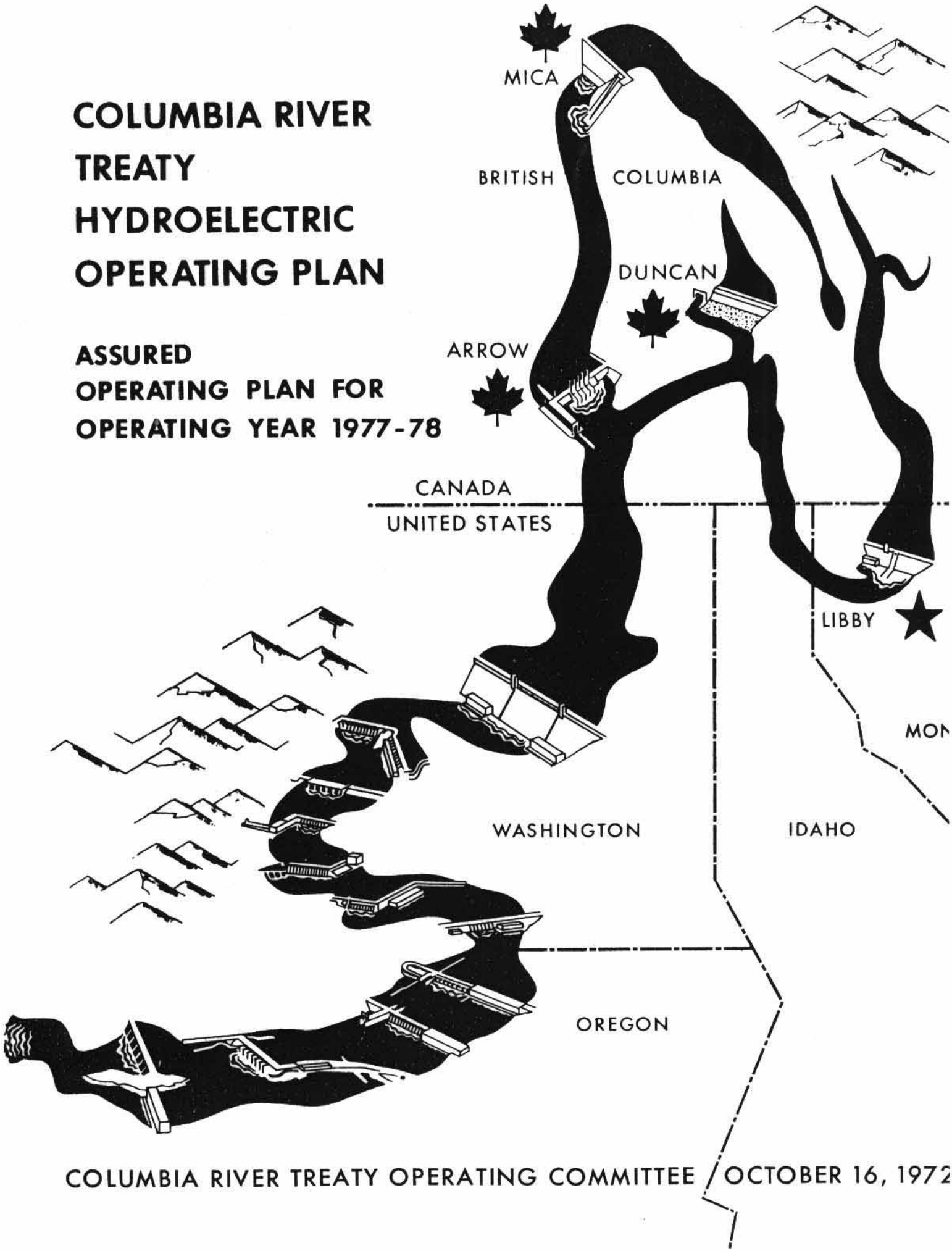
COLUMBIA RIVER TREATY HYDROELECTRIC OPERATING PLAN

ASSURED OPERATING PLAN FOR OPERATING YEAR 1977-78



COLUMBIA RIVER TREATY OPERATING COMMITTEE / OCTOBER 16, 1972

C O L U M B I A R I V E R T R E A T Y

AGREEMENT

on

HYDROELECTRIC OPERATING PLAN FOR TREATY STORAGES

OPERATING YEAR 1977-78

The Columbia River Treaty between the United States and Canada requires that hydroelectric operating plans be agreed in advance by the Entities for the operation of the storages provided in the Treaty. The Canadian Entity and the United States Entity herewith agree that the Treaty storages will be operated in accordance with the attached "Columbia River Treaty Operating Plan, Assured Operating Plan for Operating Year 1977-78," dated October 16, 1972.

W. D. Kennedy
Chairman
Canadian Entity

H. R. Richmond
Chairman
United States Entity

November 20, 1972
Date of Agreement

COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for
Operating Year 1977-78

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COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for
Operating Year 1977-78

INTRODUCTION

The Treaty between Canada and the United States of America relating to the cooperative development of the water resources of the Columbia River Basin requires that each year an Assured Operating Plan be agreed by the Entities for the operation of the Columbia River Treaty Storage in Canada during the sixth succeeding year. This plan will provide to the Entities information for the sixth succeeding year for planning the power systems in their respective countries which are dependent on or coordinated with the operation of the Canadian storage projects. The data assumed for this Assured Operating Plan will undergo review by the Entities immediately prior to the 1977-78 operating year and such data may be revised to reflect data and criteria current at that time. Should the Entities fail to agree on such revisions, then this Assured Operating Plan will form the basis for the Detailed Operating Plan for 1977-78.

This Assured Operating Plan was prepared in accordance with the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage[1/]. It is based on criteria contained in Annex A and Annex B of the Columbia River Treaty[2/], Article VII of the Protocol[3/], and Section B.1. of the Terms of Sale[4/]. Other necessary operating criteria reflected in this plan are the Program for the Initial Filling of Mica[5/] and the Columbia River Treaty Flood Control Operating Plan[6/].

The Assured Operating Plan consists of:

(a) The Operating Rule Curve for the whole of the Canadian Treaty Storage, including the Critical Rule Curve, Assured Refill Curve, Variable Refill Curves, and the individual project Flood Control Storage Reservation Curves.

(b) Operating Rules which specifically designate criteria for operation of the Canadian Treaty Projects in accordance with the principles contained in the above references.

A 30-year System Regulation Study[7/] was utilized to develop and test the operating rules and rule curves. It contains the agreed-upon operating constraints such as maximum and minimum project elevations and discharges.

SYSTEM REGULATION STUDIES

In accordance with Annex A, Paragraph 7 of the Treaty, the Columbia River Operating Committee conducted system regulation studies reflecting Canadian storage operation for optimum generation in both Canada and the United States. Downstream power benefits were computed with the Canadian storage operation based on the operating rules specified herein. There was a reduction in the Canadian Entitlement of 1.5 megawatts of dependable hydroelectric capacity and 5.5 average megawatts of average annual usable energy, which is within the limits specified by the Treaty.

System Regulation Studies for the Assured Operating Plan were based on 1977-78 estimated loads and resources in British Columbia and in the United States Pacific Northwest System. Historical flows for the period July 1928 through June 1958, modified to estimated 1977-78 conditions[8/], were used.

The Critical Rule Curve for these studies was determined from Bonneville Power Administration Study 78-41. The study indicated a 43-1/2 month

critical period for the United States system resulting from the low flows during the period from 16 August 1928 through March 1932. It was assumed that all reservoirs, both in the United States and Canada, were full at the beginning of the critical period.

In the studies, individual project flood control criteria were followed. Although only 7.0 million acre-feet of storage contents at Mica is committed for power operation purposes under the Treaty, the study is based on a full storage content of 20 million acre-feet to test compatibility with flood control parameters. Flood Control and Variable Refill Criteria are based on simulated forecasts[9/]; i.e., forecasts that would have been made at each date with the information then available.

OPERATING RULE CURVES

The operation of Canadian storage during the 1977-78 Operating Year shall be guided by an Operating Rule Curve for the whole of Canadian storage, and by Flood Control Storage Reservation Curves for the individual dual projects. The Operating Rule Curve is derived from the various curves described below. These curves are first determined for the individual Canadian storages and then summed to obtain the values for the whole of usable Canadian storage given by the composite tables included in this Plan. This is in accordance with the provision of Article VII(2) of the Protocol.

(a) Critical Rule Curve. The Critical Rule Curve indicates the end-of-month storage content of Canadian storage during the critical period. It is designed to protect the ability of the United States system to serve firm load and to protect the firm level of Mica generation with the occurrence of flows no worse than those during the most adverse

historical streamflow period. A tabulation of the Composite Critical Rule Curve for the whole of Canadian storage is included as Table 1.

(b) Refill Curve. The Refill Curve is a guide to operation of Canadian storage which defines the normal limit of storage draft for secondary energy in order to provide a high probability of refilling the storage. In general, the Operating Plan does not permit serving secondary loads at the risk of failing to refill storages and thereby jeopardizing the firm load carrying capability of the system or the Mica generating plant during subsequent years. The end of the refill period is considered to be 31 July for the Duncan and Arrow projects and 15 August for the Mica project. The later refill in Mica is planned on the basis of optimum generation in both countries.

The Refill Curve is, in turn, defined by two curves as discussed below. In each case, adjustment should be made for water required for refill of upstream reservoirs when applicable.

(1) Assured Refill Curve. The Assured Refill Curve indicates the end-of-month storage content required to assure refill of Canadian storage based on the second-lowest historical volume of inflow for the whole or remaining portion of the refill period. A tabulation of the composite Assured Refill Curve for the whole of Canadian storage is included as Table 2.

Higher flows than the minimum discharge requirements were used to compute this curve for the period January through July. This was necessary because of the use of the Power Discharge Requirements in computing the Variable Refill Curve, discussed in (2) below.

(2) Variable Refill Curve. The Variable Refill Curve gives end-of-month storage contents for the period January through July required to

refill Canadian storage based on forecast inflow volume and specified Power Discharge Requirements during the refill period. In the system regulation studies the Power Discharge Requirement was made a function of the natural January-July runoff volume at The Dalles, Oregon. In those years when this volume was lower than 90 million acre-feet, the discharge used was that required to meet firm loads while refilling, in accordance with the requirements of Principles and Procedures. In years when the runoff volume at The Dalles equaled or exceeded 90 million acre-feet the Power Discharge Requirement was the project minimum outflow. The following are the Power Discharge Requirements used in computing the Variable Refill Curves:

	Power Discharge Requirements in c.f.s. January through July Volume at The Dalles	
Project	Less Than 90 m.a.f.	Equal to or Greater Than 90 m.a.f.
Arrow	30,200	5,000
Duncan	1,000	100
Mica	21,000	3,000

Composite Variable Refill Curves for the whole of Canadian storage for the 30 years of historical record are recorded as Table 3. These illustrate the probable range of these curves based on historical conditions. In the actual operation in 1977-78, the Variable Refill Curve for each project will be based on the at-site inflow forecast reduced by upstream storage refill requirements and volume release determined from the Power Discharge Requirements given above.

(c) Flood Control Storage Reservation Curve. The Flood Control Storage Reservation Curves[10/] give end-of-month storage content to which each individual Canadian storage project shall be evacuated for flood control and other requirements during the Storage Evacuation Period.

During the Flood Control Refill Period the flood control curves used in the studies were developed from daily system regulation studies. They reflect the use of simulated runoff forecasts. Flood control curves for the thirty-year study period are shown on Tables 4, 5, and 6. Tables 5 and 6 reflect an assumed transfer of 2 million acre-feet of storage space from Arrow to Mica. In actual operation, the Flood Control Storage Reservation Curves will be based on the Flood Control Operating Plan, using the latest forecast of runoff available at that time.

(d) Definition of Operating Rule Curve. Prior to 1 January, the Operating Rule Curve is defined by the Critical Rule Curve or the Assured Refill Curve, whichever is higher. The Critical Rule Curve for the first year of the critical period is used in the foregoing determination. Beginning 1 January, the Operating Rule Curve is defined by first determining the higher of the Critical Rule Curve and the Assured Refill Curve; the Operating Rule Curve is the lower of the above-determined value or the Variable Refill Curve. Also, in all periods the Operating Rule Curve meets all requirements for flood control operation (except as noted in paragraph (d) of the Operating Rules). Composite Operating Rule Curves for the whole of Canadian storage for all 30 years of historical record are included as Table 7 to illustrate the probable future range of these curves based on historical conditions.

OPERATING RULES

The following rules, used in the System Regulation Study, will apply to the operation of Canadian storage in the 1977-78 Operating Year.

(a) The whole of the Canadian storage may be drafted to its Operating Rule Curve as required to produce optimum generation in Canada

and the United States in accordance with Annex A, Paragraph 7 of the Treaty, subject to project physical characteristics, operating constraints, and the criteria for the Mica project listed in (e) below.

(b) The whole of the Canadian storage will not be drafted below its Operating Rule Curve unless:

(1) Reservoir storage in the United States system has been drafted to its refill curve.

(2) Deliveries of secondary energy in the United States are discontinued.

(3) Committed firm thermal and miscellaneous resources not displaced by surplus firm hydro resources are in operation or other replacement energy has been secured from sources other than those committed.

(c) When the conditions of (b) above are met, and it is necessary to draft additional storage to produce optimum generation as determined by the Critical Period System Regulation study, the whole of the Canadian storage and reservoir storage in the United States system will be drafted proportionately between its Operating Rule Curve or Energy Content Curve, respectively, and its Critical Rule Curve. The proportionate draft will be made, if necessary, first to the first year Critical Rule Curve, then between the first and second year Critical Year Rule Curve, the second and third year Critical Rule Curve, etc. When it is necessary to operate the whole of the Canadian storage and the United States reservoir storage below their lowest Critical Rule Curves, each shall be operated proportionately between its lowest Critical Rule Curve and its normal minimum content. However, Mica Reservoir will continue to be operated in coordination with Arrow, so

as to optimize generation at site as well as downstream in the United States.

(d) Each project will be operated on or below the storage content defined by its Flood Control Storage Reservation Curve, unless such content is below that indicated by the Variable Refill Curve.

(e) Mica project will be operated to the following monthly criteria as qualified in (1) to (5) below:

Mica Project Operating Criteria

Month	Target End-of-Period Storage Content (KSFD)	Target Average Outflow (CFS)	Minimum Outflow (CFS)	Maximum Outflow (CFS)
July	9700.0	-	10,000	34,000
August 1-15	9990.2	-	10,000	34,000
August 16-31	9990.2	-	10,000	34,000
September	9990.2	-	10,000	34,000
October	-	15,000	10,000	-
November	-	15,000	10,000	-
December	-	21,000	15,000	-
January	-	26,000	15,000	-
February	-	26,000	15,000	-
March	-	-	15,000	34,000
April 1-15	-	15,000	15,000	-
April 16-30	-	15,000	10,000	-
May	-	10,000	10,000	34,000
June	-	10,000	10,000	34,000

(1) March outflows will be adjusted between the minimum and maximum values indicated above to allow the Canadian storage to reach appropriate Flood Control Storage Reservation or Variable Refill Curve contents. If the whole of the Canadian storage is below its Operating Rule Curve, Mica outflows during March will be set to minimum values in order that Mica storage may be refilled, unless difficulty is anticipated in maintaining the Arrow storage contents indicated in (5) above.

(2) Mica monthly average outflows will be increased in the months from October to June if required to avoid volation of the Flood Control Storage Reservation Curve.

(3) Mica monthly average outflows will be increased in any of the months from October to February if the Arrow reservoir storage content is below the following:

Arrow Reservoir End-of-Month Storage Content in Current Month (September-January)	Increase Mica Target Average Outflow Next Month By:
750 KSFD - 1000 KSFD	2000 cfs
150 KSFD - 750 KSFD	4000 cfs
0 - 150 KSFD	8000 cfs

(4) Storage releases from Mica in excess of 7 million acre-feet will be made at the discretion of the Canadian Section of the Operating Committee, and these additional storage releases will be retained in the Arrow reservoir, subject to flood control criteria at Arrow.

(5) Mica monthly average outflows will be increased, subject to the specified maximum outflow limits, during the months of July, August, September and June in abnormally low streamflow years in order to maintain the Arrow reservoir above the following storage contents:

31 July	1,057 KSFD
31 August	1,057 KSFD
31 September	665 KSFD
30 June	1,159 KSFD

The operating rules set forth above are designated to produce optimum generation in Canada and in the United States, as required by Annex A of the Treaty, when gross Mica storage content on 31 July 1977

is 15 million acre-feet or more. If the storage content filled by 31 July 1977 is less than 15 million acre-feet, some modification of the rules may be necessary to ensure adequate and complete drafting of Canadian storage in Mica Reservoir to meet United States power requirements. In that event, such modified operating rules will be included in the 1977-78 Detailed Operating Plan.

IMPLEMENTATION

The Entities have agreed that each year a Detailed Operating Plan will be prepared for the immediately succeeding operating year. Such Detailed Operating Plans are made under the authority of Article XIV 2.(k) of the Columbia River Treaty which states, ". . . the powers and the duties of the Entities include:

(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."

The Detailed Operating Plan for 1977-78 will reflect the latest available load, resource and other pertinent data to the extent the Entities agreed these data should be included in the plan. Beginning on 1 January 1977 the Assured Operating Plan contained herein will be reviewed and the data and criteria updated, as agreed by the Entities, to form the basis for a Detailed Operating Plan for the 1977-78 Operating Year. Failing agreement on updating the Assured Operating Plan, the Detailed Operating Plan will include all data and criteria given in this Assured Operating Plan. Actual operation during the 1977-78 Operating Year shall be guided by the Detailed Operating Plan.

The operating rules to be used in implementation of the Detailed Operating Plan are generally the same as the operating rules described in this document.

The values used in the study to define the various rule curves were month-end values only. In actual day-to-day operation it is necessary to operate in such a manner during the course of each month that these month-end values can be observed in accordance with the operating rules. Because of the normal variation of power load and streamflow during any month, straight line interpolation between the month-end points should not be assumed.

During the storage drawdown season, Canadian storage should not be drafted below its month-end point at any time during the month unless it can be conservatively demonstrated that sufficient inflow is available, in excess of the minimum outflow required to serve power demand, to refill the reservoir to its end-of-month value as required. During the storage evacuation and refill season, operation will be consistent with the Flood Control Operating Plan. When refill of Canadian storage is being guided by Flood Control Refill Curves[6/], such curves will be computed on a day-by-day basis using the residual volume-of-inflow forecasts depleted by the volume required for minimum outflow from each day through the end of the refill season.

REFERENCES

1/ Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage dated 25 July 1967.

2/ Treaty between Canada and the United States of America relating to Cooperative Development of the Water Resources of the Columbia River Basin dated 17 January 196.

3/ Protocol -- Annex to Exchange of Notes dated 22 January 1964.

4/ Terms of Sale -- Attachment to Exchange of Notes dated 22 January 1964.

5/ Program for Initial Filling of Mica Reservoir, dated 26 July 1967.

6/ Columbia River Treaty Flood Control Operating Plan, dated October 1972.

7/ BPA Hydroelectric Power Planning Program, 78-41 Assured Operating Plan 30-Year Study, dated 25 July 1972.

8/ Extension of Modified Flows through 1958, Water Management Subcommittee of CBIAC, dated June 1960.

9/ Volume Forecasts for Reservoir Regulation Studies, 1929-1965, Cooperative Columbia River Forecasting Unit, dated July 1967.

10/ Summary of End-of-Month Reservoir Storage Requirement from Columbia River Flood Regulation Studies 004, with subsequent minor modifications, dated 2 April 1970.

TABLE 1

COLUMBIA RIVER TREATY
COMPOSITE CRITICAL RULE CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1977-78 OPERATING YEAR

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1ST YR	7814.6	7724.1	7554.2	7214.4	6917.5	5600.9	3960.1	2508.2	1919.7	916.1	2377.1	5809.5
2ND YR	7044.5	6786.2	6335.9	5535.6	4596.0	3327.3	1633.4	1093.9	548.1	1022.3	2308.8	4004.2
3RD YR	5724.2	5767.8	5644.0	5032.1	4191.7	2586.9	1602.7	700.6	23.1	0.0	1183.0	2375.3
4TH YR	2926.1	2634.0	2488.2	2192.5	1576.3	573.8	73.1	10.0	0.0	0.0	0.0	0.0

TABLE 2

COLUMBIA RIVER TREATY
COMPOSITE ASSURED REFILL CURVE
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1977-78 OPERATING YEAR

JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
0.0	0.0	138.7	343.1	464.6	523.9	6137.1	5349.4	5136.9	4413.3	5921.3	7120.2	7814.6

TABLE 3

COLUMBIA RIVER TREATY
COMPOSITE VARIABLE REFILL CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1977-78 OPERATING YEAR

FLOW YEAR	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
1928-29							7172.1	7461.7	6696.1	5991.2	6171.5	7154.8	7814.6
1929-30							5920.5	6121.5	3200.4	2818.4	4218.0	6015.8	,,
1930-31							7554.5	7467.1	6646.6	5900.7	6262.2	7602.6	,,
1931-32							391.5	290.4	0.0	7.3	2703.9	5193.4	,,
1932-33							231.6	0.0	8.6	3.0	1306.6	4760.0	,,
1933-34							0.0	,,	.7	29.2	327.4	4680.3	,,
1934-35							,,	,,	0.0	0.0	438.9	4141.6	,,
1935-36							6589.5	5790.3	4338.0	2735.0	3961.6	6959.5	,,
1936-37							7665.6	7589.4	6052.4	6227.1	6133.0	7156.0	,,
1937-38							0.0	0.0	0.0	165.3	1971.4	5384.6	,,
1938-39							6220.0	4946.4	3225.6	2968.6	4317.1	6644.3	,,
1939-40							7037.2	7163.5	5614.1	5132.5	5805.7	7216.6	,,
1940-41							6287.3	5603.9	4665.9	4508.5	5902.8	7058.3	,,
1941-42							92.6	1243.1	1931.9	2388.4	3902.9	5818.9	,,
1942-43							398.6	797.2	995.7	1222.6	2972.9	5476.3	,,
1943-44							7515.5	7312.6	6379.2	5485.0	5850.6	7033.3	,,
1944-45							7544.1	7229.7	5322.6	4558.6	4893.1	6715.5	,,
1945-46							430.9	0.0	0.0	0.0	1087.5	5067.7	,,
1946-47							234.3	,,	15.5	99.2	2101.3	5477.2	,,
1947-48							1033.4	1449.3	381.1	737.3	1878.6	5343.4	,,
1948-49							1165.0	2145.0	1315.5	1986.9	3632.4	6543.7	,,
1949-50							1250.8	1133.3	780.8	1021.2	2539.9	5250.0	,,
1950-51							135.0	0.0	0.0	0.0	1403.6	4868.0	,,
1951-52							524.7	317.0	258.3	769.2	2711.9	5768.1	,,
1952-53							3549.0	1339.0	1341.0	1721.7	2987.6	5821.3	,,
1953-54							1818.4	920.2	9.6	273.4	1505.3	4821.7	,,
1954-55							1181.9	1636.0	1688.8	1711.4	2943.1	5170.3	,,
1955-56							0.0	0.0	0.0	0.0	1241.5	5193.1	,,
1956-57							82.3	45.3	,,	,,	2057.6	6122.5	,,
1957-58							1314.3	1119.3	1029.7	1712.9	3292.7	6649.9	,,

TABLE 4

FLOOD CONTROL STORAGE RESERVATION CURVES
DUNCAN
KSFD
1977-78 OPERATING YEAR

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
1928-29	679.1	679.1	679.1	679.1	679.1	477.4	275.8	174.9	306.0	295.9	374.1	619.1	679.1
1929-30	,,	,,	,,	,,	,,	,,	336.3	306.0	311.1	320.6	342.8	532.4	,,
1930-31	,,	,,	,,	,,	,,	,,	341.3	185.0	245.5	240.5	393.7	630.2	,,
1931-32	,,	,,	,,	,,	,,	,,	245.5	38.8	38.8	38.8	212.7	534.4	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	130.6	529.9	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	205.7	511.7	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	123.0	441.6	,,
1935-36	,,	,,	,,	,,	,,	,,	285.8	149.7	149.7	132.1	350.4	639.8	,,
1936-37	,,	,,	,,	,,	,,	,,	386.7	280.8	205.2	220.8	332.7	549.5	,,
1937-38	,,	,,	,,	,,	,,	,,	245.5	38.8	38.8	38.8	170.4	477.9	,,
1938-39	,,	,,	,,	,,	,,	,,	,,	104.3	,,	,,	246.5	433.1	,,
1939-40	,,	,,	,,	,,	,,	,,	,,	144.7	164.8	185.0	355.9	603.0	,,
1940-41	,,	,,	,,	,,	,,	,,	,,	79.1	,,	235.4	365.5	586.8	,,
1941-42	,,	,,	,,	,,	,,	,,	,,	38.8	,,	205.2	363.0	585.3	,,
1942-43	,,	,,	,,	,,	,,	,,	,,	,,	38.8	38.8	124.5	324.7	647.8
1943-44	647.8	,,	,,	,,	,,	,,	301.0	159.8	235.4	262.7	396.8	626.2	679.1
1944-45	679.1	,,	,,	,,	,,	,,	331.2	185.0	190.1	104.3	209.7	389.7	671.0
1945-46	671.0	,,	,,	,,	,,	,,	245.5	38.8	38.8	49.4	287.9	605.0	679.1
1946-47	679.1	,,	,,	,,	,,	,,	,,	,,	,,	59.5	269.2	561.6	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	38.8	231.9	603.0	,,
1948-49	,,	,,	,,	,,	,,	,,	,,	139.6	,,	58.0	283.8	497.1	677.6
1949-50	677.6	,,	,,	,,	,,	,,	250.6	38.8	,,	38.8	96.3	430.0	679.1
1950-51	679.1	,,	,,	,,	,,	,,	245.5	,,	,,	43.8	235.4	472.9	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	59.0	236.4	507.7	,,
1952-53	,,	,,	,,	,,	,,	,,	386.7	149.7	174.9	116.4	215.3	490.0	,,
1953-54	,,	,,	,,	,,	,,	,,	311.1	38.8	38.8	38.8	197.1	491.0	,,
1954-55	,,	,,	,,	,,	,,	,,	290.9	159.8	159.8	134.6	188.0	532.9	,,
1955-56	,,	,,	,,	,,	,,	,,	245.5	0.0	0.0	0.0	211.7	558.5	,,
1956-57	,,	,,	,,	,,	,,	,,	250.6	38.8	38.8	42.3	330.7	612.5	,,
1957-58	,,	,,	,,	,,	,,	,,	285.8	94.3	74.1	69.1	331.7	679.1	,,

TABLE 5

FLOOD CONTROL STORAGE RESERVATION CURVES
ARROW
KSFO
1977-78 OPERATING YEAR

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
1928-29	3602.3	3602.3	3602.3	3602.3	3602.3	3098.1	2820.8	2770.4	3098.1	3098.1	3160.1	3602.3	3602.3
1929-30	,,	,,	,,	,,	,,	,,	2493.1	2493.1	1661.3	1656.2	1579.6	,,	,,
1930-31	,,	,,	,,	,,	,,	,,	2997.3	3098.1	3098.1	3098.1	3122.8	,,	,,
1931-32	,,	,,	,,	,,	,,	,,	2392.3	1726.8	1031.0	1031.0	1080.0	2761.3	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1040.6	3254.9	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	1472.7	1535.2	3432.9	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	1031.0	1031.0	1878.6	,,
1935-36	,,	,,	,,	,,	,,	,,	3098.1	2215.8	,,	,,	2137.7	3602.3	,,
1936-37	,,	,,	,,	,,	,,	,,	,,	3098.1	2553.6	2683.7	2936.3	3305.3	,,
1937-38	,,	,,	,,	,,	,,	,,	2392.3	1726.8	1031.0	1031.0	1212.5	2639.3	,,
1938-39	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1031.0	1730.8	,,
1939-40	,,	,,	,,	,,	,,	,,	2518.3	2604.0	1106.7	1157.1	,,	1676.9	,,
1940-41	,,	,,	,,	,,	,,	,,	2392.3	1726.8	1031.0	1572.0	2688.7	3515.1	,,
1941-42	,,	,,	,,	,,	,,	,,	,,	,,	2029.3	2345.4	3421.8	3602.3	,,
1942-43	,,	,,	,,	,,	,,	,,	,,	,,	1031.0	1031.0	1031.0	1700.1	,,
1943-44	,,	,,	,,	,,	,,	,,	2846.0	3098.1	3098.1	3098.1	3098.1	3570.0	,,
1944-45	,,	,,	,,	,,	,,	,,	2836.0	2805.7	2432.6	1648.1	1714.2	2901.5	,,
1945-46	,,	,,	,,	,,	,,	,,	2392.3	1726.8	1031.0	1031.0	1561.4	2665.1	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1903.8	3602.3	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2030.3	,,	,,
1948-49	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2537.0	,,	,,
1949-50	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1031.0	2301.5	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1305.3	2399.4	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1620.4	3030.1	,,
1952-53	,,	,,	,,	,,	,,	,,	3098.1	,,	,,	,,	1031.0	3020.5	,,
1953-54	,,	,,	,,	,,	,,	,,	2392.3	,,	,,	,,	1158.1	1718.2	,,
1954-55	,,	,,	,,	,,	,,	,,	2654.5	2820.8	2694.8	1736.9	1736.9	3183.3	,,
1955-56	,,	,,	,,	,,	,,	,,	2392.3	879.8	22.7	283.4	1364.8	2807.2	,,
1956-57	,,	,,	,,	,,	,,	,,	,,	1726.8	1031.0	1031.0	2972.6	3602.3	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1964.3	3560.5	,,

TABLE 6

FLOOD CONTROL STORAGE RESERVATION CURVES
MICA
KSFD
1977-78 OPERATING YEAR

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
1928-29	3533.2	3533.2	3533.2	3432.4	3432.4	3432.4	3260.9	3235.7	3432.4	3432.4	3533.2	3533.2	3533.2
1929-30	,,	,,	,,	,,	,,	,,	3150.0	3089.5	2776.9	2742.7	2710.4	,,	,,
1930-31	,,	,,	,,	,,	,,	,,	3356.7	3432.4	3432.4	3398.1	3533.2	,,	,,
1931-32	,,	,,	,,	,,	,,	,,	3114.7	2802.2	2484.5	2484.5	3063.8	,,	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2558.1	,,	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3533.2	,,	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2572.3	,,	,,
1935-36	,,	,,	,,	,,	,,	,,	3412.2	2968.5	,,	2542.5	3401.6	,,	,,
1936-37	,,	,,	,,	,,	,,	,,	3432.4	3432.4	3104.7	3163.1	3295.7	,,	,,
1937-38	,,	,,	,,	,,	,,	,,	3114.7	2802.2	2484.5	2484.5	2682.7	,,	,,
1938-39	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3379.9	,,	,,
1939-40	,,	,,	,,	,,	,,	,,	3145.0	3104.7	,,	2550.1	2877.8	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	3114.7	2802.2	,,	2766.9	3296.7	,,	,,
1941-42	,,	,,	,,	,,	,,	,,	,,	,,	2877.8	2880.3	3360.8	,,	,,
1942-43	,,	,,	,,	,,	,,	,,	3291.2	,,	2484.5	2484.5	2745.7	,,	,,
1943-44	,,	,,	,,	,,	,,	,,	3286.2	3432.4	3432.4	3432.4	3521.6	,,	,,
1944-45	,,	,,	,,	,,	,,	,,	3114.7	3255.9	3039.1	2737.1	3001.8	,,	,,
1945-46	,,	,,	,,	,,	,,	,,	,,	2802.2	2484.5	2484.5	2978.1	,,	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3206.5	,,	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3197.4	,,	,,
1948-49	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3194.4	,,	,,
1949-50	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2484.5	,,	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	2996.8	,,	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3196.9	,,	,,
1952-53	,,	,,	,,	,,	,,	,,	3432.4	,,	,,	,,	2762.3	,,	,,
1953-54	,,	,,	,,	,,	,,	,,	3114.7	,,	,,	,,	2989.2	,,	,,
1954-55	,,	,,	,,	,,	,,	,,	3200.4	3276.1	3190.4	2787.0	2916.1	,,	,,
1955-56	,,	,,	,,	,,	,,	3029.0	2071.1	1113.2	54.4	-76.6	655.4	2302.5	,,
1956-57	,,	,,	,,	,,	,,	3432.4	3114.7	2802.2	2484.5	2484.5	3533.2	3533.2	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	3357.2	,,	,,

TABLE 7

COLUMBIA RIVER TREATY
COMPOSITE OPERATING RULE CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1977-78 OPERATING YEAR

FLOW YEAR	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
1928-29	7814.6	7724.1	7554.2	7214.4	6917.5	5600.9	5789.4	5124.9	5093.3	4229.5	5593.3	6957.3	7814.6
1929-30	,,	,,	,,	,,	,,	,,	4732.9	4781.8	3193.0	2818.4	4218.0	6015.8	,,
1930-31	,,	,,	,,	,,	,,	,,	5924.7	5130.3	5034.0	4183.2	5646.4	7092.8	,,
1931-32	,,	,,	,,	,,	,,	,,	391.5	290.4	0.0	7.3	2703.9	5193.4	,,
1932-33	,,	,,	,,	,,	,,	,,	231.6	0.0	8.6	3.0	1306.6	4760.0	,,
1933-34	,,	,,	,,	,,	,,	,,	0.0	,,	.7	29.2	327.4	4680.3	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	0.0	0.0	438.9	4141.6	,,
1935-36	,,	,,	,,	,,	,,	,,	5401.9	4484.2	3535.2	2735.0	3961.6	6799.6	,,
1936-37	,,	,,	,,	,,	,,	,,	6035.8	5252.6	5014.3	4226.2	5734.5	7036.2	,,
1937-38	,,	,,	,,	,,	,,	,,	0.0	0.0	0.0	165.3	1971.4	5384.6	,,
1938-39	,,	,,	,,	,,	,,	,,	5294.4	4368.3	3225.6	2968.6	4317.1	6644.3	,,
1939-40	,,	,,	,,	,,	,,	,,	5775.1	5130.3	4992.5	4167.5	5784.4	7099.1	,,
1940-41	,,	,,	,,	,,	,,	,,	5481.6	4985.7	4665.9	4056.5	5870.8	6962.2	,,
1941-42	,,	,,	,,	,,	,,	,,	92.6	1243.1	1931.9	2388.4	3902.9	5818.9	,,
1942-43	,,	,,	,,	,,	,,	,,	398.6	797.2	995.7	1222.6	2972.9	5476.3	,,
1943-44	,,	,,	,,	,,	,,	,,	5885.7	5147.1	5058.2	4262.9	5783.9	6994.6	,,
1944-45	,,	,,	,,	,,	,,	,,	5914.3	5145.2	4830.7	4064.5	4815.6	6712.7	,,
1945-46	,,	,,	,,	,,	,,	,,	430.9	0.0	0.0	0.0	1087.5	5067.7	,,
1946-47	,,	,,	,,	,,	,,	,,	234.3	,,	15.5	99.2	2101.3	5477.2	,,
1947-48	,,	,,	,,	,,	,,	,,	1033.4	1449.3	381.1	737.3	1878.6	5343.4	,,
1948-49	,,	,,	,,	,,	,,	,,	1165.0	2145.0	1315.5	1986.9	3632.4	6543.7	,,
1949-50	,,	,,	,,	,,	,,	,,	1250.8	1133.3	780.8	1021.2	2539.9	5250.0	,,
1950-51	,,	,,	,,	,,	,,	,,	135.0	0.0	0.0	0.0	1403.6	4868.0	,,
1951-52	,,	,,	,,	,,	,,	,,	524.7	317.0	258.3	769.2	2711.9	5768.1	,,
1952-53	,,	,,	,,	,,	,,	,,	3549.0	1339.0	1341.0	1721.7	2987.6	5821.3	,,
1953-54	,,	,,	,,	,,	,,	,,	1818.4	920.2	9.6	273.4	1505.3	4821.7	,,
1954-55	,,	,,	,,	,,	,,	,,	1181.9	1636.0	1688.8	1711.4	2943.1	5170.3	,,
1955-56	,,	,,	,,	,,	,,	,,	0.0	0.0	0.0	-76.6	1241.5	5193.1	,,
1956-57	,,	,,	,,	,,	,,	,,	82.3	45.3	,,	0.0	2057.6	6122.5	,,
1957-58	,,	,,	,,	,,	,,	,,	1314.3	1119.3	1029.7	1712.9	3292.7	6648.0	,,

C O L U M B I A R I V E R T R E A T Y

AGREEMENT

on

DETERMINATION OF DOWNSTREAM POWER BENEFITS

The Columbia River Treaty between Canada and the United States requires that the downstream power benefits resulting from operating plans agreed to by the Entities will be determined in advance by the Entities.

The determination of downstream power benefits for the operating year 1977-78 is covered in the attached report "Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1977-78," dated October 16, 1972.

The methods used in determining the downstream power benefits and the disposition of reduction in the Canadian Entitlement is covered in the attached report "Downstream Power Benefit Computations for 1977-78 Operating Year," dated 6 November 1972.

These two reports are agreed upon by the United States Entity and the Canadian Entity.

W. D. Kennedy
Chairman
Canadian Entity

H. R. Richmond
Chairman
United States Entity

November 20, 1972
Date of Agreement

DETERMINATION OF DOWNSTREAM POWER BENEFITS RESULTING FROM CANADIAN STORAGE
FOR OPERATING YEAR 1977-78
October 16, 1972

I. Introduction.

The Treaty between Canada and the United States of America and related documents relating to the cooperative development of the water resources of the Columbia River Basin requires that downstream power benefits from Canadian storage be determined in advance by the two entities. The purpose of this report is to set out the results of downstream power benefit computations for the sixth succeeding year, 1977-78, and for the storages for which the Assured Operating Plan was developed.

The procedures followed in the benefit studies are those provided in Annex A, Paragraph 7; in Annex B of the Treaty; in Articles VIII, IX, and X of the Protocol; and in the document, "Procedures for the Determination of Downstream Power Benefits Resulting from Canadian Storage," dated September 9, 1968.

The Canadian Entitlement Benefits were computed as follows:

Step I — based on the total U.S. planned hydro and thermal system with 15-1/2 maf of Canadian storage operated for optimum generation in both countries (78-41 study).

Step II — based on the U.S. base hydro and thermal system with 15-1/2 maf of Canadian storage operated for optimum generation in both countries (78-42 study).

Step III — based on the U.S. base hydro and thermal system operated for optimum generation in U.S. (78-13 study).

II. Results of Study.

The Canadian Entitlement, which is one-half the total computed downstream power benefits, was computed to be:

Dependable Capacity = 1,412.0 mw

Average Annual Energy = 672.5 mw

III. Computation of Entitlement.

The following Tables and Charts are attached and summarize the study.

Table 1. Computation of Canadian Entitlement

The essential elements used in the computation of the Canadian Entitlement as provided in Paragraph 2 and 3 of Annex B are shown in this table.

Table 2. Summary of Power Regulations for the Computation of Canadian Entitlement to Downstream Benefits

This table summarizes the Step I, II, and III regulations by projects.

Table 3. Determination of Load Shape for Steps II and III, Canadian Entitlement Computation

The load shape for Steps II and III carry the same ratio between each month and the annual average as does the Pacific Northwest area load. The Northwest area firm loads on this table were based on the current forecast data. The Grand Coulee pumping load is also included in this estimate.

The firm load for Steps II and III is computed as follows:

(1) Estimate the hydro nominal prime power for the critical period;

(2) Add the thermal from Step I less reserve;

(3) Multiply (2) by the ratio of the area annual average firm load to the area critical period firm load to obtain the annual average firm load for Steps II and III (the ratios used in this study were 0.98645 and 0.95637, respectively);

(4) Pro rate the average annual Step II or III load determined in (3) by months in the ratio that each monthly area load bears to the annual average area load; and

(5) Subtract the thermal in each month to obtain the monthly firm hydro load. The average annual hydro load for Steps II and III also becomes the firm energy considered usable according to Annex B, Paragraph 3(a).

Chart 1 & 2. Secondary Energy Duration Curve, Steps II and III

These charts are duration curves of the secondary energy for Steps II and III. The secondary energy is the capability each month which exceeds the firm hydro loads shown in Table 3. The usable secondary energy shown in average megawatts for each step is computed in accordance with Annex B, Paragraphs 3 (b) and 3 (c). The "other usable secondary" was computed on the basis of 40% of the remainder after thermal replacement. The thermal replacement was limited to the existing and scheduled thermal energy capability after allowance for reserve, except when an energy surplus condition occurs; then the thermal replacement must not exceed the total of the thermal energy capability and the estimated interruptible load.

Thermal Energy Capability - mw	5,056
Less 5% Reserve - mw	253
Less Minimum Thermal Generation	1,132
Thermal Replacement - mw	3,671

The following tabulation shows the ordinate values for usable secondary energy:

	Step II	Step III
Thermal Replacement	3,671	3,671
Other	1,588	2,366
Total - mw	5,259	6,037

TABLE 1

COMPUTATION OF CANADIAN ENTITLEMENT

Generation Figures are in Average Megawatts; Load Factors, in Percent

Determination of Dependable Capacity Credited to Canadian Storage

Critical Period Average Rate of Generation with Canadian Storage, Step II	8,963
Critical Period Average Rate of Generation without Canadian Storage, Step III	6,974
Gain Due to Canadian Storage	1,989
Estimated Average Critical Period Load Factor — Percent	70.436
Dependable Capacity Gain 1/	2,824
Canadian Share of Dependable Capacity	1,412.0

Determination of Increase in Average Annual Usable Energy

Step II (with Canadian Storage)

Annual Firm Hydro Energy	8,792
Thermal Replacement Energy	1,660
Other Usable Secondary Energy	336
System Annual Average Usable Energy	10,788

Step III (without Canadian Storage)

Annual Firm Hydro Energy	6,510
Thermal Replacement Energy	2,199
Other Usable Secondary Energy	734
System Annual Average Usable Energy	9,443

Average Annual Usable Energy Gain	1,345
Canadian Share of Average Annual Energy Gain	672.5

1/ Dependable capacity gain credited to Canadian storage equals gain in critical period average rate of generation divided by the estimated average critical period load factor.

SUMMARY OF POWER RESULTANTS FOR 1977-78
FOR THE COMPUTATIONS OF CANADIAN ENTITLEMENT
TO DOWNSTREAM BENEFITS

TABLE 2

PROJECTS:	BASIC DATA		STEP I			STEP II				STEP III			
	Number of Units	Nominal Installed Peaking Capacity mw	Usable Storage 1000 AF	January Peaking Capability mw	Critical Period Average Generation mw	Usable Storage 1000 AF	January Peaking Capability mw	Critical Period Average Generation mw	Average Annual Generation mw	Usable Storage 1000 AF	January Peaking Capability mw	Critical Period Average Generation mw	Average Annual Generation mw
CANADIAN													
Mica			7,008			7,008							
Arrow			7,145			7,145							
Duncan			1,347			1,347							
Subtotal			15,500			15,500							
BASE SYSTEM FEDERAL													
Hungry Horse	4	328	3,161	160	99	3,008	249	116	103	3,008	278	212	101
Albeni Falls	3	49	1,155	24	23	1,155	21	22	22	1,155	23	25	24
Grand Coulee	21-23+2	4,877	5,232	4,587	1,976	5,072	4,791	1,764	2,321	5,072	4,628	1,227	2,192
Chief Joseph	19-24	1,936		1,936	1,086		1,936	1,004	1,299		1,936	708	1,184
Ice Harbor	6	693		693	224		693	225	303		693	171	304
McNary	14	1,127		1,127	651		1,127	594	761		1,127	430	714
John Day	16	2,484	535	2,484	925		2,484	928	1,268		2,484	680	1,232
The Dalles	22	1,943		1,943	737		1,943	709	957		1,943	532	933
Bonneville	10	574		574	565		574	556	561		574	479	547
Subtotal		14,011	10,083	13,528	6,286	9,235	13,818	5,918	7,595	9,235	13,686	4,464	7,231
BASE SYSTEM NON-FEDERAL													
Kootenay Lake (Canadian)			787			427				427			
Kerr	3	185	1,219	172	113	1,219	174	103	121	1,219	179	151	122
Thompson Falls	6	40		40	35		37	37	32		38	36	31
Noxon Rapids	4	430	231	426	172		430	160	217		430	179	217
Cabinet Gorge	4	230		230	111		230	99	128		230	111	129
Box Canyon	4	71		71	47		71	45	50		71	52	49
Coeur d'Alene & Long Lake			327			223				223			
Wells	10	820		820	438		820	411	515		820	289	474
Chelan	2	54	677	50	38	676	51	38	46	676	52	49	45
Rocky Reach	11	1,291		1,291	643		1,291	607	768		1,291	427	716
Rock Island	10	159		155	155		156	155	149		158	124	140
Wanapum	10	986		986	557		986	526	659		986	366	599
Priest Rapids	10	912		912	526		912	497	620		912	357	565
Brownlee	4	450	980	450	226	974	450	255	269	974	450	254	259
Oxbow	4	220		220	96		220	112	118		220	115	119
Subtotal		5,848	4,221	5,823	3,157	3,519	5,828	3,045	3,692	3,519	5,837	2,510	3,465
TOTAL BASE SYSTEM HYDRO		19,859	29,804	19,351	9,443	28,254	19,646	8,963	11,287	12,754	19,523	6,974	10,696
ADDITIONAL STEP I PROJECTS													
Libby	4	483	4,965	226	186								
Boundary	4	650		650	361								
Spokane River Plants		153		147	90								
Hells Canyon	3	450		450	181								
Dworshak	3	460	2,015	413	161								
Lower Granite	3	466		466	222								
Little Goose	3-6	466		466	220								
Lower Monumental	3	466		466	222								
Pelton and Round Butte		454	274	423	132								
Subtotal		4,048	7,254	3,707	1,775								
Independent Resources		4,651	8,489	3,688	1,732								
TOTAL HYDRO RESOURCES		28,558	45,547	26,746	12,950								
MISCELLANEOUS CONTRACTS				53	17								
THERMAL RESOURCES													
Existing Thermal Plants				801	275								
Centralia #1 & #2				1,400	1,260								
Trojan				1,130	1,017								
Jim Bridger #1, #2, & #3				1,500	1,350								
Colstrip				350	315								
Hanford #2				1,100	839								
TOTAL THERMAL RESOURCES				6,281	5,056								
TOTAL IMPORTS				70	425								
TOTAL RESOURCES (HYDRO AND THERMAL)				33,150	18,448								
RESERVES 1/				-2,238	-253								
RESOURCES AVAILABLE FOR LOAD				30,912	18,195								
ESTIMATED LOAD													
Pacific Northwest Area				27,976	17,379								
SURPLUS OR (DEFICIT)				2,936	816								
CRITICAL PERIOD:													
Starts:			August 16, 1928			September 1943				September 16, 1936			
Ends:			March 1932			April 1945				April 15, 1937			
Length (Months):			43-1/2 Months			20 Months				7 Months			
STUDY IDENTIFICATION			78-41			78-42				78-13			

1/ Peak reserves are 8% of peak load; energy reserves are 5% of thermal plant energy capability.

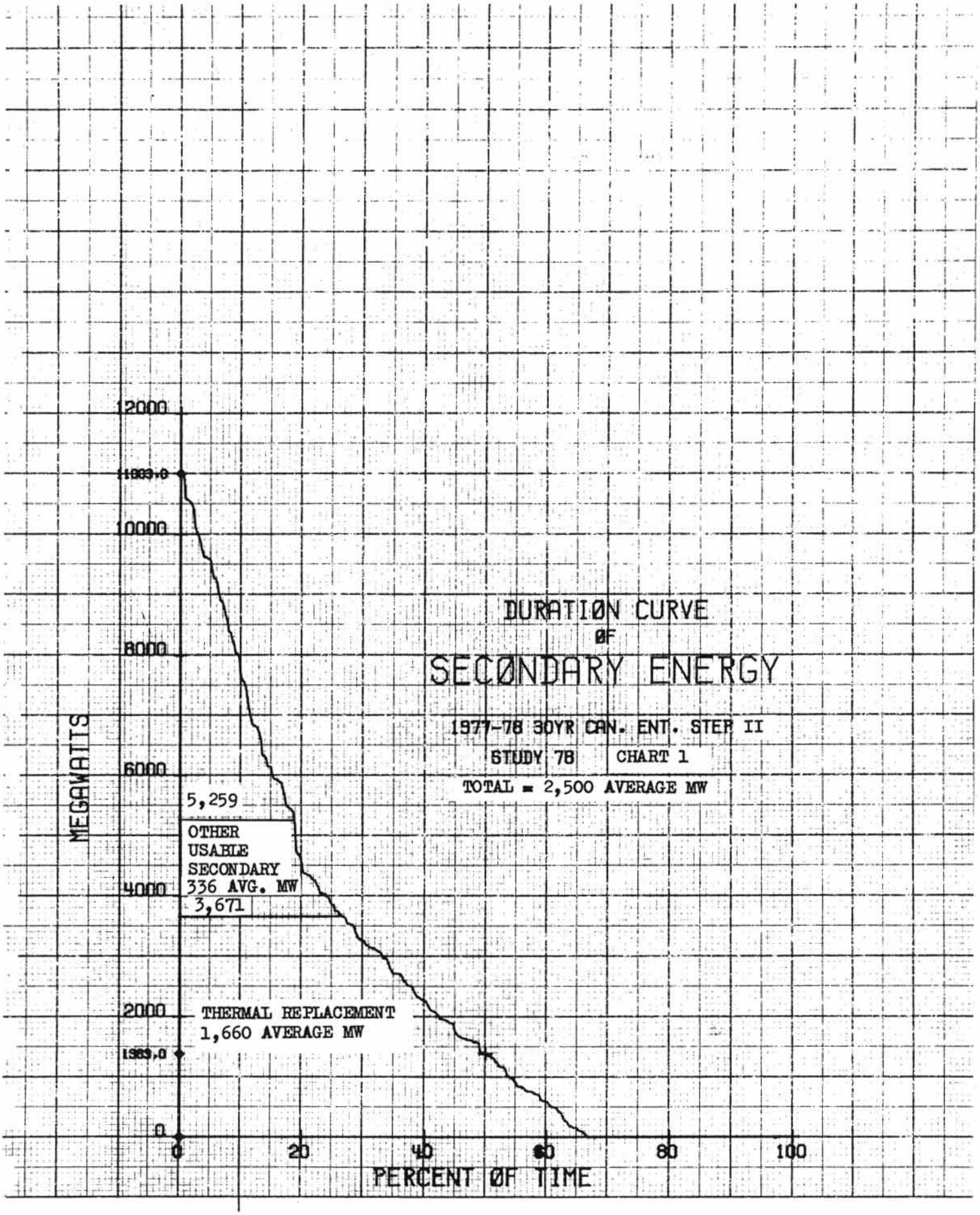
DETERMINATION OF LOAD SHAPE FOR STEP II AND III
1977-78 CANADIAN ENTITLEMENT COMPUTATIONS

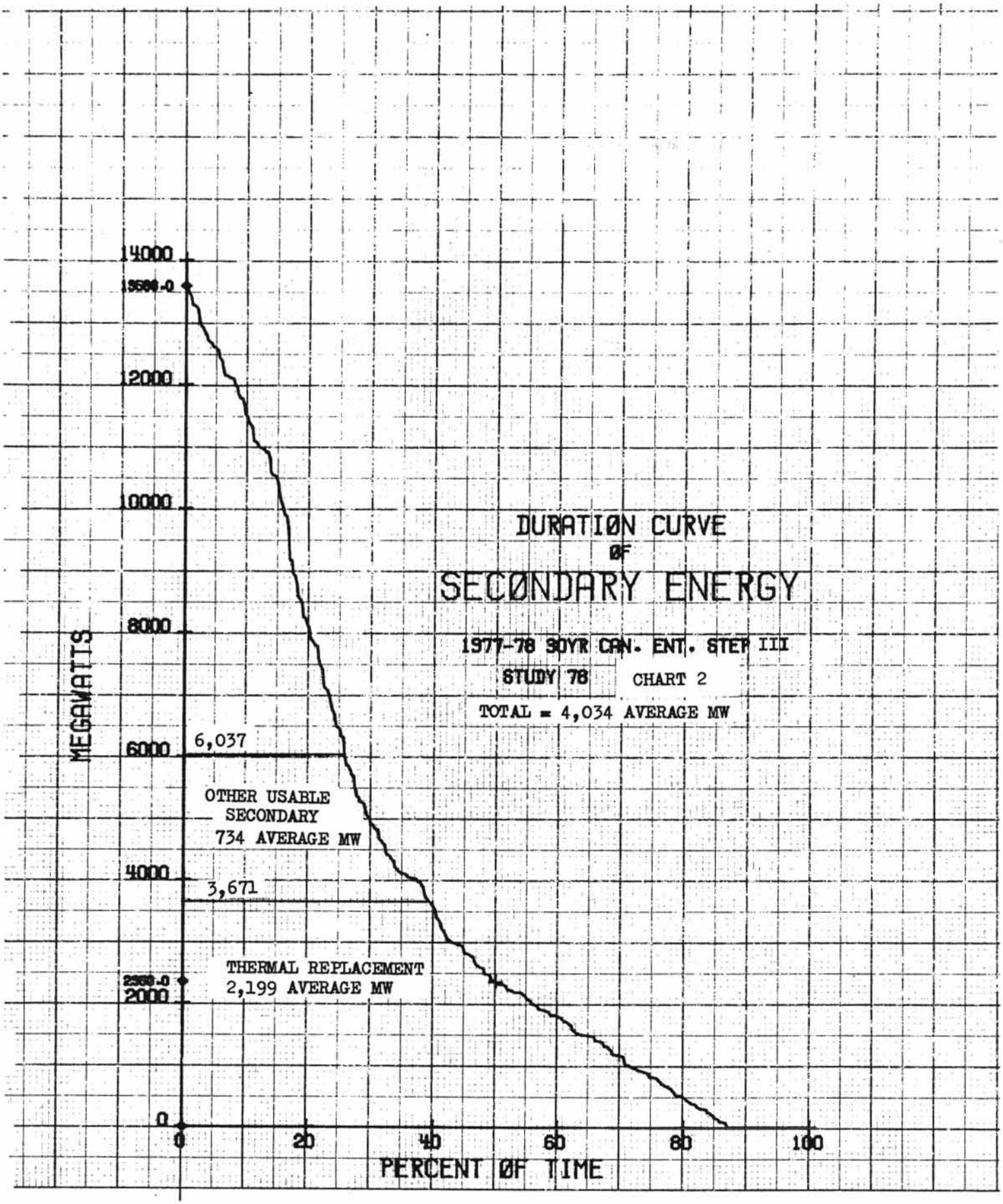
	Pacific Northwest Area Load			Step II			Step III		
	Peak	Avg.	Load Factor %	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load 1/	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load
July	21,672 *	15,801	72.91	11,393	3,671	7,722	9,307	3,671	5,636
Aug. 1-15	22,051 *	15,856	71.91	11,433	3,671	7,762	9,340	3,671	5,669
Aug. 16-31	21,960 *	15,759	71.76	11,363	3,671	7,692	9,282	3,671	5,611
Sept. 1-15	22,381 *	15,813	70.65	11,402	3,671	7,731	9,314	3,671	5,643
Sept. 16-30	22,335 *	15,777	70.64	11,376	3,671	7,705	9,293	3,671	5,622
October	23,849 *	16,570	69.48	11,948	3,671	8,277	9,760	3,671	6,089
November	25,747 *	17,809	69.17	12,841	3,671	9,170	10,490	3,671	6,819
December	27,852 *	19,141	68.72	13,802	3,671	10,131	11,274	3,671	7,603
January	27,976 *	19,797	70.76	14,275	3,671	10,604	11,661	3,671	7,990
February	26,338 *	18,831	71.50	13,578	3,671	9,907	11,092	3,671	7,421
March	25,301 *	17,945	70.93	12,940	3,671	9,269	10,570	3,671	6,899
Apr. 1-15	24,195 *	17,074	70.57	12,312	3,671	8,641	10,057	3,671	6,386
Apr. 16-30	24,196 *	17,133	70.81	12,354	3,671	8,683	10,092	3,671	6,421
May	24,089 *	16,503	68.51	11,900	3,671	8,229	9,721	3,671	6,050
June	23,222 *	16,389	70.58	11,817	3,671	8,146	9,653	3,671	5,982
Critical Period Avg.		17,379	70.436	12,634	3,671	8,963	10,645	3,671	6,974
Annual Average		17,284		12,463	3,671	8,792	10,181	3,671	6,510
January Peak	27,976 *								
Step I Critical Period	Aug. 16, 1928 - Mar. 31, 1932 43-1/2 Months			Critical Period Sept. 1943 - Apr. 1945 20 Months			Critical Period Sept. 16, 1936 - Apr. 15, 1937 7 Months		

1/ Total firm load of Step II and Step III systems, computed for each system to have an average energy load equivalent to the average energy capability within the critical period and to bear a constant ratio, month by month, to the Pacific Northwest Area Load.

* Figures so marked are peak megawatts. All other figures are monthly or semi-monthly energy in average megawatts.

TABLE 3


DURATIØN CURVE
ØF
SECØNDARY ENERGY
1977-78 30YR CAN. ENT. STEP II
STUDY 78 CHART 1
TOTAL = 2,500 AVERAGE MW
MEGAWATTS
12000
11883.0
10000
8000
6000
4000
2000
1383.0
0
5,259
OTHER
USABLE
SECONDARY
336 AVG. MW
3,671
THERMAL REPLACEMENT
1,660 AVERAGE MW
0
20
40
60
80
100
PERCENT ØF TIME


DURATIØN CURVE
ØF
SECØNDARY ENERGY
1977-78 30YR CAN. ENT. STEP III
STUDY 78
CHART 2
TOTAL = 4,034 AVERAGE MW
MEGAWATTS
14000
13500.0
12000
10000
8000
6000
6,037
OTHER USABLE
SECONDARY
734 AVERAGE MW
4000
3,671
THERMAL REPLACEMENT
2,199 AVERAGE MW
2500.0
2000
0
0
20
40
60
80
100
PERCENT ØF TIME

6 November 1972

Downstream Power Benefit Computations for 1977-78 Operating Year

The Columbia River Treaty, Annex B, paragraph 5, requires that estimates of the downstream power benefits should be made for each operating year. For the operating year 1977-78, the results of the studies are provided in the document "Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1977-78," dated October 16, 1972.

The determination of the benefits was based on the 1977-78 Assured Operating Plan (A.O.P.), dated 16 October 1972, which was designed to achieve optimum power generation at-site in Canada and downstream in the United States of America, as required by Annex A, paragraph 7.

The downstream power benefits for the operating year 1977-78 have been established as:

Dependable Capacity	:	2824.0 mw.
Average Annual Usable Energy	:	1345.0 mw.

The Canadian Entitlement, which is one-half the computed downstream power benefits, was computed to be:

Dependable Capacity	:	1412.0 mw.
Average Annual Usable Energy	:	672.5 mw.

Procedure

In addition to the determination of downstream power benefits for the operating year 1977-78, separate determinations were carried out in accordance with the document, "Operating Plans with Mica Generation," dated 15 November 1971, which was agreed by the Entities to implement the provisions of Annex A, paragraph 7, relating to the limit of year-to-year change in the operation of Canadian storage in operating plans designed to achieve optimum generation at-site in Canada and downstream in Canada and the United States of America.

Results

The minimum permitted downstream power benefits computed in accordance with paragraph 4 of the document dated 15 November 1971 were those determined for 15 m.a.f. of Canadian storage operated for optimum generation in the United States:

Dependable Capacity	:	2780.0 mw.
Average Annual Usable Energy	:	1340.0 mw.

The change in operation of the Canadian storage in the 1977-78 AOP as compared with that in the 1976-77 AOP is therefore within the permitted range.

Reduction in Canadian Entitlement

The Canadian Entitlement to downstream power benefits was sold in the United States of America under the Canadian Entitlement Purchase Agreement dated 13 August 1964. By definition, the Canadian Entitlement for 1977-78 which was sold was that which would have been computed if the 1977-78 Assured Operating Plan had been designed to achieve optimum generation downstream in the United States alone. The Canadian Entitlement determined for the conditions above would have been:

Dependable Capacity	:	½ of 2827.0 mw. or 1413.5 mw.
Average Annual Usable Energy	:	½ of 1356.0 mw. or 678.0 mw.

Since the 1977-78 AOP was in fact designed to achieve optimum generation at-site in Canada and downstream in the United States of America, there will be a reduction in the Canadian Entitlement as defined in the Canadian Entitlement Purchase Agreement. Section 7 of the Agreement requires that "any reduction in the Canadian Entitlement resulting from action taken pursuant to paragraph 7 of Annex A of the Treaty shall be determined in accordance with subsection (3) of Section 6 of this Agreement." The Canadian Entitlement to downstream power benefits under the 1977-78 Assured Operating Plan was determined as:

Dependable Capacity	:	½ of 2824.0 mw. or 1412.0 mw.
Average Annual Usable Energy	:	½ of 1345.0 mw. or 672.5 mw.

The reduction in the Canadian Entitlement therefore amounts to 1.5 megawatts of dependable hydroelectric capacity and 5.5 average megawatts of average annual usable energy. This reduction would be in respect of the period 1 April 1977 through 31 March 1978 in accordance with the document, "Procedures for the Determination of Downstream Power Benefits Resulting from Canadian Storage," dated 9 September 1968.

The Entities are agreed that the United States Entity is entitled to receive during the period 1 April 1977 through 31 March 1978, from B. C. Hydro & Power Authority, 1.5 megawatts of capacity and 5.5 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement dated 13 August 1964.