed upon by the entities, shall be based upon stream flows for the thirty-year period beginning July 1928 as contained in the report "Extension of Modified Flows Through 1958 - Columbia River Basin" and dated June 29, 1961, by the Water Management Subcommittee of the Columbia Basin Inter-Agency Committee.

IX. (1) Each load used in making the determinations required by Steps II and III of paragraph 7 of Annex B of the Treaty shall have the same shape as the load of the Pacific Northwest area as that area is defined in that paragraph.

(2) The capacity credit of Canadian storage shall not exceed the difference between the firm load carrying capabilities of the projects and installations included in Step II of paragraph 7 of Annex B of the Treaty and the projects and installations included in Step III of paragraph 7 of Annex B of the Treaty.

X. In making all determinations required by Annex B of the Treaty the loads used shall include the power required for pumping water for consumptive use into the Banks Equalizing Reservoir of the Columbia Basin Federal Reclamation Project but mention of this particular load is not intended in any way to exclude from those loads any use of power that would normally be part of such loads.

XI. In the event operation of any of the Canadian storages is commenced at a time which would result in the United States of America receiving flood protection for periods longer than those on which the amounts of flood control payments to Canada set forth in Article VI(1) of the Treaty are based, the United States of America and Canada shall consult as to the adjustments, if any, in the flood control payments that may be equitable in the light of all relevant factors. Any adjustment would be calculated over the longer period or periods on the same basis and in the same manner as the calculation of the amounts set forth in Article VI(1) of the Treaty. The consultations shall begin promptly upon the determination of definite dates for the commencement of operation of the Canadian storages.

XII. Canada and the United States of America are in agreement that the Treaty does not establish any general principle or precedent applicable to waters other than those of the Columbia River Basin and does not detract from the application of the Boundary Waters Treaty, 1909, to other waters.

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APPENDIX C

LIST OF ACRONYMS
AND GLOSSARY OF TERMS

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APPENDIX C. LIST OF ACRONYMS AND GLOSSARY OF TERMS

LIST OF ACRONYMS/ABBREVIATIONS AND GLOSSARY OF TERMS RELATING TO THE COLUMBIA RIVER TREATY 2014/2024 PHASE 1 STUDIES AND REPORT

[Based in part on the list of acronyms and glossary prepared by the Permanent Engineering Board Engineering Committee for the Columbia River Treaty Permanent Engineering Board, Treaty and Treaty-associated documents, and the BPA Dictionary]

ACRONYMS AND ABBREVIATIONS

aMW – Average MW

AOP - Assured Operating Plan

ARC - Assured Refill Curve

BC Hydro - British Columbia Hydro and Power Authority

BECC – Base Energy Content Curve

BPA - Bonneville Power Administration

CCL - Capacity Credit Limit

CE - Canadian Entitlement

cfs - cubic feet per second

CND - Canada

Corps - U.S. Army Corps of Engineers

CP - Critical Period

CRC - Critical Rule Curve

CRC1 - First Year Critical Rule Curve

CRT - Columbia River Treaty

CRTOC - Columbia River Treaty Operating Committee

CU - Called Upon

DDPB - Determination of Downstream Power Benefits

DOP - Detailed Operating Plan

EL - elevation

FCOP - Flood Control Operating Plan

FELCC - firm energy load carrying capability

FERC - Federal Energy Regulatory Commission

FLCC - firm load carrying capability

Flex – flexibility energy**,** Canada's flexibility under the Treaty to operate individual projects for maximum Canadian benefits

FPLCC - firm peak load carrying capability

FRA – Flood Risk Assessment

GCL - Grand Coulee

HYDSIM - BPA's Hydrologic Simulator Model

ICF - Initial Control Flow

IJC - International Joint Commission

Kaf - thousand acre-feet

KCFS - thousand cubic feet per second

KLBC – Kootenay Lake Board of Control

LCA – Libby Coordination Agreement

KSFD - thousand second-foot-days

Maf - million acre-feet

MW - megawatt

NGVD - National Geodetic Vertical Datum

ORC - Operating Rule Curve

ORCLL - Operating Rule Curve Lower Limit

PDR - Power Discharge Requirement

PEB - Permanent Engineering Board

PNWA - Pacific Northwest Area

PNCA - Pacific Northwest Coordination Agreement

PNW - Pacific Northwest

RPS - Renewable Portfolio Standards

SOA - Supplemental Operating Agreement

SRD - Storage Reservation Diagram

TDM - Thermal Displacement Market

TSR - Treaty Storage Regulation

URC - Upper Rule Curve

U.S. - United States of America

VarQ - Variable Discharge Flood Control

VRC - Variable Refill Curve

GLOSSARY

Acre-foot - The volume of water that will cover a one-acre [43, 560 square feet] area to a depth of one foot; one acre-foot equals 1233 cubic meters (325,000 gallons) of water.

Active Storage - That portion of the live storage capacity in which water will normally be stored or withdrawn for beneficial purposes, in compliance with operating agreements or restrictions.

Annexes A and B - Appendices to the Columbia River Treaty. Annex A deals with the principles of operation and Annex B with the determination of downstream power benefits. Annexes A and B are an integral part of the Treaty. (Treaty Article I)

Annual Firm Energy Capability – Annual FELCC: the firm energy load that the Pacific Northwest coordinated system is able to supply in a year from the firm resources of the coordinated system after deducting the required energy reserve and forced outage reserve.

Assured Operating Plan - One of the two reservoir system operating plans prepared each year to implement the Columbia River Treaty. The Assured Operating Plan is prepared six years in advance of the actual year of operation and defines the rule curves and other operating parameters to guide the operation of the system in a manner that realizes the benefits anticipated by the Treaty. This series of annual operating plans assures both Entities of the manner of operation of Canadian storage in advance for the next five years. The AOP establishes the generation potential of both systems, prescribes operating criteria and procedures to ensure that the potential will be realized, and serves as the basis for the Detailed Operating Plan in the actual year of operation. The downstream power benefits studies are conducted in conjunction with the AOP. (Treaty Article XIV-2h and Annex A Paragraph 9, Protocol VII)

Assured Refill Curve - The Assured Refill Curve indicates the end-of-month storage content required to ensure refill of the reservoir while releasing power discharge requirement outflows. The ARC is based on 1931 historical volume of inflow during the refill period. The year 1931 represents the second lowest historical January through July volume inflow for the Columbia River for the period 1928 to 1958 measured near The Dalles, Oregon.

Average Annual Energy or Average Annual Generation - The average yearly energy production of a hydroelectric project or system as determined from a long-term streamflow record. For purposes of Treaty downstream power benefit determinations, the average output of hydroelectric projects is based on regulation studies using the 30 years of historical streamflows experienced during the period 1928-58, as modified by appropriate irrigation depletions. (Protocol Section VIII)

Average Annual Usable Energy - That portion of the average annual energy production of the United States base system that is usable as defined by Annex B to the Treaty—specifically, firm energy, plus thermal displacement energy, plus up to 40 percent of remaining energy. This is one of the two components of the downstream power benefits. (Annex B Paragraph 3)

Average Annual Usable Secondary Energy - A hydro system's average annual generation less its firm energy capability. This is one of the three parameters used in Step I to evaluate generation optimality.

Average Critical Period Load Factor - The average of the monthly load factors during the critical streamflow period. (Treaty Article I)

Average Megawatt - A unit of average energy output over a specified time period (total energy in megawatt-hours divided by the number of hours in the time period). Used in the Pacific Northwest for comparing a plant or system's energy output (average power output) to its capacity.

Base System (or U.S. Base System) - The plants, works, and facilities listed in the table in Annex B of the Treaty, as enlarged from time to time by the installation of additional generating facilities, together with any projects that may be constructed on the mainstem Columbia River in the United States. The table in Annex B is in essence the 1961 Columbia River hydropower system. (Treaty Article I and Annex B)

B.C. Hydro System - The transmission facilities located within the Province of British Columbia and owned by B.C. Hydro. (Entity Agreement for Delivery and Disposition of the Canadian Entitlement, page 3)

Called Upon - Storage the U.S. can call upon beginning in the year 2024 for flood control. See also On-Call.

Canadian Entitlement - Under the Columbia River Treaty, Canada's 50-percent share of the increase in usable energy and capacity downstream ["Downstream Power Benefits"] from and based on the filling of the three reservoirs at Duncan, Keenleyside, and Mica storage dams in Canada and the reservoir behind Libby Dam in Montana.

Canadian Entitlement Capacity - Dependable hydroelectric capacity forming part of the Canadian Entitlement, expressed in megawatts. (Entity Agreement for Delivery and Disposition of the Canadian Entitlement, page 4, and Canadian Entitlement Capacity Reduction Agreement, page 3)

Canadian Entitlement Energy - Average usable hydroelectric energy forming part of the Canadian Entitlement, expressed in megawatts. (Entity Agreement for Delivery and Disposition of the Canadian Entitlement, page 4)

Canadian Entity - The agency that implements the Columbia River Treaty for Canada. The Canadian Entity for the purposes of the Treaty's Article XIV is B.C. Hydro, which is a Crown Corporation of British Columbia. For the purpose of disposing of the Canadian Entitlement to downstream power benefits directly in the United States, the Canadian Entity is the government of British Columbia.

Canadian Re-operation - Five studies are generally performed to complete the AOP and DDPB studies. Once the three U.S. optimum studies are complete, the next stage in the process is to complete the "Canadian Re-operation." This stage involves developing project-specific operating criteria for Canadian storage projects that optimize generation in both countries.

Canadian Treaty Storage - The 15.5 Maf of storage provided by Canada under Article II of the Treaty at the Mica Creek, Arrow Lakes, and Duncan Lake projects. Also called Treaty Storage. (Treaty Article I)

Canadian System - The Canadian projects included in the AOP and DOP studies. In the most recent AOPs, the Canadian System has been defined as Duncan, Arrow (Keenleyside), Mica, Revelstoke, Kootenay Canal, Corra Lynn, Upper Bonnington, Lower Bonnington, South Slocan, Brilliant, Seven Mile, and Waneta.

Capability - The maximum load that a generator, turbine, power plant, transmission circuit, or power system can supply under specified conditions for a given time interval without exceeding approved limits.

Capacity - The load for which a generator, transmission circuit, power plant, or system is rated. May be used synonymously with capability.

Capacity Credit - The dependable hydroelectric capacity to be credited to Canadian storage in accordance with Annex B of the Treaty and paragraphs IX and X of the Protocol to the Treaty. (Entity Agreement for Delivery and Disposition of the Canadian Entitlement, page 4, and Canadian Entitlement Capacity Reduction Agreement, page 3)

Capacity Credit Limit - The Treaty specifies that the dependable hydroelectric capacity benefit shall not exceed the difference between the capability of the base system without Canadian storage and the maximum feasible capability of the base system with Canadian storage to supply firm load during the critical streamflow periods.

Columbia River Treaty - The 1961 Treaty, ratified in 1964, between the United States and Canada relating to cooperative development of the water resources of the Columbia River Basin, and Annexes A and B to that Treaty.

Coordinated Hydro Load - [also Residual Hydro Load] The treatment within the PNWA of all hydro-served loads and portions of load of a service control area proportionate to that area's hydro generation as though it were all a single load of a single control area; the total load minus all resources that are not coordinated hydro.

Coordinated System - Contractually, the system of hydroelectric projects located on the U.S. portion of the Columbia River and major tributaries that are operated together on a coordinated basis under the terms of the Pacific Northwest Coordination Agreement. The term is sometimes used in a more general sense to include also those projects that are operated by utilities not participating in the Coordination Agreement.

Critical Period - The historical streamflow period when the water available from reservoir releases plus the natural streamflow is capable of producing the least amount of hydroelectric power in meeting system load requirements. Normally the critical period begins with the initial release of stored water from full reservoir conditions and ends with the reservoirs empty. (Treaty Article I) Also defined as the streamflow sequence during the historical record when water available from storage operated optimally to maximize power within all non-power constraints is capable of producing the least amount of FELCC shaped the same as the hydro firm load (i.e., uniform surplus/deficit).

Critical Period System Regulation Study - The regulation that develops critical rule curves for each reservoir and determines the length of the critical period and the firm energy load carrying capability of the system.

Critical Rule Curves - Critical rule curves, developed for each reservoir by the Critical Period System Regulation Study, are the end-of-month storage contents attained by the storage reservoirs. A critical rule curve provides a monthly guide to reservoir storage drafts and fills to provide an optimum power operation to meet system FELCC during periods of low inflows. In multiple-year critical periods, there will be a critical rule curve for each corresponding year of the critical period.

Dependable Capacity - For purposes of Treaty computations, dependable hydroelectric capacity to be credited to Canadian storage is defined as (a) the difference in the average rates of generation during the critical period with and without Canadian storage, divided by (b) the average of the monthly load factors during the critical period of the Pacific Northwest area, as determined from the Step I study. (Annex B Paragraph 2)

Dependable Peaking Capability - The reliably expected maximum output of a generating plant or plants during a specified peak-load period.

Detailed Operating Plan - The Detailed Operating Plan is similar to the Assured Operating Plan except that it is prepared immediately prior to each operating year. The DOP is developed from the AOP for that year and reflects the latest load, resource, flood control, and other pertinent data as mutually agreed to by the Entities. The Detailed Operating Plan serves as a guide and provides criteria for actual operation of the Canadian storage during the immediately ensuing operating year. (Treaty Article XIV-2(k))

Determination of Downstream Power Benefits - The calculation of downstream power benefits, both energy and capacity, in the United States resulting from Canadian Treaty Storage. This calculation is made annually in conjunction with the Assured Operating Plan.

Determination of Thermal Displacement Market - Calculation of the portion of generation in Columbia Basin from U.S. Step I thermal plants that can potentially be displaced with hydroelectric secondary energy minus System Sales, with System Sales being uniformly distributed over all months in the year. This computation is required by the Columbia River Treaty.

Discharge - Volume of water released from or through a project at a given time, usually expressed in cubic feet per second.

Downstream Power Benefit - The difference in the average annual usable energy and dependable capacity capable of being generated in the United States with and without the use of Canadian Treaty storage. (Treaty Article VII and Annex B)

Drawdown - The distance that the water surface of a reservoir is lowered from a given elevation as the result of the withdrawal of water due to discharge requirements exceeding inflows. This term is also used to refer to the maximum drawdown for power operation, from normal full pool to minimum power pool. Although drawdown is usually expressed in feet of elevation, it is sometimes expressed in terms of millions of acre-feet of storage withdrawn.

Drawdown Period (Evacuation Period) - That portion of the annual reservoir operation cycle when reservoirs are drafted to provide space for flood control and to maximize energy production; on the Columbia River system, this period typically extends from September 1 through April 15. PNCA defines the drawdown period more specifically in terms of energy in storage (PNCA Section 2k).

End-of-Month Contents - Volume of storage contained in a reservoir at the end of a given month, usually expressed in millions of acre-feet.

Energy Content Curve - As defined by the PNCA, the ECC is a guide to the use of storage water from each reservoir in the coordinated system that is used to define certain rights, entitlements, obligations, and limitations. ECCs are designed to provide sufficient storage at all times so that the coordinated system will be able to generate its firm energy load carrying capability under a recurrence of any historical streamflow sequence. As a practical matter, the ECC defines the level of drawdown below which no secondary energy loads will be carried. The ECC (sometimes called the Base Energy Content Curve) defines the reservoir levels that must be maintained to ensure that reservoirs will refill under 1931 (the third worst) water conditions. It is the higher of two curves—the Critical Rule Curve and the Assured Refill Curve—and its upper limit is the Flood Control Rule Curve.

Energy Entitlement - One-half of the difference between the Step II usable energy and the Step III usable energy (downstream benefits).

Entities - The entities designated by Canada and the United States under Article XIV of the Treaty to formulate and carry out the operating arrangements necessary to implement the Treaty. (Treaty Articles I and XIV) See United States Entity and Canadian Entity.

Firm Energy - Electric energy that is considered to have assured availability to the customer to meet all or any agreed-upon portion of the customer's firm load requirements.

Firm Energy Load Carrying Capability - As defined in the PNCA, FELCC is the firm energy load that the Pacific Northwest coordinated system is able to supply in any period from the firm

resources of the coordinated system after deducting the required energy reserve and forced outage reserve. Also called Firm Energy Capability.

Firm Hydro Energy - The firm energy capability of the hydro system, based on certain specified probability considerations. Firm hydro energy is determined for Treaty studies using the 1928-1958 historical water sequence and calculating the maximum amount of energy load that can be served in the worst water sequence and utilizing all available storage.

Firm Load - That part of the system load that must be met with firm power.

Firm Load Carrying Capability - The maximum amount of annual firm energy (shaped load) that the system can continuously support while drafting the active storage of the system from full to empty under the most adverse sequence of streamflows occurring within the adopted historical record (the Critical Period); collectively, Firm Energy Load Carrying Capability and Firm Peak Load Carrying Capability.

Firm Power - Power that is considered to have assured availability to the customer to meet all or any agreed-upon portion of a customer's load requirements. It is firm energy supported by sufficient capacity to fit the load pattern. The availability of firm power is based on the same probability considerations as is firm energy.

Flex operation - Canada's operation of individual projects for maximum Canadian benefits, so long as the flow at the border is the same as that specified in the operating plan.

Flood Control Curve - 1) Mandated and coordinated by the Corps of Engineers, a graph or table representation showing the reservoir drawdown necessary to control floods; 2) Specification of flood control storage space maintained to meet local and system flood control requirements, then used as an input to HYDSIM as monthly storage upper limits.

Flood Control Operating Plan - An operating plan that prescribes criteria and procedures by which the Mica, Duncan, Arrow, and Libby reservoirs are to be operated to achieve the flood control objectives of the Treaty. The Flood Control Operating Plan is prepared by the Entities and consists of flood control storage reservation diagrams and associated criteria for each of the reservoirs. (Annex A Paragraph 5 and FCOP Section 1-2)

Flood Control Refill Curves - Curves used to provide a 95 percent confidence level of refill. Flood Control Refill Curves help guide the refill of reservoirs during the spring refill period and ensure that the flood control regulation does not adversely affect refill insofar as possible. The refill curves define the upper reservoir elevation at any point during the refill period.

Flood Control Refill Period - Commences 10 days prior to the date the unregulated mean daily discharge is forecast to first exceed the controlled flow objective at The Dalles. The end of the Flood Control Refill Period will be when no further flood potential exists at any of the damage areas.

Flood Control Rule Curve - Flood Control Rule Curves, also called Upper Rule Curves or Mandatory Rule Curves, specify the amount of flood control storage space that must be maintained to meet local and system flood control requirements. These curves define the maximum reservoir elevation that must not be exceeded except during flood regulation. Flood Control Rule Curves are made up of two components: a fixed component guides drawdown during the fall to ensure that minimum flood control requirements can be met, and a variable component during winter and spring is based on forecast runoff. For Treaty projects, the Flood Control Rule Curves are based on the Flood Control Storage Diagram/Reservation Curves.

Flood Control Storage (Treaty) - A total of 15.5 Maf of storage is available in the three Canadian Treaty reservoirs for control of floods. Of this total, 8.45 Maf of storage is classified as Primary Storage and is available on a year-to-year basis. The remaining 7 Maf is classified as On-Call storage and is available only for control of large floods. (Treaty Articles V and VI and FCOP Section III)

Flow - Streamflow; the rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

Reservoir Elevation - The water surface elevation immediately above a dam or hydroelectric plant intake structure.

Forecast Mode - A study mode that assumes limited foreknowledge of basin hydrology.

Freshet - A substantial rise in streamflow caused by rain or snowmelt. In the Columbia River system, the freshet normally refers to the snowmelt runoff occurring in the late spring and early summer.

Generation - The act or process of producing electric energy from other forms of energy; also the amount of electric energy so produced.

Gigawatt - One million kilowatts.

Head - The measure of potential energy due to the difference in water surface elevation between two points. In hydropower regulation studies, head is the difference in elevation between the forebay elevation and the tailwater.

Headwater Projects - Reservoirs located on upper tributaries of the Columbia River. They generally have large storage capabilities relative to their inflow and are operated to provide flood control and power benefits at downstream hydro plants. They cannot be operated on a day-to-day basis for flood control of the lower Columbia due to the relatively long time it takes for a change in outflow at these reservoirs to have a significant effect upon streamflow in the lower Columbia River. Headwater Projects are those classified as Category I reservoirs in the Flood Control Operating Plan. (FCOP Section 2-4)

Hydro Independents - The hydroelectric projects of the region that are not regulated in reservoir simulation models of the coordinated Columbia River system. The output of these

projects is accounted for by reducing system loads rather than simulating the operation of the projects. These projects are small and have little or no hydraulic effect on the operation of the coordinated system. Hydro independents modeled in HYDSIM include the Federal Willamette projects, Yakima projects, and projects upstream of Brownlee.

Hydroregulation Studies - Studies that simulate operation of the reservoir system.

Hydraulic Capacity - The maximum flow that a hydroelectric plant can utilize for power generation.

HYDSIM - HYDSIM is the hydro regulation model that is used in AOP studies. It simulates the month-to-month operation of the Pacific Northwest hydropower system in accordance with operating criteria and constraints based on the Columbia River Treaty. HYDSIM is used to determine the hydro system generation and resulting project outflows, ending storage contents, and so on under varying inputs of inflows, power loads, operating procedures and constraints, and physical plant data. HYDSIM is a deterministic model that uses rule curves and flow/storage constraints to achieve operating objectives, especially for power, flood control, fish flows and spill, and recreation.

Independent Power Producer - A non-utility producer of electricity that operates one or more generation plants under the 1978 Public Utility Regulatory Policies Act (PURPA). Many independent power producers are cogenerators who produce power for their own use and sell the extra power to their local utilities.

Initial Control Flow - The annual flow target at The Dalles. The ICF is fundamentally a water balance calculated using the available system storage volume on April 30 and the forecasted seasonal runoff volume. The resultant volume is then converted to a flow rate and labeled the ICF. The simplistic interpretation of this ICF is that all unregulated flow above the ICF during the runoff season at The Dalles can be stored, thereby refilling reservoirs. The ICF is thus the trigger to initiate system refill. The ICF is used to ensure that the projects refill while minimizing the peak runoff at The Dalles. The procedure for determining the ICF is presented in the Treaty FCOP.

Installed Capacity - Same as nameplate capacity unless otherwise specified.

International Joint Commission - The IJC was created under the Boundary Waters Treaty of 1909 between the United States and Canada to render decisions on the use of boundary waters, investigate important problems arising along the common frontiers not necessarily connected with waterways, and make recommendations on any question referred to it by either government. Differences arising under the Treaty that the Entities and PEB cannot resolve may be referred by either country to the IJC for decision. (Treaty Article XVI, and Annual Report Section II)

Intertie - Transmission circuit used to tie or interconnect two load areas or two utility systems.

Irrigation Depletions - Adjustments to streamflow data to account for projected irrigation withdrawals.

Kilowatt - The electrical unit of power that equals 1,000 Watts or 1.341 horsepower.

Kilowatt-hour - The basic unit of electrical energy. It equals one kilowatt of power applied for one hour.

KSFD - thousand second-foot-days; a unit of reservoir volume equal to 86,400,000 ft^3, or ~1989 Kaf, and equivalent to a flow of 1000 ft^3/second for one day.

Libby Coordination Agreement - The Columbia River Treaty Entity Agreement Coordinating the Operation of the Libby Project With the Operation of Hydroelectric Plants on the Kootenay River and Elsewhere in Canada, signed in the year 2000.

Load - The amount of electric energy delivered or required at any specified point or points on a system.

Load Factor - The ratio of the average load over a designated period to the peak load occurring in that period.

Load Shape/Pattern - The characteristic variation in the magnitude of the power load with respect to time, such as a daily, weekly, or annual period.

Local Flood Control – Small basin or sub-basin measures taken to control flooding within a relatively limited area, usually without consequences for a larger-area flood control regime.

Long-Term Planning Studies – Hydro regulation studies that simulate longer-term system conditions; usually in a six-year AOP horizon.

Transmission Losses - The general term applied to energy (kilowatthours) and power (kilowatts) lost when operating an electric system, occurring mainly as energy turns to waste heat in electrical conductors and apparatus. System losses consist of transmission, transformation, and distribution losses and unaccounted-for energy losses between sources of supply and points of delivery.

Maximum Outflows - Maximum discharge levels that have been established either for flood control or to ensure that as much of the project discharge as possible is used for power generation.

Megawatt - One thousand kilowatts.

Megawatt-hour - One thousand kilowatt-hours.

Mica/Arrow Balancing - The operation of Mica to specific Project Operating Criteria, together with compensating changes to Arrow's operation (in the event that Mica's operation results in more or less than Mica's share of draft, compensating changes will be made from Arrow to the extent possible).

Minimum Outflows - Minimum discharge levels that must be maintained either for power or for non-power river uses such as fish and wildlife, navigation, or irrigation; in some cases minimum generation requirements establish minimum discharge levels.

Modified Flows/Streamflows - Observed or historical flows that have been adjusted to a common level of development by correcting for the effects of irrigation and other diversion demands, return flows, and changes in storage of upstream reservoirs and lakes that are not included in the reservoir simulation model. Modified flows are used for all Treaty regulation studies.

Modified Regulation - The Modified Regulation fine-tunes the Preliminary Regulation to ensure that the hydro system is used to its fullest potential. Part of this process includes determining interchange energy obligations and shifting and shaping FELCC. (PNCA Sections 6c and 6d)

Monthly Load Factor - The ratio of the average load over a month to the peak load occurring in that month.

NGVD - National Geodetic Vertical Datum; a measure of land elevation essentially the same as Mean Sea Level (MSL); a fixed surface reference established by the U.S. Coast and Geodetic Survey in 1929 as the datum to which relief features and elevation data are referenced.

Non-firm Energy - Same as Secondary Energy.

Non-Power Operating Requirements - Operating requirements at hydroelectric projects that pertain to navigation, flood control, recreation, irrigation, fish and wildlife mitigation, and other non-power uses of the river.

Non-Treaty Storage - Reservoir storage in Canadian reservoirs on the Columbia River in excess of that which is regulated under the Treaty.

Non-Triggered Years - Years for which Called Upon was not triggered based on forecast flow volume.

Minimum Pool - The minimum forebay water surface elevation within the reservoir's normal operating range.

Observed Mode - A mode of conducting a study in which perfect foreknowledge of the basin hydrology is assumed.

Operating Criteria – All the rule curves of all kinds, APOC, Mica operating limits, draft limits, maximum and minimum flows that apply to and guide reservoir operations.

Operating Limits - Operating rules that set limits on the operation of projects for hydropower. Examples are flood control rule curves, minimum discharge requirements for fisheries and navigation, and maximum and minimum reservoir elevations/content.

Operating Procedures - Specific steps or tasks that should be taken by one or more specific operating positions to achieve specific operating goal(s). **OR** Documents that identify specific steps or tasks that should be taken by one or more specific operating positions to achieve specific operating goal(s). The steps in an operating procedure should be followed in the order in which they are presented, and should be performed by the position(s) identified; a document that lists the specific steps for a system operator to take in removing a specific transmission line from service is an example of an operating procedure.

Operating Rule Curve - The Operating Rule Curve for each reservoir is a synthesis of other curves, as follows:

Aug 1 – Dec 31:	ORC = Higher of CRC1 and ARC
Jan 1 - Jul 31:	ORC = Lower of VRC and Higher of CRC1 and ARC
Jan 1 - Apr 15:	ORC is limited to no lower than ORCLL
At all times:	ORC is limited to no higher than the URC

The Operating Rule Curve allows, but limits, reservoir operation for the purpose of producing secondary energy. Reservoirs are drafted below Operating Rule Curves only if required to maintain the FELCC of the system.

Operating Rule Curve Lower Limit - The minimum month-end storage contents that provide a high probability that the system will be capable of meeting its FELCC during the period January 1 through April 30 in the event that the Variable Refill Curves permit storage to be emptied prior to the start of the freshet. The ORCLL is developed from 1936-37 water conditions, which represent the lowest January 1 through April 30 run-off volume for the system as a whole.

Operating Year - The period upon which the system's reservoir seasonal operating cycle is based. It begins on August 1, which is when the reservoir system is generally at its highest level, and extends through July 31 of the following year.

Outflow - The total flow released from a reservoir project, including water passed through the powerhouse, spillway, regulating outlets, fish passage facilities, and navigation facilities.

Pacific Northwest Area - As defined in Section 7 of Treaty Annex A, the area comprised of Oregon, Washington, Idaho, and Montana west of the continental divide, but excluding areas served on the Treaty ratification date by the California-Oregon Power Company and the Utah Power & Light Company (now the service area of Pacific Power & Light Company and still excluded from the Pacific Northwest Area loads).

Peak Load - Literally, the maximum load in a stated period of time. Sometimes the term is used in a general sense to describe that portion of the load above the base load.

Peaking - Power plant operation to meet the variable portion of the daily load.

Peaking Capability - The maximum peak load that can be supplied by a generating unit, station, or system in a stated time period. For a hydro project, the peaking capability would be equal to the maximum plant capability only under optimum head and flow conditions; often the peaking capability may be less due to reservoir drawdown or tailwater encroachment. Also called Peaking Capacity.

Peak Reserve - Extra generating capacity available to meet unanticipated demands for power

Permanent Engineering Board - An independent board established under provisions of the Treaty to periodically review and report to the governments of Canada and the United States on operation of the Treaty projects and to investigate and report on any other matter coming within the scope of the Treaty at the request of either Canada or the United State. (Treaty Article XV)

Plant Factor - The ratio of (a) the average load on the generating plant for the period of time considered to (b) the capacity rating of the plant. Unless otherwise identified, capacity factor is computed on an annual basis.

Power Discharge Requirements - The project discharges used to compute VECCs and determined from the Refill Studies. These flows are based on FELCC needs and ensure a reasonable probability of refill under better than critical water conditions. The PDRs, which are established for the months of January through July for each year in the study period, set a limit on the amount of secondary energy that can be produced under various runoff conditions. In planning, PDRs are determined for three forecast runoff levels. When the runoff forecast becomes available in January, new PDRs are determined by interpolation.

Power Draft – Release of water from a reservoir(s) through a generator(s) for the purpose of producing electric power.

Power Refill studies - These studies develop guidelines for generation to produce secondary energy while protecting future FELCC and ensuring a high probability of refill.

Primary Storage - The 8.45 Maf of flood control storage that is available in each year in the three Canadian Treaty reservoirs for control of floods. (Treaty Article VI and FCOP Section 3-1)

Principles and Procedures (POP) - A document prepared by the Columbia River Treaty Operating Committee to serve as a guide for the preparation and use of hydroelectric operating plans for Canadian storage. It is updated periodically to incorporate changes that reflect current operating practices.

Project Operating Criteria – Constraints on operations (e.g., flow targets, minimum and maximum discharge) at a particular generating project to reflect characteristics and uses of the environment at and near the project.

Project Operating Procedures - Specific steps or tasks that should be taken by one or more specific operating positions to achieve specific operating goal(s) for one specific project/dam/reservoir.

Proportional Draft – A procedure for equitably distributing draft of storage among the reservoirs in the system during poor water years to ensure that FELCC will be met when reservoirs must be drafted below Energy Content Curves.

Proportional Draft Point - Points for each reservoir established to distribute proportional draft among reservoirs when low water conditions occur.

Protocol - A document accompanying an exchange of notes dated January 22, 1964 that clarifies certain particulars of the Treaty. The Protocol has the same force as the Treaty itself.

Refill Curve - A guide to operation of a reservoir that optimizes the production of usable energy consistent with an agreed probability that reservoir refill will not be jeopardized by secondary energy production. A reservoir shall not be drafted below its Refill Curve to serve any secondary energy loads, unless required by established operating procedures at the project. Two Refill Curves are developed to guide reservoir operations. The Variable Refill Curve is based on a 95 percent refill probability, and the Assured Refill Curve is developed using the second lowest January-July volume inflow of historical streamflows (1931). In essence, the ARC provides a check on the VRC and allows a deeper draft if the VRC is found to be overly conservative.

Refill Period - That portion of the annual reservoir operation cycle when reservoirs are allowed to refill; on the Columbia River system, this period typically extends from the middle of April through the end of July. The PNCA defines the refill-hold period as that period beginning at the end of the Drawdown Period and ending at the beginning of the next subsequent Drawdown Period. (PNCA Section 2dd)

Refill Study - Refill studies develop PDRs used to compute the ARC and VRC. The studies incorporate the CRCs and FELCC developed in the Critical Period System Regulation Study. The AOP refill studies use a 30-year historical streamflow record, and the PNCA refill studies use a 50-year historical streamflow record. The Refill Studies are intended to determine if energy content curves based on the AOP or Final Regulation will permit meeting FELCC under historical streamflow conditions and will meet a refill objective of 95 percent confidence of refill before production of secondary energy. (PNCA Section 7)

Regulated Flow - The controlled rate of flow at a given point during a specified period resulting from actual reservoir operation or a simulated reservoir operation.

Hydroregulation Study - A study of simulated operation of a reservoir system.

Renewable Portfolio Standards - Policy of various states, including Oregon, Washington, Montana, and California, that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date.

Reoperation – The review and recalculation of the U.S. Optimum Long-Term Study by Canada to produce optimal benefits of power and flood control for both nations.

Reserves - Generating capability that must be provided by a power system in excess of that required to meet forecasted peak loads. This "extra" generation is required to meet unanticipated demands for power or to generate power in the event of loss of generation resulting from scheduled or unscheduled outages of regularly used generating capacity.

Residual Hydro Load - The net result of PNWA loads, thermal installations, and other resources; a residual load for the coordinated hydropower system to meet.

Resources - Means of producing or saving energy that can be used to meet demand for energy (loads).

Return Flow - The portion of a water diversion demand that is returned to the stream system and is available for use downstream.

Rule Curves - Rule curves specify the end of month storage content for the reservoirs. In doing so, they delineate a schedule of reservoir drafts and fills that are designed to utilize storage and natural flow in such a manner as to produce the optimum amount of FELCC, usable secondary energy, and reservoir refill probability under any pattern of streamflow. Flood control rule curves also provide guidance to ensure adequate flood control on the Columbia River and its tributaries. The rule curves are derived from system-wide power regulation studies and hydrologic analyses of flood control needs in the basin designed specifically to develop and test the criteria.

Run-of-River Plant - A hydroelectric plant that depends for generation chiefly on the flow of a stream as it occurs, as opposed to a storage project that has sufficient storage capacity to carry water from one season to another. Some run-of-river projects have a limited storage capacity (pondage) that permits them to regulate streamflow on a daily or weekly basis.

Secondary Energy - All hydroelectric energy generated in excess of the firm energy capability. This additional generation results from streamflows greater than those in the critical period studies that determine the hydro firm energy capability.
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Shaped Load - Energy demand whose variance over time has been revised mathematically to dispose of surplus energy and balance loads and resources.

Short-Term Market - Purchases and sales of firm and non-firm power ranging from the next hour, for an hour, up to five years.

Spill - Water passed over a spillway without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity; can be due to lack of market; or can be planned. An example of planned spill is when water is spilled to enhance juvenile fish passage.

Standard Flood Control - Standard Flood Control is used in all Treaty regulation studies including the AOP, DOP, and TSR and is defined in the Columbia River Treaty Flood Control Operating Plan. See also VarQ, Libby variable outflow flood control.

Step I/II/III Studies - Thirty-year system regulation studies made annually to determine the increase in dependable hydroelectric capacity and the increase in average annual hydroelectric energy resulting from operation of the Treaty projects. These studies are a part of the process to develop the AOP and the downstream power benefits. These studies are prepared each year for the sixth succeeding year in accordance with Treaty Annex B. (Annex B Paragraph 7)

> ***Step I Study*** - The Step I system, defined in Annex B, includes the planned total US hydro and thermal system, including projected and existing resources used to meet Step I loads, with 15.5 Maf of Canadian Treaty storage. The Step I loads are the Pacific Northwest Area loads, including Grand Coulee pumping, adjusted for power flows into and out of the Pacific Northwest in accordance with the 1988 Entity agreements. The thermal installations, hydro plant data, and operating procedures, to the extent they apply to the respective critical periods, are carried over from Step I to the Step II and III studies. The Step I studies also determine the operating criteria for Treaty projects to be used in the DOP unless otherwise agreed by the Entities.
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> ***Step II and III Studies*** - The Step II system is the Base system as defined in Annex B (essentially the 1961 hydro system) with the addition of 15.5 Maf of Treaty storage. The Step III hydro system is the Base system only and does not include Treaty storage. The thermal installations, hydro plant data, and operating procedures, to the extent they apply to the respective critical periods, are carried over from Step I to the Step II and III studies. Step II and III loads are shaped to the PNWA load shape, including Grand Coulee pumping. The downstream power benefits are calculated from the results of system capability studies for the Step II and III systems.

Storage - Space in a reservoir that is usable for impounding water. The Treaty deals only with storage regulation for flood control and hydroelectric power generation, but many of the reservoirs in the system are regulated for other purposes as well. (Treaty Article I)

Storage Content - Volume of water in a reservoir at any particular point in time.

Storage Project - A project with a reservoir of sufficient size to store water in the high-flow season for release in the low-flow season, thus providing a firm flow substantially greater than the minimum natural flow. A storage project may have its own power plant or may be used only for increasing generation at downstream plants.

Storage Reservation Diagram - A graph of a family of curves of Required Storage Space by month. Each curve on the SRD corresponds to a given seasonal volume—the volume of flow to pass a certain point over a period of months.

Streamline Procedures – Reference to a way to complete AOP studies by utilizing either 1) numbers and calculations from previous years or 2) agreed-upon numbers and values in place of extensive studies and modeling.

System Regulation Study - Each operating plan specifies System Operating Criteria, which are developed from a series of System Regulation Studies designed specifically to develop and test the criteria:

- Critical Period System Regulation Studies establish U.S. system FLCC and low streamflow operating criteria, based on the worst water years.
- Refill Studies establish operating criteria for middle and high water years by analyzing 70 water years (30 for Steps II/III), with all reservoirs reinitialized to as full as possible at the start of each operating year.
- System Regulation Studies simulate a continuous operation over 70 years (30 for Steps II/III) with the operating criteria established above and, if applicable, Mica/Arrow operating criteria that optimize generation in both countries.

System Sales - Flows of firm power out of the Pacific Northwest Area, excluding:

- flows of power from exchanges of firm power that neither increase nor decrease the net flow of power between the PNWA and other regions
- plant sales
- flow-through transfers of power from outside the PNWA to outside the PNWA
- delivery of Canadian Entitlement out of the PNWA

Thermal Displacement Market - That portion of the generation from the U.S. Step I thermal plants that can potentially be displaced with hydro secondary energy minus System Sales, with System Sales being uniformly distributed over all months in the year. (Annex B Paragraph 3)

Transmission Interconnection (Intertie) - Transmission circuit used to tie or interconnect two load areas or two utility systems.

Treaty - The Treaty between Canada and the United States of America relating to the Co-operative Development of the Water Resources of the Columbia River Basin, including its Annexes A and B, ratified on September 16, 1964.

Treaty Obligation - All of the series of obligations, tasks, duties and responsibilities from Canada to the U.S., and the U.S. to Canada, spelled out in the Treaty.

Treaty Storage - Usually refers to the storage provided by Canada under Article II of the Treaty at the Mica Creek, Arrow Lakes, and Duncan Lake projects. All storage authorized by the Treaty, including Libby, is sometimes loosely referred to as Treaty storage.

Treaty Storage Regulation - A hydroregulation study based on the DOP operating criteria and current operating data, including streamflows, operating rule curves, and flood control rule curves. A TSR study is completed at least twice per month to compute the DOP storage obligation for Canadian storage. Loads and non-power constraints are not updated for current conditions.

U.S. Entity - One of the two parties designated to operate the Columbia River Treaty; made up of the Administrator of the Bonneville Power Administration (chairman) and the Division Engineer, North Pacific Division, U.S. Army Corps of Engineers (member).

Unregulated Flow - Observed streamflow adjusted to eliminate the effects of reservoir regulation but reflecting the effects of natural storage in lakes and river channels.

Upper Rule Curve - The month-end reservoir levels at each project during the evacuation and refill periods. Upper Rule Curves define the maximum allowable storage content of each reservoir and are determined from flood control regulations, in accordance with the Treaty FCOP. Also see Flood Control Rule Curve.

Usable Energy - All hydroelectric energy that can be used in meeting system firm and secondary loads. It is possible that there may not be a market for all of the secondary energy that could be generated in years of abundant water supply, and some of the water may have to be diverted over project spillways and the energy wasted.

U.S. Optimum Study - The U.S. AOP-like study that determines what the power output and flood control protection should be for the maximum benefit in the U.S.

Variable Refill Curve - The VRC indicates the end-of-month storage content required during the refill period to refill with 95 percent confidence each cyclic reservoir consistent with (1) at-site volume inflow forecasts, (2) Power Discharge Requirements, and (3) upstream reservoir refill requirements.

VarQ - VarQ means variable Q, or variable flow, as it pertains to flood control limits. It is an adaptive management technique that, rather than requiring fixed and rigid releases of water as levels in a reservoir approach a fixed flood control rule curve, allows managers to retain more water during the flood control season.

Year - A 12-month period for a particular purpose.

Operating Year - The August 1 through July 31 period, used for regulation studies for both the Treaty and PNCA.

Reporting Year (Entity and PEB) - The period covered by the Annual Report of the Columbia River Treaty, Canadian and United States Entities, and the Permanent Engineering Board's Annual Report to the Governments of The United States and Canada, specifically, October 1 through September 30. The reporting period is tied primarily to the need to report flow data, which is published by the responsible agencies on a Water Year basis. (Treaty Article XV)

Streamflow Year (Treaty) - The Water Year used in developing the streamflow data upon which Treaty regulation studies are performed: specifically, July 1 through June 30. (Protocol Section VIII)

Water Year - Established by Canadian and United States water resources agencies for purposes of uniformly reporting hydrologic records. The Water Year extends from

October 1 through September 30, but the streamflows used for all reservoir regulation studies of the Columbia River system are based on the period August 1 through July 31.

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