

COLUMBIA RIVER TREATY

PRINCIPLES AND PROCEDURES

FOR PREPARATION AND USE OF

HYDROELECTRIC OPERATING PLANS

Prepared by the

Columbia River Treaty
Operating Committee

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PART I INTRODUCTION

1. AUTHORITY AND PURPOSE

This document has been produced by the Columbia River Treaty Operating Committee with the authorization of the United States and Canadian Entities as a guide for the preparation and use of hydroelectric operating plans for Canadian storage. It replaces the document, "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage", dated May 1983, which was agreed to by the Entities on 31 May 1983. This revision includes the following changes resulting from Agreements dated 28 July 1988 and 12 August 1988, and other changes that reflect current operating practices.

- a. Use of updated estimates of irrigation depletions and return flows when calculating the streamflows.

- b. Clarification of the definitions of loads and resources in the hydroregulation studies.

- c. Addition of principles and procedures for potential inclusion of firm energy shifting in the hydroelectric operating plans.

- d. Use of consistent operating procedures throughout the Steps I, II and III studies in the Assured Operating Plan and Determination of Downstream Power Benefits.

- e. Clarification to the procedures for determining thermal displacement energy in the Determination of Downstream Power Benefits.

- f. Use of the Actual Energy Regulation to determine proportional draft in actual operations.

2. SCOPE

The Columbia River Treaty provides that the operating arrangements necessary to implement the Treaty will be formulated and carried out by the Entities designated by the United States and Canada. Article XIV 2. of the Treaty specifies that the powers and duties of the Entities include, among other things:

"(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;"

"(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."

Guidance for flood control planning and operations is provided in the Columbia River Treaty Flood Control Operating Plan submitted by the United States Entity in accordance with Annex A, paragraph 5 of the Treaty. Guidance for the preparation of hydroelectric operating plans and for the calculation of downstream benefits is provided in this document. In addition, the Principles and Procedures, together with the Flood Control Operating Plan, detail the steps necessary to prepare and implement the detailed operating plans. This document will be reviewed periodically and revised as necessary to take advantage of actual operating experience and to deal with any problems resulting from the need to operate towards the optimization of generation in Canada, in the United States, or in both countries.

Each year two operating plans shall be prepared. An Assured Operating Plan will be prepared for the sixth succeeding year which, with previous plans, will assure both Entities of the manner of operation of Canadian storage in advance for the next succeeding five years and will also be the basis for computing downstream power benefits for the corresponding year. Once the downstream power benefits are agreed to they shall not be changed even though the data and operating plan on which it was developed may change. Immediately prior to each operating year, a Detailed Operating Plan will be developed from the Assured Operating Plan for that operating year. The Detailed Operating Plan will reflect the latest load, resource, flood control, and other pertinent data if mutually agreed by the Entities. The Detailed Operating Plan will serve as a guide and provide criteria for actual operation of the Canadian storage during the immediately ensuing operating year. An operating year shall mean the period 1 August through 31 July.

3. REFERENCES

a. Columbia River Treaty dated 17 January, 1961, and its allied documents, pertaining to the preparation and use of operating plans.

(1) Article IV - Operation by Canada; paragraphs 1 and 2.

(2) Article V - Entitlement to Downstream Power Benefits; paragraph 1.

(3) Article VI - Payment for Flood Control; paragraphs 3, 4 and 5.

(4) Article VII - Determination of Downstream Power Benefits; paragraphs 1 and 2.

(5) Article XII - Kootenai River Development; paragraphs 5 and 6.

(6) Article XIV - Arrangements for Implementation; paragraph 2.

(7) Annex A - Principles of Operation.

(8) Annex B - Determination of Downstream Power Benefits.

(9) Terms of Sale - Attachment to Exchange of Notes dated 22 January, 1964; Section B.1.

(10) Protocol - Annex to Exchange of Notes dated 22 January, 1964; paragraph V, VII, VIII, IX and X.

(11) Canadian Entitlement Purchase Agreement - Sections 6 and 7.

b. Columbia River Treaty Flood Control Operating Plan dated October 1972, as amended.

4. DEFINITIONS

Terms defined in Article I of the Columbia River Treaty dated 17 January, 1961, have the same meanings in this document except "storage" which refers to water content rather than space.

The "load of the Pacific Northwest Area" described in Annex B, paragraph 7, and referred to in Protocol paragraph IX, is equal to the amount of electric power used to serve firm load in the Pacific Northwest Area as that area is defined in Annex B. Firm load in the Pacific Northwest Area is the load for which resources have been or must be acquired to serve that load. The firm energy load carrying capability of a

system is the maximum generation, shaped the same as the firm energy load of that system, that the system can produce during its critical period.

"Month" shall mean a calendar month except in April and August when it shall mean each of the following periods:

1 April to 15 April

16 April to 30 April

1 August to 15 August

16 August to 31 August

Other terms have the meanings given in the Glossary of Electric Power Terms, Appendix XV, Columbia-North Pacific Region Comprehensive Framework Study, Pacific Northwest River Basins Commission dated October 1970.

5. TREATY ORGANIZATION

Implementation of the Columbia River Treaty is carried out by the United States and Canadian Entities, which were appointed by the two Governments for this purpose. The Canadian Entity is the British Columbia Hydro and Power Authority. The United States Entity is composed of the Administrator of the Bonneville Power Administration and the Division Engineer of the North Pacific Division, Corps of Engineers. The Administrator is designated as Chairman of the United States Entity.

The United States Entity has appointed a Secretary and two Coordinators, one from the Corps of Engineers and one from the Bonneville Power Administration, to coordinate the activities of the Entity. The Canadian Section has established the position of Manager, Canadian Entity Services to manage the activities of its Entity.

The Entities have, in turn, established two committees: the Columbia River Treaty Operating Committee and the Columbia River Treaty Hydrometeorological Committee. Each committee has a United States Section and a Canadian Section. The United States Sections of these committees have equal representation by the Corps of Engineers and the Bonneville Power Administration. The chairmanship of the United States Section of the Operating Committee rotates between the Corps of Engineers and the Bonneville Power Administration. From 1 March through 31 August a representative of the Corps of Engineers is chairman. From 1 September through the end of February, a representative of the Bonneville Power Administration is chairman. Chart 1 outlines the Treaty organization.

The Operating Committee membership is limited to four members from each country. The Committee is responsible for making the system regulation studies, preparing the operating plans, insuring that the plans are carried out, and performing other duties as required by the Entities.

Each Entity shall give evidence of appointment of representatives by written notice to the other Entity, and by similar notice either Entity may at any time change its representatives.

6. THE POWER AND RESERVOIR SYSTEM

The operation of the Canadian storage at Duncan, Arrow, and Mica reservoirs is designed to increase power generation downstream in the United States and downstream in Canada, as soon as the latter can be effected. In the plans, storage at the three Canadian projects is considered an element in the Columbia Basin power system, within which individual storage operation may be varied by the Canadian Entity.

In the United States the system consists of all the hydroelectric projects on the main stem of the Columbia River, including large-capacity multipurpose storage reservoirs and run-of-the-river projects with storage capacity sufficient for weekly load factoring only. In addition, the system includes numerous reservoirs of both types on tributary streams of the Columbia River and coastal streams in the States of Washington, Oregon, Montana and Idaho. The combined power output is supplied to the regional electrical transmission network.

In Canada, the system included in the hydroelectric operating plans consists of Duncan, Keenleyside, Mica, power generation downstream of those sites, and any other power generation coordinated therewith.

Libby project, which is located in the United States, and whose reservoir extends into Canada is assumed to be a normal United States tributary reservoir although the Treaty provides that its regulation may be planned to improve the inflows to those projects immediately downstream of Kootenay Lake, provided that there is no disadvantage to the United States.

CHART 1

COLUMBIA RIVER TREATY ORGANIZATION

The seasonal pattern of operation of storage projects depends on their location in the basin. Reservoirs on the main stem of the Columbia River, and those tributary streams whose headwaters are in the interior ranges, attain their maximum pool elevations in July or August from streamflow runoff caused primarily by snowmelt. Streamflows gradually fall after the summer snowmelt is complete. These reservoirs are lowered by withdrawals required to augment winter streamflows to sustain the region's winter electric power demand, which is at a maximum during this period. Additional storage withdrawals may be made for the purpose of controlling floods, should the potential runoff be great enough. Regulation of these reservoirs during the spring season is for power or flood control, or both purposes coincidentally.

Coastal reservoirs in the United States are subject to high winter season inflows, hence they are normally drafted a significant amount in advance to provide enough reservoir space to minimize the possibility of spilling winter freshets and to prevent flood damage.

Most coastal reservoirs, operate to predetermined elevations for power and flood control except during the time that such floods are being controlled. Normally, coastal reservoirs fill by late May or June, and water thus stored is retained until drafts are required in late summer or early fall.

The entire hydroelectric system is integrated with the thermal generating facilities required to serve the load in the region.

The seasonal operation of storage reservoirs is guided by project rule curves, variable and assured refill curves, upper rule curves, flood control refill curves, and other operating criteria which are developed from system-wide power and flood control studies as well as operating experience. These operating guidelines are incorporated into the Assured Operating Plans and Detailed Operating Plans, and their development is described in detail in Parts II, III and IV of this document. These operating guidelines are also used for guiding storage use during the course of actual operations.

PART II - GENERAL OPERATING GUIDELINES & RULES USED IN SYSTEM REGULATION STUDIES

7. PURPOSE OF GUIDELINES AND OPERATING RULES

Seasonal operation of storage reservoirs in both the United States and Canada is governed by operating criteria generally known as "rule curves." Such curves delineate a schedule of reservoir drafts which, together with other criteria, assure the system of meeting electric power loads efficiently and of utilizing storage and natural flow in such a manner as to produce the optimum amount of usable energy under any pattern of streamflow. They also provide guidance to assure adequate flood control on the Columbia River and its tributaries and insure refill of the system reservoirs with a high degree of probability.

Special operating criteria and operating rules supplement rule curves and also guide the use of system storage. Some examples are: Mica project target outflows, system draft below operating rule curves to meet load, and physical project operating constraints.

These parameters are derived from system wide power regulation studies and previous operating experience, as well as hydrologic analyses of flood control problems in the basin. Both are usually developed in part by simulation techniques using mathematical models.

The rule curves, special operating criteria, and operating rules so developed by the mathematical simulations are intended for use in guiding the actual system operation. They prescribe a coordinated use of storage so that optimum power generation in the combined systems will be achieved in accordance with the provisions of Annex A, paragraphs 7 and 8 of the Treaty, whichever apply.

8. OPERATING GUIDELINES

a. Critical Rule Curves

A Critical Rule Curve provides a monthly guide to reservoir storage drafts and fills so as to provide optimum energy to meet system firm loads (see Chart 2). The end-of-month storage contents attained by the storage reservoirs in the Critical Period Regulation Study will form the Critical Rule Curve for each project (refer to Subsection 13e(1)). In multiple-year critical periods there will be a Critical Rule Curve for each corresponding year of the critical period. The first curve will be highest in indicated system storage energy on 31 July, the second being next highest, etc. For 30-year studies and actual operations the second curve will be limited to no higher than the first, the third no higher than the second, and the fourth no higher than the third for each project for each month.

CHART 2

Illustration of Critical Rule Curves for a Reservoir

in a Multi-Year Critical Period

b. Refill Curves

A Refill Curve is a guide to operation of a reservoir which allows the production of the greatest amount of usable energy consistent with an agreed probability of refill. 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. Unless otherwise agreed, Refill Curves, as described in Subsection (1) and (2), below, will be prepared for use as operating guides in the 30-Year System Regulation Studies made for the Assured Operating Plan and Detailed Operating Plan. In actual system operations, Refill Curves are usually based on actual forecasts and are supplemented by the Flood Control Refill Curve, from 1 April through 31 July of each year, as defined in the Implementation of the Detailed Operating Plan, Section 24.

The end of the refill period for computation of the Refill Curves for each Canadian reservoir shall be that which provides generation in accordance with Annex A, paragraph 7 and 8 of the Treaty, whichever applies.

(1) Assured Refill Curves: The Assured Refill Curve indicates the end-of-month storage content required to assure refill of the reservoir 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. In computing water available for refill of the reservoir, the following shall be deducted to obtain the net inflow volume: the power discharge requirement, as described in paragraph (2)(d) below; consumptive requirements for water at-site and upstream; and water required for refill of upstream reservoirs, which is the difference between full and the higher of the first-year Critical Rule Curve and the Assured Refill Curve at each of the upstream reservoirs.

If necessary, the Assured Refill Curve shall be adjusted to prevent the Variable Refill Curves from failing the refill test described in paragraph (2)(c), below.

(2) Variable Refill Curves: The Variable Refill Curve indicates the end-of-month storage content required during the refill period to refill each cyclic reservoir consistent with at-site volume inflow forecasts and consistent with upstream

reservoir refill requirements.

In the system regulation studies, the Variable Refill Curve shall be developed as shown in Table 1 and detailed below:

(a) Forecast volumes of inflow used in the 30-Year System Regulation Studies shall be the historical inflow volume experienced during each of the 30 years included in the studies. Each forecast volume shall be reduced by a

TABLE 1

Sample of Computation of Variable Refill Curves (VRC) Duncan

forecast error such that there is a 95 percent probability that the reduced forecast volume will be equaled or exceeded. The inflow volume shall be determined for each of the periods from the first day of January, February, March, etc., to the end of the refill period using appropriate adjustments for forecast error. In computing water available for refill of the reservoir, the following shall be deducted to obtain the net inflow volume: Power Discharge Requirement, as described in paragraph (2)(d); consumptive requirements for water at-site and upstream; and water required for refill of upstream reservoirs, which is the difference between full and the Operating Rule Curve for each of the upstream reservoirs.

(b) Using the net volumes of inflow determined in (a) above, Variable Refill Curves shall be determined for each of the periods of (a) above, giving the month-end storage content required to assure refilling the reservoir (see Table 1).

(c) The Variable Refill Curves determined in (b) above shall be tested by making 30-year Refill Studies wherein the cyclic reservoirs are drafted each year on the Operating Rule Curve, or below the Operating Rule Curve if required, as defined in Subsection 9b.

The storage content of each reservoir at the start of each of the 30 years of historical record shall be its normal full pool content in the Assured Operating Plan studies and the Actual Energy Regulation storage contents, as defined in Subsection 24c, for the Detailed Operating Plan studies. If, in more than 5 percent of the years in the historical period the storage energy in the reservoirs fails to fill to 98 percent of the total system storage energy in the years in which secondary energy was produced in the January through July period, the net volumes available for refill determined in (a) above shall be reduced and the Variable Refill Curves shall be re-computed until the system meets this test.

These become the Variable Refill Curves that will be used in the studies and shall serve to guide the computation of Variable Refill Curves based on forecast volume inflow in actual system operation as described in Subsection 24b(2). Failure of any reservoir to refill when secondary energy is produced by the system, during January through July, when all major projects are limited by maximum storage or minimum outflows during periods with secondary generation, shall not constitute a violation.

(d) In executing the test of (c), the net volumes available for refill shall be reduced, if required, by increasing the Power Discharge Requirement. The increase will be to an extent necessary that each project will have its pro-rata

share of storage draft decreased to allow a greater portion of its natural inflow to be utilized for generation purposes during the refill period. The Power Discharge Requirement for each project shall be a function of project outflow allocation during the refill period, and the January through July natural volume runoff at The Dalles, Oregon (inversely proportional). The Power Discharge Requirement shall be not less than the project minimum discharge requirement.

c. Limiting Rule Curves: The Limiting Rule Curves shall consist of month-end storage contents which must be maintained to guarantee the system meeting its firm load carrying capability during the period 1 January through 31 March in the event that the Variable Refill Curves permit storage to be emptied and sufficient natural flow is not available to carry the load prior to the start of the freshet. Such rule curves shall limit the Variable Refill Curve to be no lower than the Limiting Rule Curve. The Limiting Rule Curve shall not be higher than the Upper Rule Curve at each project. The Limiting Rule Curve shall be developed from 1936-37 water conditions.

d. Upper Rule Curves: The Upper Rule Curves shall consist of the following.

(1) During the Flood Control Evacuation Period the Upper Rule Curve shall be derived from Flood Control Storage Reservation Diagrams which provide the required storage space. Required drawdown for headwater projects are based on at-site inflow forecasts. Drawdown for major lakes controlled by dams is designed to achieve the maximum natural storage effect of the lakes during the refill period. Grand Coulee and Keenleyside project Storage Reservation Diagrams reflect the unregulated runoff forecasts for the Columbia River at The Dalles, Oregon, for the period April through August.

(2) During the refill period the Upper Rule Curve shall be the storage content necessary to control the flood runoff to non-damaging levels if possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space. This regulation is accomplished by establishing a flood control objective at The Dalles and adjusting outflows from Keenleyside, Grand Coulee, and John Day projects to meet the controlled flow. The initial objective, the "Initial Controlled Flow for the Columbia River at The Dalles", is determined as described in the "Columbia River Treaty Flood Control Operating Plan", dated October 1972. Adjustments to the controlled flow objective can be made, if necessary, as the refill period proceeds. During this period the headwater project outflows are normally reduced to their minimums unless greater flows are required to meet power demands. Higher outflows may also be maintained if they are determined not to be detrimental to flood control, or are required to control storage space during exceedingly large floods.

(3) During both the evacuation and refill periods, the Upper Rule Curve may be modified by project construction or other contingency requirements.

(4) In the studies, Upper Rule Curves define the maximum allowable storage content of each reservoir. Such data is determined from independent flood control regulations for the historical period 1928 to 1958, in accordance with the concepts of the Flood Control Operating Plan.

e. Operating Rule Curves: The Operating Rule Curve for each reservoir for use in the 30-year System Regulation Studies is a synthesis of all of the preceding operating guidelines. It shall be developed from the Critical Rule Curve, Assured Refill Curve, Variable Refill Curve, and the Upper Rule Curve as follows: During the period 1 August through 31 December, the Operating Rule Curve shall be defined by the first Critical Rule Curve or the Assured Refill Curve, whichever is higher. During the period 1 January through 31 July the Operating Rule Curve shall be defined by the higher of the first Critical Rule Curve or the Assured Refill Curve, unless the Variable Refill Curve is below the higher of the two above curves, then it

shall be defined by the Variable Refill Curve. In no case shall the Operating Rule Curve be higher than the Upper Rule Curve; it shall not be lower than the Limiting Rule Curve developed for such year (see Charts 3 and 4) during the period 1 January through 31 March. The Operating Rule Curve for the whole of Canadian storage is the summation, by months, of the usable storage corresponding to the Operating Rule Curve indicated for each individual project.

f. Special Mica Operating Criteria

(1) In accordance with paragraph VII (3) of the Protocol, Canadian storage is operated to provide optimum generation in Canada and the United States. To accomplish this, the Mica project is operated to criteria developed annually in the Hydroelectric Operating Plans and Detailed Operating Plans. The operating criteria for Mica project typically consist of target end-of-month storage content, target outflows and modifications as a function of Arrow reservoir storage content, maximum outflows and minimum outflows.

The Mica operating criteria are designed to accomplish the following:

- (a) Increase the firm energy, secondary energy, and/or dependable capacity of the Mica and Canadian downstream projects.

- (b) Improve the monthly distribution of energy production on the Canadian system.

Chart 3

Illustration of Operating Rule Curve for a Reservoir

Chart 4

Illustration of Steps in Development of Operating Rule Curve

for 30-Year System Regulation Studies

(c) Maintain sufficient outflow to allow peaking at all times; and

(d) Provide for reservoir drawdown, including drawdown into non-Treaty storage, at times required by the Canadian system.

A sample set of Mica operating criteria is shown in Table 2.

(2) Mica operating criteria may require non-Treaty storage releases from Mica reservoir. When possible these releases will be held in Arrow reservoir and transferred back to Mica reservoir. This operation may cause additional losses to the United States if the Mica minimum release requirements prevent water from being transferred back to Mica prior to the time Arrow fills or reaches the Upper Rule Curve. Allowance for this possible loss is included as a reduction in Canadian Entitlement.

9. OPERATING RULES

Operating Rules, as outlined below, shall be developed and applied jointly by the Canadian and United States Entities to describe the operation of the system, including the Canadian storages, for optimum generation in accordance with Annex A, paragraph 7 or 8 of the Treaty, whichever applies (Optimum generation is defined by a series of system regulation studies and downstream benefit determinations, see Subsection 13c). These Operating Rules shall be observed in conducting the System Regulation Studies in Part III and Part IV and in actual operation.

Notwithstanding these Operating Rules, exchanges of capacity and energy may be substituted for releases from Canadian storage, if mutually agreed by the Entities as to quantities, timing and method, and energy acquired by United States Systems from sources outside the Pacific Northwest Coordinated System may be used in lieu of energy otherwise produced by proportionate draft of such system reservoirs.

a. Operating Constraints

Constraints to be considered include:

(1) Maximum rate of storage draft and refill.

(2) Maximum and minimum flows.

(3) Maximum and minimum reservoir elevations.

(4) Flood control criteria.

(5) At site nonpower requirements.

TABLE 2

Sample of Mica Operating Criteria

(6) Maximum powerhouse capacity at storage reservoirs.

b. Operation Above the Operating Rule Curve

The whole of the Canadian storage shall be drafted to its Operating Rule Curve as required to produce optimum generation.

c. Proportional Draft Below the Operating Rule Curve

(1) The whole of the Canadian storage shall be drafted below its Operating Rule

Curve as required to produce optimum generation to the extent that a System Regulation Study determines that proportional draft below the Operating Rule Curves/Energy Content Curves is required to produce the hydro firm energy load carrying capability of the United States system as determined by the applicable Critical Period Regulation Study. Energy Content Curves for United States reservoirs are equivalent to the Operating Rule Curves.

(2) When the conditions of paragraph c(1) above are met, the whole of the Canadian storage and all reservoirs in the United States system shall be drafted proportionately between their respective Operating Rule Curves or Energy Content 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 proportionate draft shall be made between their first and second Critical Rule Curves, their second and third Critical Rule Curves, etc. When it is necessary to operate the whole of the Canadian storage and the United States reservoirs below their lowest Critical Rule Curves, they shall be operated proportionately between their lowest Critical Rule Curves and their normal minimum contents. If the storage content for any reservoir is equal to or lower than the Critical Rule Curve to which the system is being proportionately drafted, such reservoir shall not participate in proportionate draft until the system proportionate draft exceeds such Operating Rule Curve or Energy Content Curve for such reservoir. It shall then participate in the additional system draft.

(3) In the studies, proportionality between rule curves shall be computed in terms of storage.

(4) In actual operations, proportionate draft between Critical Rule Curves for the whole of Canadian storage and United States reservoirs shall be computed in terms of elevation and shall be determined as set out in Subsection 24c.

PART III - ASSURED OPERATING PLAN AND DOWNSTREAM BENEFIT COMPUTATION

10. OBJECTIVES AND USE OF ASSURED OPERATING PLANS

An Assured Operating Plan shall be prepared each year for the sixth succeeding year of operation. This requirement will provide that an Assured Operating Plan will always be available for five complete operating years. An operating year, as used herein, shall mean the period 1 August through 31 July. The

plan will establish the generation potential of both systems, prescribe operating criteria and procedures to insure that the potential will be realized, and will serve as a basis for the Detailed Operating Plan. It is intended that the Assured Operating Plan will also provide the Entities with essential information for effective operational planning of their respective power systems which are dependent on or coordinated with the operation of Canadian storage.

The Assured Operating Plan shall reflect the requirements included in the Treaty, its annexes, and related documents. The studies necessary to develop the plan shall be undertaken by the Entities jointly.

11. OBJECTIVES AND USE OF THE DOWNSTREAM BENEFIT COMPUTATIONS

Downstream Benefit Computations shall be prepared annually in accordance with Annex A, paragraph 7 and Annex B of the Treaty, paragraphs VIII, IX and X of the Protocol; and as detailed in Section 18. They shall be prepared in conjunction with the Assured Operating Plan, as outlined in Section 13, and shall define the downstream power benefits in the United States from Canadian storage five years in advance for each year in which the Treaty is in force. As indicated in Section 13 below, they shall also serve to define the limit to which Canadian storage may be reregulated to Canadian advantage so as to develop optimum power generation in Canada and the United States.

12. DATA REQUIREMENTS

Prior to March of each year the Entities shall exchange information and data for the systems in the two countries not previously exchanged and which are necessary for development of the Assured Operating Plan. The information and data to be exchanged shall include: schedules for initial operation of power generating and storage facilities, peak and energy load data, adjustments to project modified flows for the 30 historical years beginning with 1 August 1928, reservoir capacity, conversion factors and peaking capacities throughout the operating range, constraints, minimum flow limitations, limitations including flood control criteria, maintenance or construction schedules, and any other data necessary to establish the required operating plans.

13. GENERAL PROCEDURES FOR DEVELOPING THE ASSURED OPERATING PLAN AND DOWNSTREAM POWER BENEFIT STUDIES

a. Introduction - Because the Assured Operating Plan and the Downstream Benefit Power Computation are mutually dependent, their development

is accomplished concurrently. Each step of the procedure, as outlined below, evolved from experience for ease and efficiency of deriving the operating plan. It assumes that generating facilities exist at Mica Dam and downstream thereof, and that the plans must be 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". (Reference: Annex A, paragraph 7 of the Treaty.)

b. Step I, II, III Systems - In determining, for each year, the increase in dependable hydroelectric capacity and the increase in average annual hydroelectric energy, 30-year system regulation studies shall be made as follows.

Step I: These studies will establish the plant installation of the United States system required to serve the "load of the Pacific Northwest Area", in accordance with Section 18. These studies are also used to determine whether the proposed operating rules are optimum in both countries, in accordance with Subsection 14c.

Step II: These studies will determine the critical period energy capability and the average annual usable hydro energy capability of the system using the same thermal installation as the Step I studies; the United States base system, with the same hydro plant installation as in Step I; and the Canadian storage.

Step III: These studies will determine the critical period energy capability and the average annual usable hydro energy capability of the system using the same thermal installation as in the Step I studies and the United States base system, with the same hydro plant installation as in Step I.

c. Optimum Power Generation - In accordance with Annex A, paragraph 7 of the Treaty and paragraph VII (3) of the Protocol to the Treaty, optimum power generation in both Canada and the United States is achieved in the Assured Operating Plan through analysis of the following modes of Canadian storage operation.

(1) Canadian storage in the Annex B, Step I system is initially operated for optimum generation in the United States which maximizes the firm energy capability in the United States system. Three quantities are then computed for both the Canadian and United States systems:

(a) firm energy capability;

(b) dependable peak capability; and

(c) average annual usable secondary energy capability.

(2) The Canadian storage operation in (1) is then modified to achieve a weighted sum for Canada and the United States of the three quantities listed in (1) that is greater than the weighted sum achieved under operation for optimum generation in the United States alone.

(3) When an operation in (2) is achieved such that the weighted firm energy, dependable peak, and average annual usable secondary energy capabilities are maximized, the mode of Canadian storage operation is entered into a Downstream Benefit Computation (Annex B of the Treaty, Step II and Step III systems) to determine:

(a) the resulting downstream benefits; and

(b) whether the loss of downstream benefits to the United States are within the allowable limits.

If the loss in downstream benefits exceeds the allowable limits described in Subsection 15c, the modified operation of Canadian storage in (2) above must be revised so that the downstream benefits are within the limits. In order to select the optimum system operation from the studies in (1) and (2) above, the sum of the gains or losses in firm energy, dependable peak and average annual secondary energy capability that is usable in each system must be defined by the respective Entities. A relative value of each of the three quantities shall be assigned for the purpose of establishing a common measure of the gains or losses.

d. Operating Procedures and Constraints - The U.S. Base System Projects and all other main stem Columbia River hydro projects shall be operated for optimum power and flood control operation within established project operating procedures as required by the Treaty and Protocol (See Section 9).

The same project operating procedures and constraints shall be used in all Assured Operating Plan and Determination of Downstream Power Benefit studies, apart from changes required to account for different critical period lengths and different projects included in the studies.

Other changes and clarifications to project operating procedures include the following:

(1) The secondary energy market limit used in the Assured Operating Plan Step I

30-year system regulation study to guide storage operation above the operating rule curves shall be determined in a manner similar to established Pacific Northwest Coordination Agreement procedures, including those adjustments required by firm energy shifting. The secondary energy market limit used in the Step I study shall also be used in the Step II and Step III studies, except for differences required by firm energy shifting.

(2) The operation of Kootenay Lake in the Step I, II and III studies shall be consistent and follow the International Joint Commission (IJC) rule curves and constraints, except that the lake shall be drafted to the full amount of usable storage declared in Annex B at the end of the critical period in order to provide an optimum power operation.

(3) The established minimum flow requirements at Dworshak dam shall be used in the Assured Operating Plan Step I system regulation study.

(4) The Brownlee reservoir operation in the Assured Operating Plan Step I study shall be the current forecast of project operation used by the Idaho Power Company in the Pacific Northwest Coordination Agreement critical period planning and refill studies, except that the project shall be drafted empty at the end of the critical period in order to provide an optimum power operation for the Step I system. In the Step II and Step III studies Brownlee shall be operated as in Step I, except to the extent that the operation must be modified to allow refill prior to the start of the critical period and draft of total storage during the critical period of each study.

(5) Priest Lake shall be included in the Step II and III studies as a natural lake. It shall be regulated so as to model the effects of natural lake regulation on the inflows to downstream projects.

(6) The usable storage operating in the Step I study shall be the current best estimate of usable project storage. The usable storage operated in the Step II and Step III studies for U.S. Base System projects shall be the amounts listed in Annex B, except that Priest Lake may be included to the extent mentioned above.

e. Hydroregulation Studies - In order to assess the quantities defined in Subsection 13c(1), a number of system regulation studies are required. These studies are described in the following sections.

(1) Critical Period System Regulation Studies: The Critical Period Regulation Study shall be adopted to form a basis for the Critical Rule Curves, which are developed from a hindsight evaluation of the critical period. The Critical Period Study is normally incorporated into a 30-year study which operates the system identically during the water years applicable to the Critical Period; the Rule Curves developed also guide storage use in other periods when they govern the Operating Rule Curve. The critical period itself is the most adverse flow sequence of the historical period of streamflows and the one which produces the least amount of firm energy load-carrying capability for the system. The critical period can be of varying length depending on the number of storage reservoirs in the system, the schedule of incoming resources, and the shape of the system load.

This system regulation study shall be prepared in accordance with established utility practice. The regulation shall assume:

(a) Each reservoir shall be at its normal top elevation or filled to the extent feasible at the beginning of the critical period, and shall be drafted to its normal bottom elevation or to the extent feasible by the end of the critical period.

(b) The system shall be regulated with the intent to maximize critical period energy, consistent with the de-maximization limits provided for in the downstream benefit computations.

(c) When other authorized reservoir uses limit release of storage water in the critical period, such regulation shall be based on the maximum storage use consistent with the limitations.

(d) The output at any project shall not exceed an 85 percent plant factor in any period, unless a higher plant factor is necessary to make all storage water usable during the critical period.

(e) In multiple-year critical periods, no reservoir shall be drafted by any 1 April below the elevations determined by its Assured Refill Curve, unless all reservoirs have been drafted to such elevations and additional draft is required to meet the firm load of the system.

(2) 30-Year System Regulation Studies: 30-Year System Regulation Studies shall be made for each operating year using the appropriate Operating Rule Curve and Operating Rules described in Part II. It is intended that the Operating Rule Curve and associated operating criteria, including the Critical Rule Curves, be designed to regulate the system for the entire 30 years sequentially, without the benefit of historical hindsight. Failure of the system to operate in accordance with the refill principle set forth in Subsection 8b(2)(c) shall require that the Operating Rules or the Operating Rule Curve, including its component parts, be modified to eliminate such failures.

f. Unregulated Streamflows - The unregulated streamflows used in the Assured Operating Plan and Determination of Downstream Power Benefits studies shall be based on the 30 years of streamflows, August 1928 to July 1958, contained in the Extension of Modified Flows report named in Protocol paragraph VIII, with updates for current best estimates of irrigation depletions and return flows, and corrections for errors and omitted projects.

The unregulated streamflows used in the Step I study shall be used in the Step II and Step III studies, except for adjustments needed to reflect different upstream storage projects, e.g. Libby, and Canadian Treaty Projects.

g. Step I Firm Load - The load to be served by the Step I system of Annex B, paragraph 7, shall be:

(1) The load of the Pacific Northwest Area; including the power required for pumping water into Banks Lake from Grand Coulee reservoir; and

(2) All flows of firm power out of the Pacific Northwest Area, except plant sales which are those flows of power from a generating facility located in the Pacific Northwest Area sold to serve loads outside the Pacific Northwest Area;

Reduced by:

(3) The load served by all flows of firm power into the Pacific Northwest Area, except power from Thermal Installations referred to in Annex B, paragraph 7;

(4) The load served by those hydro and non-thermal generating resources that are located in the Pacific Northwest Area and that are not included in the Step I

system; and

(5) Any conservation added to balance loads and resources pursuant to paragraph i below.

h. Surplus Firm Energy - Step I system firm energy capability in excess of the Step I system firm load shall be used to serve loads outside the Pacific Northwest Area. This surplus firm energy capability may be shaped seasonally similar to the load that it is expected to serve.

i. Added Resources - Any initial Step I system firm energy capability less than the Step I system load shall be balanced by adding feasible resources and/or conservation consistent with current Pacific Northwest Area resource acquisition plans.

j. Step I Resources - The resources included in the Step I system shall include:

(1) The U.S. Base System hydro projects;

(2) All other storage projects upstream of Bonneville Dam, and U.S. hydroelectric projects upstream of Bonneville Dam; and

(3) The Thermal Installations that will be used to meet the Step I system loads.

The Step II and Step III system resources shall be the U.S. Base System hydro projects and the Thermal Installations included in the Step I system.

k. Thermal Installations - Thermal Installations, referred to in Annex B, paragraph 7, shall include the current best estimate for thermal power that will be used to meet the Step I system load, regardless of the location of the thermal power plants which generate the thermal power.

l. Exchanges of Firm Power - Contractual exchanges of firm power with other regions which neither increase nor decrease the net flow of power between the Pacific Northwest Area and other regions shall be treated as follows:

(1) Flows of power into the Pacific Northwest Area shall not be included as part of the Thermal Installations as described in Annex B, paragraph 7; and

(2) Flows of power out of the Pacific Northwest Area shall not be included as part of the thermal power used outside the Pacific Northwest Area, pursuant to Subsection 18b.

m. Loads for Step II and Step III Studies - The load shape used in the Step II and Step III studies shall have the same monthly firm energy load shape as the firm energy loads in the Pacific Northwest Area. The residual load in the Step II and Step III studies which must be met by the hydro system shall include the effect of the varying monthly generation from the Thermal Installations.

The loads for Step II and Step III studies shall be taken as equal to the energy capabilities of the systems and shall be determined as follows:

(1) Estimate the average hydro energy capabilities for the critical periods of the Step II and Step III systems;

(2) Add the thermal energy capability to each of the capabilities of (1) above to obtain a total average critical period energy capability for the Step II and Step III systems;

(3) Multiply the totals obtained in (2) above by the ratio

area average annual firm energy load

area average critical period firm load

to obtain the average annual firm energy loads for the Step II and Step III systems;

(4) Prorate the average annual firm energy loads determined in (3) in the ratio

Step I monthly area firm energy load

Step I annual area firm energy load

to obtain a monthly firm energy load for Step II and Step III systems; and

(5) Subtract the monthly thermal energy capability to determine the monthly firm hydro energy loads of Step II and Step III systems.

The average annual hydro energy loads for Step II and Step III systems also become the firm energy considered usable according to Annex B, paragraph 3(a) of the Treaty.

14. DEVELOPMENT OF THE ASSURED OPERATING PLAN

a. A total of seven studies are required to complete the Assured Operating Plan and downstream power benefit studies. The basic assumptions for these studies and their basic purpose is shown in Table 3. This table assumes that the Assured Operating Plan is being developed in accordance with Annex A, paragraph 7 of the Treaty. In the event that the plan is to be developed for optimum generation in either country, a similar schedule of studies to be performed shall be developed to insure compliance with the provisions of Annex A, paragraph 8 of the Treaty.

b. YR -11 Study

This is a detailed system regulation of the total United States power system less minor resources with the Canadian storage operated to provide optimum power generation in the United States. Optimum power generation is achieved by maximizing the firm energy capability of the United States system in a manner consistent with the Pacific Northwest Coordination Agreement.

Both the United States and Canadian systems' firm energy, secondary energy and dependable capacity are then summed per Subsection 13c.

c. YR-41 Study

The study objective is to modify the operation of Canadian storage in the YR-11 Study to achieve optimum generation in both countries as indicated in Subsection 13c. The Mica project is operated to fixed rules similar to those outlined in Subsection 8f. Arrow storage

operation is modified when possible to compensate for the changes in flows at the international boundary caused by the change in Mica operation. Because Arrow storage may not fully mitigate these changes there may be a net loss in the United States system relative to the United States optimum YR-11 Study.

U.S. and Canadian Operating Rule Curves and Critical Rule Curves used in the YR-41 and YR-42 Studies shall be changed from those used in YR-11 and YR-12 Studies only to the extent that U.S. reservoirs are required to balance Canadian Storage re-operation.

Generally, losses to the United States system result from the following conditions:

(1) Water is trapped in Mica, and Arrow is empty or at maximum discharge capability, resulting in a decrease of water being released from Canadian storage in a given period compared to that indicated in the United States optimum study. The deficit must then be compensated by United States reservoirs.

(2) Additional water is released from Mica in a given period, Arrow storage is full or governed by flood control requirements and, therefore, unable to hold the additional water. Water is thus released at a time not required in the United States.

TABLE 3

SUMMARY OF ASSURED OPERATING PLAN SYSTEM REGULATION STUDIES

<u>Study Designation</u>	<u>Annex B Step No.</u>	<u>Study System</u>	<u>Study Purpose</u>
YR-11	I	Canada=15.15 maf US = All Columbia reservoirs and run-of-river projects Step I Load	Establishes operation of real system operated for optimum power in U.S.; determines Step I load and thermal; compared to YR-41 Study to insure total generation capabilities increase due to optimization in both countries.

		Step I Thermal	
YR-12	II	Canada= 15.5 maf U.S.= Base System Step I Load Shape Step I Thermal	Computation of Downstream Power Benefits (DPB) for optimum operation in U.S. Compared to YR-42 Study to determine payment required by Canadian Entitlement Purchase Agreement (CEPA)
YR-13	III	Canada= None U.S.= Base System Step I Load Shape Step I Thermal	Base case for all DPB computations. Uses no Canadian storage and operates U.S. Base system for optimum power operation in U.S.
YR-22	II	Canada= 15.0 maf U.S.= Base System Step I Load Shape Step I Thermal	Used for computation of allowable annual reduction in DPB's. Uses 0.5 maf less Canadian storage operated for optimum power operation in U.S.
YR-32	II	Canada= 12.5 maf U.S.= Base System Step I Load Shape Step I Thermal	Used for computation of maximum total permitted reduction in DPB's. Uses 3 maf less Canadian storage operated for optimum power operation in U.S.
YR-41	I	Canada= 15.5 maf U.S.= All Columbia Hydro Projects Step I Load Step I Thermal	Final adopted operation for Assured Operating Plan from optimum power operation for power in both countries. Must increase total generation capabilities in both countries compared to YR-11 Study
YR-42	II	Canada= 15.5 maf U.S.= Base System Step I Load Shape Step I Thermal	Final computation of DPB; establishes payment required by CEPA for reduction in DSB due to optimum power operation in both countries when compared to YR-12 Study

Notes: 1. YR denotes study year, e.g. 95-11 is the YR-11 Study for operating year 1 August 1994 to 31 July 1995.

2. U.S. Base System is defined in Annex B, Base System Table.

(3) Minimum release requirements at Mica project prevent Kinbasket Lake from refilling when all other projects in the basin refill. This may result in increased spill at downstream projects in the United States, reduction in usable surplus or reduction in firm energy capability for the next operating year.

These expected real losses to the United States system must be at least equaled by increases in the Canadian system in order for the modified Canadian system operation to be allowable. When this condition and the condition described in Subsection 15c below are satisfied, the YR-41 Study shall form the basis for the Assured Operating Plan.

15. DEVELOPMENT OF THE DOWNSTREAM POWER BENEFIT STUDIES

a. Five downstream power benefit studies are required coincidentally with the Step I studies prepared for the Assured Operating Plan. The downstream power benefit studies contain the United States base system as defined in Annex B, Base System Table, and where applicable, Canadian storage.

b. The YR-13 Study (Step III) includes the United States base system only, with generation optimized for the United States (see Table 3). The YR-12, YR-22, YR-32, and YR-42 (Step II) Studies include Canadian storage in the first-added position to the base system. Generation is optimized for the United States in the YR-12, YR-22, and YR-32 Studies, and in both countries in the YR-42 Study. The differences in capacity and energy derived from the Step II and Step III studies provide the computed downstream benefits for the year and are used to compute the limits to which Canadian storage may be reregulated to achieve optimum generation in both countries. These studies are based on the same regulation criteria used in the applicable Step I study. Special operating rules for Mica project which are developed for the Assured Operating Plan are recognized in the YR-42 Study and are identical to those used in the YR-41 Study. The differences in capacity and energy derived from the YR-42 and YR-13 Studies provide the computed downstream power benefits for the year.

c. From the studies listed above, the minimum permitted downstream power benefits shall be the higher of the two following conditions.

(1) The downstream power benefits associated with 12.5 million acre-feet (maf) of Canadian storage in any year, which is derived from the YR-32 and YR-13 Studies for the year under study; or

(2) The downstream power benefits associated with the preceding year's benefits reduced by the effect of withdrawing 0.5 maf of Canadian storage in addition to natural reductions caused by irrigation depletions and system growth.

Condition 1 defines the benefits of 12.5 maf of Canadian storage operated for optimum generation in the United States compared to the United States base system operating alone. Condition 1 has not controlled the minimum permitted benefits through 1996, hence the YR-32 Study has not been performed each year.

Condition 2 is defined by the following.

$$DSB_{\text{minimum}} = X + (Y_c - Y) - (Y_c - Z)$$

$$= X - Y + Z$$

$$= X - (Y - Z)$$

where:

X is the previous year's downstream power benefits which is derived from the YR-42 Study operated for optimum generation in both countries and the YR-13 Study; and

Y is derived from the previous year's YR-12 and YR-13 Studies, both operated for optimum generation in the United States; and

Y_c is derived from the current year's YR-12 and YR-13 Studies, both operated for optimum generation in the United States; and

Z is derived from the current year's YR-22 Study (15 maf) and the YR-13 Study, both operated for optimum generation in the United States.

The computation above recognizes that in addition to the allowable decrease equivalent to the withholding of 0.5 maf of Canadian storage, there is a normal decrease (or increase) from year-to-year due to irrigation depletions and resource changes in the United States base system. Such increase/decrease is the difference between the benefits derived from the previous year's YR-12 and YR-13 Studies, and the current year's YR-12 and YR-13 Studies ($Y_c - Y$).

The differences in capacity and energy derived from the YR-42 and YR-13 Studies shall provide the computed downstream power benefits for the year. The resulting benefits shall not be less than the greater of the two minimum permitted benefits calculated above. If this condition and the condition described in Subsection 14c are met, then the YR-41 Study shall be the basis for the Assured Operating Plan for the year under study.

d. The compensation due to Columbia Storage Power Exchange with respect to reduction of the Canadian Entitlement, in accordance with Section 7 of the Canadian Entitlement Purchase Agreement, is half the differences between the computed downstream power benefits derived from the YR-12 and YR-13 Studies, i.e. Y_c , and the computed downstream power benefits derived from the YR-42 and YR-13 Studies.

16. FIRM ENERGY SHIFTING

Shifting of firm energy between years of the critical period may be included in the Assured Operating Plan and Determination of Downstream Power Benefits studies in the following manner.

a. When the U.S. Entity determines that shifting will produce optimum power in the U.S., the Entities shall conduct additional studies that determine the changes to the Assured Operating Plan and Determination of Downstream Power Benefits that would occur if shifted firm energy had not been included.

The purpose of these studies is:

(1) to provide a non-shifted firm energy operating plan that the U.S. Entity may elect to implement in the Detailed Operating Plan, and

(2) to define the incremental change in the downstream power benefits due to the

inclusion of shifted firm energy.

b. If the U.S. Entity does not determine that shifting may produce optimum power in the U.S. at the time of preparation of the Assured Operating Plan, the Entities may prepare additional studies that determine the changes to the Assured Operating Plan and Determination of Downstream Power Benefits that would occur if shifted energy had been included. The purpose of these studies is:

(1) to provide a shifted firm energy operating plan that the Entities may elect to implement in the Detailed Operating Plan, and

(2) to define the incremental change in downstream benefits due to the inclusion of shifted firm energy.

c. If shifted firm energy is included in either the Assured Operating Plan or the Detailed Operating Plan, the downstream power benefits to which Canada is entitled shall be those which include the effect of shifting. If firm energy shifting is included in the Assured Operating Plan or Detailed Operating Plan during the period in which any portion of the Canadian Entitlement has been sold pursuant to the Canadian Entitlement Purchase Agreement, the U.S. Entity shall deliver to the Canadian Entity an amount of power equal to any increase in the purchased portion of the Canadian Entitlement due to the inclusion of firm energy shifting.

d. Assured Operating Plan and Determination of Downstream Power Benefits studies that include shifted energy shall be similar to other Assured Operating Plan and Determination of Downstream Power Benefits studies. The Step I study firm energy load carrying capability may be increased in the first year of the critical period by shifting energy capability uniformly from latter years of the critical period, if:

(1) the rate of return energy in the latter years of the critical period can be served by a critical period surplus firm energy, or a backup thermal resource, or a firm load reduction, and

(2) the amount of energy shifting does not cause the Canadian reservoirs to draft more than the following amounts at the end of the first year of the Step I critical period (31 July 1929).

Mica 700 ksf

Arrow 300 ksf

Duncan 143 ksf

e. The shifted firm energy shall be used either to meet Pacific Northwest Area firm loads or to increase the initial firm surplus. During the 30-year system regulation studies the surplus firm energy shall be shifted into water years that begin on August 1st with the reservoir system energy content at or above a point half-way between full and the first critical rule curve for 31 July. Shifted firm energy shall be returned at uniform monthly rates in all water years that begin with the reservoir system energy content below that point.

f. Any firm energy shifted in the Step I study shall also be shifted in the Step II study by using the same rate of return energy in both studies. The rate of return of shifted firm energy in the Step I study shall determine the amount of shifting used in the first year of the critical period of the Step II study. The increased firm load in the first year of the Step II critical period study shall be shaped similar to the Pacific Northwest Area load. The Step III study does not have shifted energy because the critical period is less than one year in length.

The Step II 30-year system regulation study shall raise and lower the firm load using the same criteria as the Step I study. If a backup thermal resource is included to meet loads in latter years of the Step I critical period when shifted energy is returned, it shall be included in the determination of displaceable thermal resources for the Step II study.

17. CONTENT OF THE ASSURED OPERATING PLAN

The following items used in or developed from the 30-Year System Regulation Study adopted in Sections 13 and 14, for each of the operating years, shall form the Assured Operating Plan for the Canadian storages for the particular operating year concerned. It shall be compiled by the Entities by 1 September of each year and shall contain the following.

a. The Critical Rule Curves in terms of end-of-month storage content for each Treaty project and for the whole of the Canadian storage. The Critical Rule Curves shall be composed of the tabulated storage contents for the water years which are included in the Critical Period System Regulation Study for the particular operating year.

b. Assured Refill Curves and Variable Refill Curves in terms of end-of-month storage content for each Canadian Treaty storage project for the period 1928 to 1958. These project

curves are used in development of curves for the whole of Canadian Storage

c. Upper Rule Curves for Duncan, Keenleyside and Mica projects, in terms of end-of-month storage content for the period 1928 to 1958.

d. The Operating Rule Curve, in terms of end-of-month storage content for the whole of Canadian storage for the period 1928 to 1958.

e. The procedures for development of Variable Refill Curves.

f. Operating Rules, including special Mica Project Operating Criteria, such as maximum/minimum outflows, target end-of-month storage contents, and target flows as a function of Arrow reservoir storage contents.

g. Text, as required to supplement the tables in 17a through 17d above, including amplifying comments regarding operating rules, constraints, loads, resources, construction requirements, or other pertinent data unique to the operating year.

An implementation section consistent with Article XIV2(k) of the Treaty shall also be included.

18. METHOD OF DETERMINING DOWNSTREAM POWER BENEFITS

The determination of the downstream power benefits and Canadian Entitlement shall be based on the following procedures.

a. The priority of use of energy in the Step II and Step III studies shall be in the order as listed in Annex B, paragraph 3 of the Treaty.

b. The thermal displacement market used in the computation of "average annual usable energy" is the displaceable portion of generation from the Step I Thermal Installations that are used to meet the Pacific Northwest Area firm load. The amount of thermal displacement market is defined by the following equation:

$$TD(m) = TI(m) - MG(m) - SS$$

Where:

TD(m) = The monthly thermal displacement market (only valid for positive numbers), and

TI(m) = The monthly generation from the Thermal Installations in the Step I, Step II and Step III systems, and

MG(m) = The monthly sum of the minimum amount of generation required from each Thermal Installation, as declared by the project operating agency or required by the minimum purchase provisions of a contract for a thermal resource, and

SS = The annual average amount of System Sales, prorated by month to give a uniform rate of delivery throughout the year.

System sales are those flows of firm power out of the Pacific Northwest Area, excluding:

- (1) flows of power from exchanges of firm power pursuant to Subsection 131,
- (2) plant sales,
- (3) flow through transfers of power from outside the Pacific Northwest Area to outside the Pacific Northwest Area, and
- (4) delivery of the Canadian Entitlement out of the Pacific Northwest Area.

c. The Canadian Entitlement to downstream power benefits for any operating year, in accordance with paragraph 1 of Article V of the Treaty, shall be one-half of the dependable hydroelectric capacity benefit and one-half the average annual usable hydroelectric energy determined, in accordance with (1) and (2) below.

(1) Dependable Hydroelectric Capacity Benefit: The capacity benefit from Canadian storage shall be the difference between the average rates of generation during the critical periods of the Step II and Step III hydro systems 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.

(2) Average Annual Usable Hydroelectric Energy Benefits: The energy benefit from Canadian storage shall be the difference in the average annual usable energy of the Step II and Step III systems computed for the system of each step as the sum of:

(a) The firm hydro energy, plus

(b) The energy which can be used in the thermal displacement market, plus

(c) Forty (40) percent of the energy remaining.

d. The operating year, 1 August through 31 July, is the period for which downstream power benefits will be determined. During the period of the Canadian Entitlement Purchase Agreement, the Canadian Entitlement to downstream power benefits shall begin on 1 April prior to the 1 August commencement of the operating year for which the determination has been made and shall end on the following 31 March.

19. CONTENT OF THE DOWNSTREAM POWER BENEFIT DOCUMENT

The Downstream Power Benefit Document shall include the following information (refer to Tables 4, 5, and 6, and Chart 5).

a. The Canadian Entitlement, which is one-half the total computed downstream power benefits for the Assured Operating Plan studies adopted.

b. One-half the minimum permitted downstream power benefits, as indicated by Subsection 15c.

c. Effect on the Canadian Entitlement Purchase Agreement which is the difference between paragraph 19a above, and one-half the downstream power benefits which would have been computed if the Assured Operating Plan had been designed to achieve optimum generation downstream in the United States alone.

d. Tables and charts as follows:

(1) Computation of Canadian Entitlement;

(2) Summary of Power Regulations;

(3) Determination of Loads for Steps I, II, and III;

(4) Determination of Displaceable Thermal Market; and

(5) Secondary Energy Duration Curves for Steps II and III.

TABLE 4

Computation of the Canadian Entitlement

TABLE 5

**Summary of Power Regulations for the Computations of
Canadian Entitlement to Downstream Power Benefits**

TABLE 6

**Determination of Load Shape for Step II and Step III
Canadian Entitlement to Downstream Power Benefits**

CHART 5

Duration Curve of Secondary Energy for a Reservoir

PART IV - DETAILED OPERATING PLAN

20. GENERAL

Each year a Detailed Operating Plan shall be developed for each of the Canadian storage reservoirs and the whole of the Canadian storage, and for the Libby reservoir. The Detailed Operating Plan shall be developed, as described below, from the Assured Operating Plan previously agreed to for that operating year. Planning for the Detailed Operating Plan shall begin in January for the August through July operating year immediately following, and the plan shall be completed by September 1. In general, all system regulation studies necessary for the formulation of the Detailed Operating Plan shall be done by the U.S. Entity in consultation with the Canadian Entity.

21. REVIEW OF ASSURED OPERATING PLAN

a. The Canadian and United States Entities shall review the Assured Operating Plan applicable to the immediately ensuing operating year. Changes in system load estimates, energy shifting assumptions, resources, duration of the critical period, flood control criteria, irrigation depletions, nonpower requirements, and any other pertinent data shall be considered in this review using the latest available data in comparison with that used in the original study. If the Entities agree that these changes warrant further investigation, joint studies analyzing the impacts of implementing the changed data with Critical Period Rule Curves from the Assured Operating Plan, the Alternative Operating Plan, or other operating criteria shall be made.

b. The Entities shall agree prior to 1 February on the need for revised Critical Period Rule Curves and operating criteria for Canadian reservoirs or to use the Critical Period Regulation from the Assured Operating Plan or the Alternative Operating Plan as the basis for the Preliminary Critical Period Regulation Study. If the necessity for revised Critical Period Rule Curves and operating criteria for Canadian reservoirs cannot be agreed upon, the Detailed Operating Plan shall be based on Critical Period System Regulation from the Assured Operating Plan, or if the Assured Operating Plan was prepared in accordance with Subsection 16a, at the option of the U.S. Entity, the Alternative Operating Plan.

22. SYSTEM REGULATION STUDIES

If new Operating Rule Curves or operating rules are to be developed for the Detailed Operating Plan, they shall be developed from a load-growth type regulation study. In this case, the estimated loads and scheduled resources shall be accounted for during the entire length of the Critical Period.

a. Preliminary Critical Period Regulation: A Preliminary Regulation shall be made using the latest data and the critical period rule curves and operating criteria for Canadian storage defined in Subsection 21b. The Entities may agree to analyze other Critical Period System Regulation Studies including operating criteria from the Assured Operating Plan, Alternative Operating Plan, or other changes to the Canadian operating criteria. In addition, 30-Year System Regulation Studies may be made as desired by the Entities to evaluate all effects of the changes in the operating plan.

b. Modified Critical Period Regulation: Prior to 1 April, the Entities shall agree on any modifications to the regulation of Canadian storage which may be mutually desirable, or which may be desirable to one Entity and is acceptable to the other Entity.

c. Final Critical Period System Regulation: Further changes to the Critical Period System Regulation may be made after 1 April, provided that: (1) such changes are made pursuant to existing contracts in the United States; and (2) changes to Canadian reservoirs are made only with both Entities agreement. Using the regulation of Canadian storage, as agreed to or as modified within limits agreed in this paragraph and Subsections 22a and 22b, a Final Critical Period System Regulation shall be made by the United States Entity by 1 July. The Critical Rule Curves and related operating criteria developed from the final study will then provide the operating guides for Canadian storage and Libby until the completion of the term of the Detailed Operating Plan.

d. Refill Studies: Using the Critical Rule Curves developed in the Final Critical Period Regulation, 30 separate 1-year System Regulation Studies, beginning with August 1928 flows, shall be made by the Entities to insure the adequacy of the operating guidelines and criteria, in accordance with the principles set forth in Subsection 8b. The Operating Rule Curve and its components shall be changed, if necessary, to comply with the principles set forth in Subsection 8b. These studies shall be completed by 1 September.

23. CONTENT OF DETAILED OPERATING PLAN

The Detailed Operating Plan shall consist of the data and criteria listed below. It shall be compiled by the Entities by 1 October.

a. Distribution of usable Canadian storage space available for power and flood control purposes.

b. Definition of the Operating Rule Curve.

c. Guidelines for the anticipated means of implementing the Detailed Operating Plan.

d. Definition of operating rules and project operating limits.

e. Critical Rule Curves for each of the Canadian reservoirs and for the whole of the Canadian storage tabulated in terms of end-of-month storage contents. The first Critical Rule Curve data shall be taken from the Final Critical Period Regulation study described in Subsection 22c. In addition, Critical Rule Curves from previous Detailed Operating Plan Final Critical Period Regulation studies that are applicable to the operating year shall be tabulated herein and identified as second, third, etc., on the basis of their time sequence (see

Chart 6).

f. Assured Refill Curves for each of the Canadian reservoirs tabulated in terms of month-end storage contents. These data are to be those finally agreed upon, as described in Subsection 22d.

g. Procedure for determining the Variable Refill Curves for each of the Canadian reservoirs.

h. Procedure for determining the Flood Control Refill Curves for each of the Canadian reservoirs, if required.

i. Storage-elevation tables for Keenleyside, Mica, Duncan and Libby projects.

j. Any additional supplementary text or tables required to limit or clarify the intended operation of the system which would be unique to the operating year for which the plan is devised.

k. Special Mica project rules and operating criteria.

l. Critical Rule Curves, Energy Content Curves and pertinent operating criteria for Libby project.

m. The amount and procedures for delivery of any power by the U.S. Entity to the Canadian Entity required by Subsection 16c, and for delivery of any power by the Canadian Entity to the U.S. Entity of any power required by Subsection 15d.

24. IMPLEMENTATION

Actual operation of the Canadian storage shall be guided by the Detailed Operating Plan and by any other operating arrangements that may be worked out by the operating or scheduling personnel. These detailed operating arrangements shall be made in accordance with established utility and water management practices. The Entities shall exchange all current operating data necessary for continuing review of system operations.

a. Scheduling Operation of Canadian Storage

Requests by the United States Entity for storage operation shall be directed to the whole of the Canadian storage consistent with the Operating Rule Curve and other operating criteria designed to provide optimum generation in accordance with Annex A, paragraphs 7 or 8 of

CHART 6

**Illustration of Selection of Critical Rule Curves for the
Detailed Operating Plan for Reservoir in a Multi-Year Critical Period**

the Treaty, whichever applies. Requests shall be made on a regular weekly basis, or as otherwise mutually agreed and shall be in terms of storage water delivered at the Canadian-United States border. In honoring such requests, the Canadian Entity shall operate Canadian storage consistent with optimum storage use. The Operating Rule Curves, or system proportionate draft point, or special operating criteria prepared for the individual Canadian reservoirs shall be used as a measure of any deviation from the optimum operation.

b. Operating Rule Curves

(1) During the period 1 August through 31 December the Operating Rule Curve for each Canadian reservoir shall be that indicated in Subsection 8e.

(2) During the period 1 January through 31 March, the Operating Rule Curve shall be that indicated for the period beginning 1 January in Subsection 8e, except that Variable Refill Curves shall be based on the actual 95 percent confidence volume inflow forecasts at-site and the most probable inflow forecast at The Dalles, Oregon, utilizing the same principles indicated in Subsection 8b. The Upper Rule Curve shall be based on the procedures set forth in the Flood Control Operating Plan.

(3) During the period 1 April through 31 July, the Operating Rule Curve shall be defined as the higher of the first Critical Rule Curve or the Assured Refill Curve unless the Flood Control Refill curve is below the higher of the above two curves. Then it is defined as the Flood Control Refill Curve. In addition, the Operating Rule Curve for this period shall not be higher than the Upper Rule

Curve, which is developed from day-by-day computer regulations of the system during the refill period consistent with flood control objectives and the most current forecasts of volume and distribution of flow. The Upper Rule Curve shall not be lower than the Flood Control Refill Curve, except when Treaty storage is operated for On-Call flood control storage.

(4) In the period 1 January through the end of the drawdown period, the Operating Rule Curve shall not be lower than the Limiting Rule Curve developed for such year.

(5) Flood Control Refill Curves are computed on a similar basis to the Variable Refill Curves, except that daily inflows into the reservoir are accounted for and deducted from the first of the month 95 percent confidence inflow forecast to determine the residual volume inflow. They represent the lower limit to which the project should normally be operated during the refill period to serve a secondary energy market. The power discharge requirements shall be the same as those computed for Variable Refill Curves. A sample form for making this computation is shown on Table 7.

TABLE 7

Reservoir Flood Control Refill Curve, Sample Computation

(6) During the course of an operating year, the Operating Rule Curve for the whole of the Canadian storage shall be continuously available as a guide to actual operations. Operation of the individual Canadian reservoirs to fulfill the United States Entity's requests shall be the responsibility of the Canadian Entity. Actual operation shall be guided by the Operating Rule Curve, as follows.

(a) Operation When the Whole of Canadian Storage is Above Operating Rule Curve

The whole of the Canadian storage shall be drafted to its Operating Rule Curve as required to produce optimum power generation subject to the stated operating rules and constraints in the Detailed Operating Plan.

(b) Operation When the Whole of Canadian Storage is On or Below Operating Rule Curve

Draft of the whole of Canadian storage below its Operating Rule Curve shall be in accordance with Subsections 9b, 9c, and 24c.

(c) Operation of the Whole of Canadian Storage Provisionally Below Operating Rule Curve

The Entities have agreed to principles for provisional draft of Canadian storage as an alternative method of implementing firm energy shifting that was included in the Assured Operating Plan or Alternative Operating Plan.

The Entities may agree to detailed procedures for provisional draft of Canadian storage based on the following principles.

(i) The arrangement shall produce advantages to each country compared to operating to the Assured Operating Plan Operating Rule Curve or to the modified Assured Operating Plan Operating Rule Curve agreed by the Entities in the Detailed Operating Plan.

(ii) The arrangement shall provide both Entities with the same assurance as provided by the Assured Operating Plan.

(iii) The arrangement shall specify limits on the provisional drafting of Canadian Treaty Storage.

(iv) Either Entity can request a provisional draft of Canadian Treaty storage, however, the other Entity would have the option of accepting up to 50 percent of the additional energy generated downstream in the

United States or some other agreed compensation. The liabilities incurred by provisional drafting including the provision of replacement energy or its equivalent, would be

shared by the Entities in proportion to the energy actually received by each.

c. System Proportionate Draft Between Critical Rule Curves

The system proportionate draft point shall be calculated at the beginning and end of each month, or weekly if required, by regulating the whole of Canadian storage and major United States reservoirs with a system regulation model to meet the system firm energy load carrying capability in accordance with the following conditions.

(1) The whole of Canadian storage shall be regulated as one reservoir with special cognizance of Subsection 8f, Special Mica Operating Criteria.

(2) The Entities shall utilize the system regulation model defined as the Actual Energy Regulation prepared by the Northwest Power Pool Coordinating Group. The Actual Energy Regulation shall recognize all agreed planned operating constraints from the Detailed Operating Plan and shall be based on the seasonal model that was used to develop the Detailed Operating Plan studies defined in Subsection 22d.

(3) Flows used in the Actual Energy Regulation shall be based on most probable inflow forecasts for each project for the months to be modeled. The operation of the reservoirs shall be constrained by actual operating limitations to reduce spill or other losses.

(4) The Actual Energy Regulation shall model operation of the system by drafting to the Operating Rule Curve (Energy Content Curve for United States reservoirs) or below that point if required to meet the system firm energy load carrying capability. Proportional draft below the Operating Rule Curve shall be determined according to Section 9 except that proportionality between rule curves (Subsection 9c2) shall be computed in terms of elevation.

Notwithstanding the operating rules as stated above, exchanges of capacity and energy may be substituted for releases from Canadian storage, if mutually agreed by the Entities as to quantities, timing and method, and energy acquired by United States systems from sources outside the Pacific Northwest Coordinated System may be used in lieu of energy otherwise produced by proportionate draft of such systems reservoirs.

d. Operation for Flood Control

The regulation of Canadian storage for system flood control requires that outflows be specified from individual projects on a daily basis during the spring runoff period. Such regulation shall be in effect during the Flood Control Refill Period. The Flood Control Operating Plan defines the Flood Control Refill Period and provides charts which are to be used for guidance of operation during this period. Project release shall be based on these charts, on volumetric runoff forecasts, and on daily computer regulations of streamflow and reservoir regulation to provide effective flood stage reduction of the Columbia River at The Dalles, Oregon, and at tributary control points. Occasionally, flood control regulation of Arrow project will be required during the winter period, as defined in the Flood Control Operating Plan. The regulation for system flood control shall be the responsibility of the North Pacific Division, Corps of Engineers.

e. Computation of Operating Parameters and Exchange of Pertinent Operating Data

From 1 January to the end of the refill period, computations related to the operating parameters of each Canadian reservoir shall be performed as follows:

(1) By the second working day of each month the Corps of Engineers shall issue a preliminary January through July natural volume runoff forecast for the Columbia River at The Dalles, Oregon. Such forecasts are issued only for the purpose of defining the power discharge requirement in computing Variable Refill Curves and Flood Control Refill Curves.

(2) By the seventh day of each month, through 7 June, the Canadian Section of the Operating Committee shall issue the volume forecasts for each Canadian reservoir, its computed end-of-month Variable Refill Curve, and corresponding Operating Rule Curve storage content. Variable Refill Curves shall be computed according to Subsection 8b(2).

(3) By the seventh day of each month, through 7 June, the Corps of Engineers shall issue the volume forecasts, Variable Refill Curve, and Operating Rule Curve end-of-month storage contents for Libby reservoir.

(4) Computation of Flood Control Refill Curves, Upper Rule Curves, and exchange of pertinent data for flood control purposes shall be accomplished in accordance with Section V and X of the Flood Control Operating Plan.

f. Delivery of Power and Energy

Prior to the Operating Year, the Entities shall agree on procedures for scheduling the delivery of the power required by Subsections 15d and 16c.

**PART V - PROCEDURE FOR CALCULATING HYDROELECTRIC POWER
LOSSES BY CANADA AS A RESULT OF OPERATING ON-CALL STORAGE**

25. CONSIDERATION FOR ON-CALL STORAGE

Consideration for the need for On-Call storage shall be initiated by the United States Section in consultation with the Canadian Section as soon after 1 January as conditions indicate that On-Call may be necessary. Results of these considerations shall be reported to the respective Entities, together with the assessment of the effects of the drawdown on the production of power. A formal call for On-Call storage space may be made by the United States Entity following the above consultation.

26. STUDIES REQUIRED UPON INITIATION OF ON-CALL REQUEST

Upon acceptance of a request for On-Call storage use by the Canadian Entity, the Operating Committee shall make a set of seven-month system studies for the period 1 January to 31 July of the current operating year in the following manner:

a. The studies shall be based on a selected set of streamflow conditions from the available hydrologic record in which the January through July volume at The Dalles, Oregon, was greater than or equal to the most probable January through July runoff volume forecast at The Dalles, Oregon, for the current operating year. If the forecast indicates a probable flood of unprecedented size, reasonable estimates of the natural flows that could be expected shall be used.

b. The system studies shall incorporate the rule curves, operating rules, etc., for Canadian

storage contained in the current Detailed Operating Plan adjusted for current conditions. The purpose of the studies is to estimate Mica and downstream Canadian projects' monthly outflows revised from those indicated in the Detailed Operating Plan for the remainder of the current operating year if On-Call storage were not requested.

c. The outflows used in the studies in Subsection 26b, shall not be less than those indicated in the Detailed Operating Plan.

d. If the On-Call storage request is accepted after 1 January, system studies shall be performed utilizing the most current conditions relating to initial reservoir elevations and outflows; the study period may then be shortened to less than seven months.

e. The studies above shall be completed in a timely manner so that United States liabilities for capacity and energy may be computed as indicated in Section 27.

27. PROCEDURE FOR ESTIMATING LOSSES

The Canadian Section of the Operating Committee shall perform the following daily calculations from the time that On-Call storage evacuation of Canadian storage is initiated to the end of the current operating year.

a. The energy and capacity at Mica and downstream projects in Canada shall be calculated based on actual recorded inflows and the monthly outflows computed in Section 26.

b. The actual daily energy and capacity at Mica and downstream projects in Canada shall be tabulated.

Energy and capacity computations shall take into account the actual availability of generating units throughout the January through July period.

The capacity loss (or gain) in Canada at Mica and at downstream projects shall be computed on a daily basis by subtracting the capacity in Subsection 27b above from that in Subsection 27a above.

The energy loss (or gain) shall be accumulated on a daily basis by adding the daily energy difference obtained by subtracting the energy capability in Subsection 27b above from that in Subsection 27a above.

If the volume runoff forecast at The Dalles changes significantly after initiation of the daily calculations in Subsections 27a and 27b, target and actual monthly outflows may be adjusted accordingly at the request of either Entity. Such adjustment shall consider Mica project at-site volume forecasts as well as Canadian system energy/capacity requirements.

28. DELIVERY OF CAPACITY AND ENERGY TO CANADA

a. Capacity Deliveries

If a capacity loss occurs based on the computations of Section 27 above, then daily capacity deliveries up to the daily loss shall be scheduled by the United States Entity based on the need as stated by the Canadian Entity. If agreed to by both Entities, loss in capacity can be offset by gains in energy if energy is usable in the Canadian system.

b. Energy Deliveries

It will normally not be possible to determine whether a net loss of energy has occurred until the end of the operating year. Nevertheless, energy deliveries shall be scheduled by the Entities, based on the need as stated by the Canadian Entity, to compensate for any reduction in energy in Canada in the interim period.

c. Resources

The United States Entity shall provide sufficient resources to cover actual Canadian energy and capacity losses.

29. LIABILITY OF UNITED STATES ENTITY

The procedure established in Sections 25, 26, 27, and 28 are designed as a practical means of estimating, measuring, and offsetting power losses in Canada which could reasonably be considered as a result of On-Call operation.

However, there remains the remote possibility that some combination of unforeseen circumstances, coupled with an operation of On-Call storage, could prevent the Canadian storage from refilling during the current operating year. In that unlikely event, special procedures based on the particular circumstances may have to be instituted by the Entities to cover any losses not covered by the procedures above.

The period of potential liability of the United States Entity to offset capacity or energy losses in Canada shall begin when On-Call storage evacuation begins, and shall end when each of the Canadian storages reaches its normal Operating Rule Curve computed for the current or succeeding year, unless the Entities otherwise agree.

J.Hyde;jh:x2143 05/02/96 (7075-MGHO-P:\GRPMGHO\HYDE\TREATY\MANAGE\AGREEMTS\91POP.DOC)