COLUMBIA RIVER TREATY HYDROELECTRIC OPERATING PLAN

ASSURED OPERATING PLAN FOR OPERATING YEAR 1988-89

COLUMBIA RIVER TREATY OPERATING COMMITTEE

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TABLE OF CONTENTS

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Operating Year 1988-89

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 1988-89 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 1988-89.

This Assured Operating Plan was prepared in accordance with the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans.[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] Terms of Sale,[4] and the Columbia River Treaty Flood Control Operating Plan.[5]

The Assured Operating Plan consists of:

(a) The Operating Rule Curve for the whole of the Canadian storage, including the Critical Rule Curve, Assured Refill Curve, Variable Refill Curves, and the individual project Upper Rule Curves.

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

A 30-year System Regulation Study[6] 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 Treaty 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 is a reduction of 2.8 average megawatts of average annual usable energy in the Canadian Entitlement of downstream power benefits. This is within the limits specified by the Treaty.

System Regulation Studies for the Assured Operating Plan were based on 1988-89 estimated loads and resources in British Columbia and in the United States Pacific Northwest System. The Entities have agreed that the 1988-89 Assured Operating Plan would be based on a 30-year streamflow period and an operating year of 1 August to 31 July. Historical flows for the period August 1928 through July 1958, modified to estimated 1988-89 conditions,[7] were used.

The Critical Rule Curve for these studies was determined from Bonneville Power Administration Study 89-41. The study indicated a 42-1/2 month critical period for the United States system resulting from the low flows during the period from 16 August 1928 through February 1932. It was assumed that all reservoirs, both in the United States and Canada, were full at the beginning of the critical period except where minimum release requirements made this impossible.

In the studies, individual project flood control criteria were followed. Flood Control and Variable Refill Criteria are based on historical inflow volumes. Although only 7.0 million acre-feet of usable storage at Mica is committed for power operation purposes under the Treaty, the Columbia River Treaty Flood Control Operating Plan provides for the full draft of the total 12 million acre-feet of storage at Mica in an on-call flood control situation.

DETERMINATION OF OPTIMUM GENERATION IN CANADA AND THE UNITED STATES

In order to determine whether optimum generation in both Canada and the United States was achieved in the system regulation studies, the following three quantities were computed for both the Canadian and United States systems:

(a) firm energy capability

(b) January peaking capability

(c) average annual usable secondary energy

In the studies for the 1988-89 Assured Operating Plan, the Canadian storage operation was operated to achieve a weighted sum of the three quantities that was greater than the weighted sum achieved under an operation of Canadian storage for optimum generation in the United States alone.

The table on page 5 shows the results from the studies adopted for the 1988-89 Assured Operating Plan and from studies designed to achieve optimum generation in the United States.

The Columbia River Treaty Operating Committee agreed that for the 1988-89 Assured Operating Plan the three quantities would be assigned the following relative values:

Quantity	Relative Value
firm energy capability (Av. MW)	3
January peaking capability (MW)	1
average annual usable secondary energy (Av. MW)	2

The three quantities were added after weighting on this basis and there was a net gain to the combined Canadian and United States systems with the study designed for optimum generation in Canada and the United States.

OPERATING RULE CURVES

The operation of Canadian storage during the 1988-89 Operating Year shall be guided by an Operating Rule Curve for the whole of Canadian storage, Flood Control Storage Reservation Curves for the individual projects, and operating rules for specific projects. The Operating Rule Curve is derived from the various curves described below. These curves are first determined for the individual Canadian projects, which in turn are used to determine Operating Rules Curves for the individual projects which are then summed to yield the Composite Operating Rule Curve for the whole of Canadian storage. This is in accordance with the provision of Article VII(2) of the Protocol.

COMPARISON OF ASSURED OPERATING PLAN STUDY RESULTS

	Optimum Generation in Canada and the United States	Optimum Generation in the United States					
	Study No. 89-41	Study No. 89-11	Loss	Gain	Net Gain	Weight	Value
1. Firm Energy Capability (Av. MW)							
U.S. System1/	12,224	12,225	1	-			
Canada (Mica + Rev.)2/	1,598	1,546	-	52			
Total (Av. MW)	13,822	13,771	1	52	51	3	153
2. January Peaking Capacity (MW)							
U.S. System3/	31,440	31,443	3	-			
Canada (Mica + Rev.)4/	3,387	3,410	23	-			
Total (MW)	34,827	34,853	26	-	(26)	1	(26)
3. Average Annual Usable Secondary Energy (Av. MW)							
U.S. System5/	3,020	3,021	1	-			
Canada (Mica + Rev.)6/	153	199	46	-			
Total (Av. MW)	3,173	3,220	47	-	(47)	2	(94)
						Total Value	33

1/ U.S. System firm energy capability was determined over the U.S. system critical period beginning 16 August 1928 and ending 29 February 1932.

2/ Canadian (Mica + Revelstoke) system firm energy capability was determined over the Canadian system critical period beginning 1 October 1940 and ending 30 April 1946.

3/ U.S. system January peaking capability was determined from January 1937.

4/ Canadian (Mica + Revelstoke) system January peaking capability was determined from January 1945.

5/ U.S. system 30-year average secondary energy limited to secondary market.

6/ Canadian (Mica and Revelstoke) 30-year average generation minus firm generation.

(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 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 in 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 United States system or the Mica and Revelstoke generating plants during subsequent years. The end of the refill period is considered to be 31 July.

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 1930-31 water year, the system's second lowest historical volume of inflow for the period January through July as measured at The Dalles, Oregon. The tabulation of the composite Assured Refill Curve for the whole of Canadian storage is included as Table 2.

The schedule of outflows is the same as the Power Discharge Requirements used in computing the Variable Refill Curve discussed in (2) below when The Dalles volume runoff is at 80 million acre-feet.

(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 during the refill period. It was based on historical inflow volume and Power Discharge Requirements determined in accordance with the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans.[1] 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 80 million acre-feet, the discharge used was that required to meet firm loads while refilling at 80 million acre-feet. In years when the runoff volume at The Dalles exceeded 95 million acre-feet, the Power Discharge Requirement was the project minimum outflow. For intermediate volumes, the Power Discharge Requirement used in computing the Variable Refill Curves was interpolated linearly between the values shown in the table on page 8.

Composite Variable Refill Curves for the whole of Canadian storage for the 30 years of historical record are recorded in Table 3; the effect of the Limiting Rule Curve, as described below, is included. These illustrate the probable range of these curves based on historical conditions. In the actual operation in 1988-89, the Power Discharge Requirements will be based on the forecast of unregulated runoff at The Dalles.

(c) Limiting Rule Curve. The Limiting Rule Curves indicate month-end storage contents which must be maintained to guarantee the system meeting its firm load during the period January 1 - March 31 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 be developed for 1936-37 water conditions.

POWER DISCHARGE REQUIREMENTS IN CFS
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

80 MAF

Project	January February March	April	May	June	July
Mica	3,000	11,600	11,600	11,600	14,600
Arrow	5,000	22,000	31,000	31,000	48,000
Duncan	100	1,700	1,700	1,700	1,700

POWER DISCHARGE REQUIREMENTS IN CFS
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

90 MAF

Project	January February March	April	May	June	July
Mica	3,000	3,000	3,000	3,000	3,000
Arrow	5,000	9,600	9,600	26,500	29,000
Duncan	100	900	900	900	900

POWER DISCHARGE REQUIREMENTS IN CFS
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

95 MAF

Project	January February March	April	May	June	July
Mica	3,000	3,000	3,000	3,000	3,000
Arrow	5,000	5,000	5,000	14,000	14,000
Duncan	100	100	100	100	100

(d) Upper Rule Curve. The Upper Rule Curves[8] indicate end-of-month storage content to which each individual Canadian storage project shall be evacuated for flood control and other requirements. The Upper Rule Curves used in the studies were based upon Flood Control Storage Reservation Diagrams contained in the Columbia River Treaty Flood Control Operating Plan and analysis of system flood control simulations. Each Upper Rule Curve is constrained to be not lower than the Variable Refill Curve, except in those years in which the April-August unregulated volume of runoff for the Columbia River at The Dalles exceeds 120 million acre-feet, and Canadian storage is subject to on-call request. Flood control curves for each of the Canadian Treaty projects for the 30 year study period are shown on Tables 4, 5, and 6; however, the tables do not reflect the constraint that the Upper Rule Curve not be lower than the Variable Refill Curve. Table 5 and 6 reflect an assumed transfer of 2 million acre-feet of flood control storage space from Arrow to Mica. In actual operation, the Flood Control Storage Reservation Curves will be computed as outlined in the Flood Control Operating Plan, using the latest forecast of runoff available at that time.

(e) Definition of Operating Rule Curve. During the period 1 August through 31 December, 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. During the period 1 January through 31 July, the Operating Rule Curve is defined by the higher of the Critical Rule Curve and the Assured Refill Curve; unless the Variable Refill Curve is lower than this value, then it is defined by the Variable Refill Curve. During the period 1 January through 31 March, it will not be lower than the Limiting Rule Curve. The Operating Rule Curve meets all requirements for flood control operation. 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 89-41 System Regulation Study, will apply to the operation of Canadian storage in the 1988-89 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 (d) below.

(b) The whole of 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 Energy Content 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 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 accordance with (d) below, so as to optimize generation at site as well as downstream in the United States. In the event the Mica operation results in less than the project's proportional share of draft from the whole of Canadian storage, compensating drafts will be made from Arrow to the extent possible.

(d) Mica project operation will be determined by the end of previous period Arrow storage content as shown in the table on page 12 and as qualified in (1) and (2) below:

(1) Mica monthly outflows will be increased in the months from October to June if required to avoid violation of the Upper Rule Curve.

(2) Mica monthly average outflows will be decreased to minimum if required to avoid withdrawing more than 7 million acre-feet of storage.

Under this Assured Operating Plan, Mica storage releases in excess of the 7 million acre-feet that are required to maintain the minimum Mica outflows specified under this plan will be retained in the Arrow reservoir, subject to flood control criteria at Arrow. The total combined storage draft from Mica and Arrow will not exceed 14.1 million acre-feet unless flood control criteria will not permit the additional Mica storage releases for minimum flow purposes to be retained at Arrow. Should storage releases in excess of 14.1 million acre-feet be made, the target Mica operation will remain as specified in the table on page 12.

Revelstoke has been included in the 1988-89 Assured Operating Plan and has been operated as a run-of-river project.

MICA PROJECT OPERATING CRITERIA

Month	End of Previous Period Arrow Storage Content (KSFD)	Target Operation Period Average Outflow (CFS)	Target Operation End-of-Period[1] Storage Content (KSFD)	Minimum Outflow (CFS)
August 1-15	0 - FULL	-	3 456.2	10 000
August 16-31	2 500 - FULL	-	3 529.2	10 000
	0 - 2 500	30 000		
September	2 300 - FULL	-	3 529.2	10 000
	0 - 2 300	30 000		
October	3 200 - FULL	10 000	-	10 000
	0 - 3 200	27 000		
November	3 200 - FULL	-	3 122.2	10 000
	0 - 3 200	32 000		
December	3 200 - FULL	28 000	-	15 000
	0 - 3 200	34 000		
January	2 800 - FULL	28 000	-	15 000
	0 - 2 800	34 000		
February	600 - FULL	23 000	-	15 000
	0 - 600	28 000		
March	0 - FULL	17 000	-	15 000
April 1-15	0 - FULL	15 000	-	15 000
April 16-30	300 - FULL	10 000	-	10 000
	0 - 300	20 000		
May	350 - FULL	10 000	-	10 000
	0 - 350	20 000		
June	0 - FULL	10 000	-	10 000
July	0 - FULL	-	3 356.2	10 000

NOTE: (1) A maximum outflow of 34000 cfs will apply if the target end of period storage content is less than 3529.2 KSFD.

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 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 1988-89 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 1988, 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 1988-89 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 1988-89 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 Assured Operating Plan studies 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,[5] 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 dated May 1983.

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 1961.

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 Columbia River Treaty Flood Control Operating Plan dated October 1972.

6 BPA Hydroelectric Power Planning Program, Assured Operating Plan 30-year System Regulation Study 89-41, dated 17 October 1983.

7 Provisional Report on Modified Flows at Selected Sites, 1928 to 1968 for the 1970 and 2020 Level of Development, Columbia River and Coastal Basins, Columbia River Water Management Group, Revision 2, dated April 1974 and May 1974, respectively.

8 Summary of End-of-month Reservoir Storage Requirement from Columbia River Flood Regulation Studies dated April 1973 and as updated March 1975.

COLUMBIA RIVER TREATY
COMPOSITE CRITICAL RULE CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1988-89 OPERATING YEAR

TABLE 1

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	7814.6	7814.6	7790.5	7575.8	7281.6	5961.3	3972.5	2822.3	2678.4	1584.9	928.1	2367.8	5788.3	7189.7
2ND YR	7712.0	7800.8	7422.6	6938.5	5938.9	4568.3	2626.7	1981.3	1915.8	922.9	906.9	2255.6	4274.8	6665.1
3RD YR	7145.0	7417.2	7206.8	7154.8	5890.4	4393.0	2592.1	1667.2	1627.6	650.5	175.1	1528.1	3412.2	4988.8
4TH YR	5217.4	5197.8	4923.1	4292.1	3137.7	1215.7	575.4	0.0	0.0	0.0	0.0	109.0	3861.2	0.0

COLUMBIA RIVER TREATY
COMPOSITE ASSURED REFILL CURVE
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1988-89 OPERATING YEAR

TABLE 2

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
37.8	881.9	1996.4	2332.7	2490.7	2557.7	2615.9	2648.6	2747.9	2595.0	2529.6	3766.4	6421.4	7814.6

COLUMBIA RIVER TREATY
COMPOSITE VARIABLE REFILL CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1988-89 OPERATING YEAR

TABLE 3

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							6126.7	5964.6	5919.3	5944.7	5970.3	5763.2	6891.9	7814.6
1929-30							4193.9	3601.9	3631.2	4172.7	4714.1	4571.8	6627.1	,,
1930-31							4558.6	4296.7	4403.3	4790.1	5176.9	4532.9	6785.5	,,
1931-32							1760.1	758.6	372.2	21.3	42.5	1154.2	5007.1	,,
1932-33							,,	,,	,,	131.6	263.3	1141.6	4666.3	,,
1933-34							,,	,,	,,	24.7	49.4	1471.7	5582.7	,,
1934-35							1961.6	1364.9	1483.2	1930.1	2377.2	2881.5	5640.3	,,
1935-36							2060.7	1462.5	1399.6	1810.5	2221.5	2950.8	6319.5	,,
1936-37							6191.5	5878.8	5819.2	5876.9	5934.5	5841.0	6910.3	,,
1937-38							1760.1	758.6	372.2	623.2	1223.2	2154.5	5395.9	,,
1938-39							4217.5	3665.4	3788.8	4252.2	4715.7	4410.7	6896.0	,,
1939-40							3733.8	3139.1	3264.1	3840.0	4416.0	4087.4	6718.7	,,
1940-41							5153.2	5070.3	5225.1	5443.7	5662.4	5726.4	6966.8	,,
1941-42							3664.8	3077.5	3066.3	3446.1	3825.6	4160.7	6438.0	,,
1942-43							2470.9	1885.8	1842.6	2406.2	2969.8	3677.2	5892.9	,,
1943-44							6455.8	6144.1	6099.7	6126.6	6153.5	6078.6	7126.0	,,
1944-45							6288.8	5976.4	5935.8	5966.4	5997.0	5883.9	6973.6	,,
1945-46							1760.1	758.6	372.2	77.6	155.2	1155.9	5224.3	,,
1946-47							,,	,,	,,	393.4	786.7	1880.5	5401.9	,,
1947-48							,,	,,	,,	210.7	421.3	1337.9	5207.9	,,
1948-49							2291.0	1705.1	1693.4	2435.0	3176.6	3705.4	6649.2	,,
1949-50							1760.1	758.6	372.2	360.7	721.5	1512.1	4635.3	,,
1950-51							,,	,,	,,	519.8	1039.5	1897.0	5497.3	,,
1951-52							,,	,,	,,	765.2	1307.2	2328.9	5636.7	,,
1952-53							,,	1016.4	977.7	1421.3	1890.6	2589.0	5559.4	,,
1953-54							,,	758.6	372.2	23.4	46.8	828.3	4585.0	,,
1954-55							,,	,,	500.9	955.9	1485.8	2175.8	4913.0	,,
1955-56							,,	,,	372.2	246.6	493.2	1592.7	5300.9	,,
1956-57							,,	,,	,,	278.2	556.6	1453.1	5772.1	,,
1957-58							,,	,,	,,	176.2	352.4	1269.7	5364.0	,,

FLOOD CONTROL STORAGE RESERVATION CURVES
DUNCAN
KSFO
1988-89 OPERATING YEAR

TABLE 4

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	705.8	705.8	705.8	705.8	705.8	504.1	397.2	303.0	303.0	311.0	324.6	416.4	560.6	705.8
1929-30	"	"	"	"	"	"	385.7	281.3	281.3	289.9	304.0	400.6	553.0	"
1930-31	"	"	"	"	"	"	368.5	268.0	268.0	257.1	272.7	377.1	540.9	"
1931-32	"	"	"	"	"	"	272.2	65.5	65.5	80.6	108.9	281.3	609.5	"
1932-33	"	"	"	"	"	"	"	"	"	75.1	94.2	191.5	573.2	"
1933-34	"	"	"	"	"	"	"	"	"	65.5	127.0	339.8	605.5	"
1934-35	"	"	"	"	"	"	"	"	"	"	83.7	187.0	488.0	"
1935-36	"	"	"	"	"	"	"	"	"	71.1	119.5	351.9	705.8	"
1936-37	"	"	"	"	"	"	353.9	219.0	219.0	229.4	246.0	356.9	530.9	"
1937-38	"	"	"	"	"	"	272.2	65.5	65.5	77.1	83.7	217.3	542.4	"
1938-39	"	"	"	"	"	"	"	"	"	82.6	107.4	385.7	705.8	"
1939-40	"	"	"	"	"	"	"	"	"	78.1	103.8	"	"	"
1940-41	"	"	"	"	"	"	321.1	156.3	156.3	167.3	186.0	311.0	508.2	"
1941-42	"	"	"	"	"	"	302.0	121.0	121.0	131.0	155.2	291.9	483.0	"
1942-43	"	"	"	"	"	"	305.0	126.0	126.0	141.1	172.9	248.0	647.8	"
1943-44	"	"	"	"	"	"	392.7	294.4	294.4	302.5	316.6	410.4	557.6	"
1944-45	"	"	"	"	"	"	361.5	234.4	234.4	235.9	236.9	349.9	567.7	"
1945-46	"	"	"	"	"	"	272.2	65.5	65.5	75.6	95.8	322.1	647.3	"
1946-47	"	"	"	"	"	"	"	"	"	77.1	101.8	314.1	629.7	"
1947-48	"	"	"	"	"	"	"	"	"	65.5	65.5	300.4	705.8	"
1948-49	"	"	"	"	"	"	348.3	208.7	208.7	215.2	236.9	408.8	"	"
1949-50	"	"	"	"	"	"	272.2	65.5	65.5	72.1	84.7	184.0	525.3	"
1950-51	"	"	"	"	"	"	"	"	"	79.6	103.3	285.3	534.4	"
1951-52	"	"	"	"	"	"	"	"	"	65.5	67.5	92.2	255.1	"
1952-53	"	"	"	"	"	"	"	"	"	72.1	84.7	234.4	522.8	"
1953-54	"	"	"	"	"	"	"	"	"	73.1	84.2	236.9	547.5	"
1954-55	"	"	"	"	"	"	"	"	"	72.1	80.6	154.7	488.5	"
1955-56	"	"	"	"	"	"	"	26.7	26.7	26.7	26.7	239.9	578.2	"
1956-57	"	"	"	"	"	"	"	65.5	65.5	74.6	89.7	376.1	655.9	"
1957-58	"	"	"	"	"	"	"	"	"	77.1	96.3	359.4	705.8	"

FLOOD CONTROL STORAGE RESERVATION CURVES

ARROW

KSFD

1988-89 OPERATING YEAR

TABLE 5

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	3579.6	3579.6	3579.6	3453.6	3453.6	3075.4	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	3579.6	3579.6
1929-30	"	"	"	"	"	"	3060.8	3047.7	3033.1	3047.2	3071.9	3207.0	"	"
1930-31	"	"	"	"	"	"	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	"	"
1931-32	"	"	"	"	"	"	2364.6	1719.2	1008.3	1015.9	1126.8	2224.4	"	"
1932-33	"	"	"	"	"	"	"	"	"	1008.3	1036.6	1761.6	3034.6	"
1933-34	"	"	"	"	"	"	"	"	"	"	1784.8	2327.2	3579.6	"
1934-35	"	"	"	"	"	"	"	"	"	"	1008.3	1725.8	3034.6	"
1935-36	"	"	"	"	"	"	"	"	"	1069.9	1373.4	2134.7	3579.6	"
1936-37	"	"	"	"	"	"	2998.3	2927.7	2850.6	2869.7	2902.5	3082.5	"	"
1937-38	"	"	"	"	"	"	2364.6	1719.2	1008.3	1083.0	1278.1	1831.1	3147.5	"
1938-39	"	"	"	"	"	"	2637.8	2243.6	1805.9	1869.5	1983.4	2735.1	3579.6	"
1939-40	"	"	"	"	"	"	2849.6	2645.4	2420.0	2454.8	2536.0	2999.8	"	"
1940-41	"	"	"	"	"	"	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	"	"
1941-42	"	"	"	"	"	"	2364.6	1719.2	1008.3	1064.8	1149.5	1934.0	"	"
1942-43	"	"	"	"	"	"	"	"	"	1111.2	1321.9	1440.4	2389.3	"
1943-44	"	"	"	"	"	"	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	3579.6	"
1944-45	"	"	"	"	"	"	2641.8	2251.6	1818.0	1842.7	1908.3	2477.0	3368.4	"
1945-46	"	"	"	"	"	"	2364.6	1719.2	1008.3	1072.4	1242.3	2201.2	3579.6	"
1946-47	"	"	"	"	"	"	"	"	"	1075.4	1360.8	2147.3	"	"
1947-48	"	"	"	"	"	"	"	"	"	1036.6	1183.3	2216.8	"	"
1948-49	"	"	"	"	"	"	"	"	"	1144.5	1375.9	2494.6	"	"
1949-50	"	"	"	"	"	"	"	"	"	1103.6	1113.7	1113.7	2232.5	"
1950-51	"	"	"	"	"	"	"	"	"	1052.2	1101.1	1355.2	3338.1	"
1951-52	"	"	"	"	"	"	"	"	"	1069.9	1345.1	1792.3	3013.9	"
1952-53	"	"	"	"	"	"	"	"	"	1057.3	1172.7	1476.2	"	"
1953-54	"	"	"	"	"	"	"	"	"	"	1134.4	1628.0	1898.2	"
1954-55	"	"	"	"	"	"	"	"	"	1075.4	1090.5	1653.7	3224.7	"
1955-56	"	"	"	"	"	"	"	857.1	0.0	0.0	289.9	1367.3	2763.4	"
1956-57	"	"	"	"	"	"	"	1719.2	1008.3	1077.9	1224.1	2651.4	3579.6	"
1957-58	"	"	"	"	"	"	"	"	"	1046.7	1190.9	2242.5	"	"

FLOOD CONTROL STORAGE RESERVATION CURVES

NICA

KSFD

1988-89 OPERATING YEAR

TABLE 6

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	3529.2	3529.2	3529.2	3428.4	3428.4	3428.4	3406.7	3367.0	3365.3	3369.9	3380.5	3412.2	3469.7	3529.2
1929-30	"	"	"	"	"	"	3378.5	3332.6	3282.7	3290.2	3305.9	3353.2	3440.0	"
1930-31	"	"	"	"	"	"	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	"
1931-32	"	"	"	"	"	"	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	"
1932-33	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1933-34	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1934-35	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1935-36	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1936-37	"	"	"	"	"	"	3353.2	3283.7	3208.5	3218.1	3238.3	3300.8	3413.2	"
1937-38	"	"	"	"	"	"	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	"
1938-39	"	"	"	"	"	"	3213.1	3018.5	2806.7	2828.4	2873.8	3013.9	3267.5	"
1939-40	"	"	"	"	"	"	3296.8	3174.3	3042.7	3057.3	3088.1	3182.3	3353.2	"
1940-41	"	"	"	"	"	"	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	"
1941-42	"	"	"	"	"	"	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	"
1942-43	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1943-44	"	"	"	"	"	"	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	"
1944-45	"	"	"	"	"	"	3214.6	3021.5	2811.3	2832.9	2878.3	3017.5	3269.6	"
1945-46	"	"	"	"	"	"	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	"
1946-47	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1947-48	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1948-49	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1949-50	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1950-51	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1951-52	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1952-53	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1953-54	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1954-55	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1955-56	"	"	"	"	"	"	2067.1	1058.8	100.9	100.9	100.9	803.7	2363.6	"
1956-57	"	"	"	"	"	"	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	"
1957-58	"	"	"	"	"	"	"	"	"	"	"	"	"	"

COLUMBIA RIVER TREATY
COMPOSITE OPERATING RULE CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1988-89 OPERATING YEAR

TABLE 7

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	7814.6	7814.6	7790.5	7575.8	7281.6	5961.3	3972.5	2909.4	2988.5	2595.0	2529.6	3766.4	6421.4	7814.6
1929-30	"	"	"	"	"	"	3540.8	2770.0	"	"	"	"	6410.3	"
1930-31	"	"	"	"	"	"	3972.5	2909.4	"	"	"	"	6421.4	"
1931-32	"	"	"	"	"	"	1760.1	758.6	372.2	21.3	42.5	1154.2	5007.1	"
1932-33	"	"	"	"	"	"	"	"	"	131.6	263.3	1141.6	4666.3	"
1933-34	"	"	"	"	"	"	"	"	"	24.7	49.4	1471.7	5582.7	"
1934-35	"	"	"	"	"	"	1961.6	1364.9	1483.2	1930.1	2301.2	2881.5	5640.3	"
1935-36	"	"	"	"	"	"	2060.7	1462.5	1399.6	1810.5	2221.5	2950.8	6319.5	"
1936-37	"	"	"	"	"	"	3972.5	2909.4	2988.5	2595.0	2529.6	3766.4	6421.4	"
1937-38	"	"	"	"	"	"	1760.1	758.6	372.2	623.2	1223.2	2154.5	5395.9	"
1938-39	"	"	"	"	"	"	3640.0	2884.4	2958.1	2595.0	2529.6	3726.3	6421.4	"
1939-40	"	"	"	"	"	"	3503.0	2787.3	2954.2	"	"	3728.5	"	"
1940-41	"	"	"	"	"	"	3959.6	2909.4	2988.5	"	"	3766.4	"	"
1941-42	"	"	"	"	"	"	3318.8	2299.9	2548.2	2466.2	"	3571.0	6302.0	"
1942-43	"	"	"	"	"	"	2470.9	1885.8	1842.6	2366.0	2486.6	3644.4	5892.9	"
1943-44	"	"	"	"	"	"	3972.5	2909.4	2988.5	2595.0	2529.6	3766.4	6421.4	"
1944-45	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1945-46	"	"	"	"	"	"	1760.1	758.6	372.2	77.6	155.2	1155.9	5224.3	"
1946-47	"	"	"	"	"	"	"	"	"	393.4	786.7	1880.5	5401.9	"
1947-48	"	"	"	"	"	"	"	"	"	210.7	421.3	1337.9	5207.9	"
1948-49	"	"	"	"	"	"	2291.0	1705.1	1662.8	2148.7	2519.8	3439.9	6374.3	"
1949-50	"	"	"	"	"	"	1760.1	758.6	372.2	360.7	721.5	1512.1	4635.3	"
1950-51	"	"	"	"	"	"	"	"	"	519.8	1039.5	1897.0	5497.3	"
1951-52	"	"	"	"	"	"	"	"	"	765.2	1307.2	2328.9	5636.7	"
1952-53	"	"	"	"	"	"	"	1016.4	977.7	1421.3	1890.6	2589.0	5559.4	"
1953-54	"	"	"	"	"	"	"	758.6	372.2	23.4	46.8	828.3	4585.0	"
1954-55	"	"	"	"	"	"	"	"	500.9	955.9	1485.8	2175.8	4913.0	"
1955-56	"	"	"	"	"	"	"	737.3	74.9	0.0	289.9	1592.7	5225.8	"
1956-57	"	"	"	"	"	"	"	758.6	372.2	278.2	556.6	1453.1	5772.1	"
1957-58	"	"	"	"	"	"	"	"	"	176.2	352.4	1269.7	5364.0	"

Columbia River Treaty

Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1988-89

Columbia River Treaty Operating Committee

October 1983

DETERMINATION OF DOWNSTREAM POWER BENEFITS RESULTING FROM
CANADIAN STORAGE FOR OPERATING YEAR 1988-89
October 1983

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 require that downstream power benefits from Canadian storage be determined in advance by the two Entities. The purpose of this report is to describe the results of those downstream power benefit computations developed from the 1988-89 Assured Operating Plan .

The procedures followed in the benefit studies are those provided in Annex A, Paragraph 7, and Annex B of the Treaty; in Articles VIII, IX, and X of the Protocol; and in the document, "Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans," dated May 1983 (POP).

The Canadian Entitlement Benefits were computed from the following studies:

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.

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.

Step III - based on the U.S. base hydro and thermal system operated for optimum generation in the U.S.

As part of the determination of downstream power benefits for the operating year 1988-89, separate determinations were carried out relating to the limit of year-to-year change in benefits attributable to 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.

II. Results of Study.

(a) The Canadian Entitlement, which is one-half the total computed downstream power benefits, was computed to be 1/:

Dependable Capacity	=	1,321.6 MW
Average Annual Energy	=	544.9 MW

(b) One-half of the downstream power benefits determined for 15 maf of Canadian storage operated for optimum generation in the United States was computed to be 2/:

Dependable Capacity	=	1,298.8 MW
Average Annual Energy	=	546.9 MW

In accordance with Part III, Paragraph 15c(2) of POP, the Canadian share of the minimum permitted downstream power benefits for the 1988-89 operating year are as follows:

Dependable Capacity	= 1,318.0 - (1,318.0 - 1,298.8)	= 1,298.8 MW
Average Annual Energy	= 524.5 - (528.0 - 546.9)	= 543.4 MW

The above computations are based on the formula X - (Y - Z), where the quantities X, Y, and Z are defined in POP 3/. The quantities X and Y are derived from the downstream power benefit computations set out in the 1987-88 agreement. The computed downstream power benefits exceed these amounts.

III. Effect on Canadian Entitlement.

The Canadian Entitlement to downstream power benefits for operating year 1988-89 was sold to the United States of America under the Canadian Entitlement Purchase Agreement dated 13 August 1964. The studies developed for this sale included the assumption of optimum generation downstream in the United States alone. The Canadian Entitlement determined from the 1988-89 Assured Operating Plan for this condition would have been 4/:

Dependable Capacity	= 1/2 of 2,643.1 MW	or 1,321.6 MW
Average Annual Energy	= 1/2 of 1,095.3 MW	or 547.7 MW

Since the 1988-89 Assured Operating Plan was in fact designed to achieve optimum generation at-site in Canada and downstream in the United States of America, 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 1988-89 Assured Operating Plan was determined to be 1/:

Dependable Capacity	= 1/2 of 2,643.1 MW	or 1,321.6 MW
Average Annual Energy	= 1/2 of 1,089.8 MW	or 544.9 MW

A comparison indicates a reduction in Canadian Entitlement of 2.8 average megawatts of average annual usable energy, but no reduction in dependable capacity. This reduction is for the period 1 April 1988 through 31 March 1989 in accordance with POP.

The Entities are agreed that the United States Entity is entitled to receive during the period 1 April 1988 through 31 March 1989, from B.C. Hydro & Power Authority, 2.8 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement dated 13 August 1964.

IV. 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 Paragraphs 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 0.98548 and 0.95151, respectively);

(4) Pro rate the average annual Step II and 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 loads for Steps II and III also become the firm energy considered usable according to Annex B, Paragraph 3(a).

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

These charts are duration curves of the secondary energy for Steps II and III 5/. The secondary energy is the capability each month which exceeds the firm hydro loads shown in Table 3. The usable secondary energy 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 percent of the remainder after thermal displacement. The thermal displacement was limited to the existing and scheduled thermal energy capability after allowance for reserve and minimum thermal generation.

Thermal Energy Capability - MW	7265 6/
Less Minimum Thermal Generation - MW	1781
Potential Thermal Displacement - MW	5484

1/ Difference between studies 89-42 and 89-13.
2/ Difference between studies 89-22 and 89-13.
3/ X = Difference between studies 88-42 and 88-13.
Y = Difference between studies 88-12 and 88-13.
Z = Difference between studies 89-22 and 89-13.
4/ Difference between studies 89-12 and 89-13.
5/ Studies 89-42 and 89-13.
6/ Thermal energy capabilities are based on an annual plant factor of 60 percent the first full year of operation and 75 percent thereafter, unless specified differently by project owner. These annual plant factors include deductions for energy reserves and scheduled maintenance. This value includes Added Thermal Requirement from the Step I Study. (See Table 2)

TABLE 1

COMPUTATION OF CANADIAN ENTITLEMENT
1988-1989

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

Determination of Dependable Capacity Credited to Canadian Storage

Critical Period Average Generation with Canadian Storage, Step II 1/	8969.5
Critical Period Average Generation without Canadian Storage Step III 2/	6969.7
Gain Due to Canadian Storage	1999.8
Estimated Average Critical Period Load Factor -- Percent	75.66
Dependable Capacity Gain 3/	2643.1
Canadian Share of Dependable Capacity 4/	1321.6

Determination of Increase in Average Annual Usable Energy

Step II (with Canadian Storage) 1/

Annual Firm Hydro Energy 5/	8733.4
Thermal Replacement Energy 6/	2079.9
Other Usable Secondary Energy 6/	272.3
System Annual Average Usable Energy	11085.6

Step III (without Canadian Storage) 2/

Annual Firm Hydro Energy 5/	6279.7
Thermal Replacement Energy 7/	3026.4
Other Usable Secondary Energy 7/	689.7
System Annual Average Usable Energy	9995.8
Average Annual Usable Energy Gain 8/	1,089.8
Canadian Share of Average Annual Energy Gain 4/	544.9

1/ Step II values were obtained from the 89-42 study.
2/ Step III values were obtained from the 89-13 study.
3/ Dependable capacity gain credited to Canadian storage equals gain in critical period average generation divided by the estimated average critical period load factor.
4/ One-half of Total Gain.
5/ From Table 3.
6/ From Chart 1.
7/ From Chart 2.
8/ Difference between Step II and Step III System Annual Average Useable Energy.

SUMMARY OF POWER REGULATIONS FROM 1988-89
ASSURED OPERATING PLAN FOR THE
COMPUTATION OF CANADIAN ENTITLEMENT
TO DOWNSTREAM BENEFITS

TABLE 2

PROJECTS	Number of Units	Nominal Installed Peaking Capacity MW	Usable Storage 1000 AF	STEP I: January Peaking Capability MW	STEP I: Critical Period Average Generation MW	STEP II: Usable Storage 1000 AF	STEP II: January Peaking Capability MW	STEP II: Critical Period Average Generation MW	STEP II: Average Annual Generation MW	STEP III: Usable Storage 1000 AF	STEP III: January Peaking Capability MW	STEP III: Critical Period Average Generation MW	STEP III: Average Annual Generation MW
CANADIAN													
Mica			7,000			7,000							
Arrow			7,100			7,100							
Duncan			1,400			1,400							
Subtotal			15,500			15,500							
BASE FEDERAL SYSTEM													
Hungry Horse	4	328	3,161	307	99	3,008	187	115	102	3,008	236	187	101
Albeni Falls	3	49	1,155	24	25	1,155	24	24	24	1,155	37	28	26
Grand Coulee	24 + 2	6,684	5,185	6,377	1,980	5,072	6,357	1,766	2,358	5,072	5,837	1,216	2,267
Chief Joseph	27	2,655		2,655	1,085		2,655	999	1,327		2,655	710	1,275
Ice Harbor	6	693		693	209		693	218	298		693	169	299
McNary	14	1,127		1,127	636		1,124	589	753		1,124	430	711
John Day	16	2,484	535	2,484	913		2,484	918	1,249		2,484	684	1,219
The Dalles	22 + 2	2,076		2,076	811		2,076	791	1,032		2,076	633	1,018
Bonneville	18 + 2	1,147		1,147	625		1,147	608	754		1,147	479	725
Subtotal		17,243	10,036	16,890	6,383	9,235	16,747	6,028	7,897	9,235	16,289	4,536	7,641
BASE SYSTEM NON-FEDERAL													
Kootenay Lake (Canadian)			649			427				427			
Kerr	3	160	1,219	150	112	1,219	149	101	115	1,219	154	132	116
Thompson Falls	6	40		40	38		40	39	38		40	39	37
Noxon Rapids	5	554	231	536	146		553	139	209		553	156	209
Cabinet Gorge	4	227		227	103		227	91	120		227	101	120
Box Canyon	4	74		71	46		71	44	48		70	51	48
Coeur d'Alene			223			223				223			
Wells	10	820		820	391		820	369	451		820	264	422
Chelan	2	54	677	51	38	676	50	37	45	676	51	49	45
Rocky Reach	11	1,267		1,267	565		1,267	533	679		1,267	382	641
Rock Island	18	544		544	274		544	259	323		544	182	298
Wanapum	10	986		986	520		986	492	607		986	347	553
Priest Rapids	10	912		912	513		912	485	580		912	355	526
Brownlee	5	675	980	675	199	974	675	245	269	974	675	262	262
Oxbow	4	220		220	83		220	107	114		220	114	113
Subtotal		6,533	3,979	6,499	3,028	3,519	6,514	2,941	3,598	3,519	6,519	2,434	3,390
TOTAL BASE SYSTEM HYDRO		23,776	29,515	23,389	9,411	28,254	23,261	8,969	11,495	12,754	22,808	6,970	11,031
ADDITIONAL STEP I PROJECTS													
Libby	4	483	4,980	397	193								
Boundary	4	655		655	359								
Spokane River Plants		157	104	155	90								
Hells Canyon	3	450		399	163								
Dworshak	3	460	2,015	460	183								
Lower Granite	6	930		930	212								
Little Goose	6	930		930	212								
Lower Monumental	6	930		930	208								
Felton, Rereg., & Round Butte		413	274	408	127								
West Side Hydro		1,381	5,693	2,787	1,068								
Subtotal		8,749	13,066	8,051	2,815								
Independent Resources		1,700	4,400	1,331	732								
TOTAL HYDRO RESOURCES		34,225	46,981	32,771	12,958								
ESTIMATED HYDRO MAINTENANCE				-1090	-61								
TOTAL IMPORTS				191	29								
MISCELLANEOUS CONTRACTS				135	124								
THERMAL RESOURCES[1]													
Small Existing Thermal Plants				1,721	228								
NPR				0	425								
Centralia #1 & #2				1,280	809								
Jim Bridger #1, #2, #3, & #4				2,027	1,409								
Colstrip #1 & #2				330	230								
Trojan				1,080	788								
Boardman				530	406								
Valmy				250	201								
WNP #2				1,100	749								
Colstrip #3 & #4				980	745								
WNP #3				1,240	802								
Added Thermal Requirement				788	473								
TOTAL THERMAL RESOURCES				11,326	7,265		11,326	7,265			11,326	7,265	
TOTAL RESOURCES (HYDRO AND THERMAL)				43,333	20,315		34,587	16,234			34,134	14,235	
RESERVES[2]				-2,595	0		-2,056	0			-1,740	0	
RESOURCES AVAILABLE FOR LOAD				40,738	20,315		32,531	16,234			32,394	14,235	
ESTIMATED LOAD													
Pacific Northwest Area				32,442	20,315		25,696	16,234			21,756	14,235	
SURPLUS OR (DEFICIT)				8,296	0		6,835	0			10,638	0	

CRITICAL PERIOD

	STEP I	STEP II	STEP III
Starts:	August 16, 1928	September 1943	September 16, 1936
Ends:	February 1932	April 1945	April 15, 1937
Length (Months):	42-1/2 Months	20 Months	7 Months
Study Identification	89-41	89-42	89-13

1/ Thermal energy capabilities are based on an annual plant factor of 60 percent the first full year of operation and 75 percent thereafter unless specified differently by project owner. These annual plant factors include deductions for energy reserves and scheduled maintenance.

2/ Peak reserves are 8 percent of peak load; energy reserve deductions have been included in thermal plant energy capability.

TABLE 3

DETERMINATION OF LOAD SHAPE FOR STEPS II AND III
1988-89 CANADIAN ENTITLEMENT COMPUTATIONS

	Pacific Northwest Area Load			Step II			Step III		
	Peak 1/	Avg.	Load Factor %	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load
Aug. 1-15	23,266	18,527	79.63	14,675	7,265	7,410	12,424	7,265	5,159
Aug. 16-31	23,187	18,311	78.97	14,504	7,265	7,239	12,280	7,265	5,015
Sep. 1-15	23,275	18,171	78.07	14,393	7,265	7,128	12,186	7,265	4,921
Sep. 16-30	23,230	18,133	78.06	14,363	7,265	7,098	12,160	7,265	4,895
October	25,695	18,809	73.20	14,899	7,265	7,634	12,614	7,265	5,349
November	28,553	21,011	73.59	16,643	7,265	9,378	14,090	7,265	6,825
December	30,746	22,746	73.98	18,017	7,265	10,752	15,253	7,265	7,988
January	32,442	23,908	73.69	18,937	7,265	11,672	16,032	7,265	8,767
February	30,466	22,554	74.03	17,864	7,265	10,599	15,124	7,265	7,859
March	28,099	20,777	73.94	16,457	7,265	9,192	13,933	7,265	6,668
Apr. 1-15	26,128	19,524	74.72	15,465	7,265	8,200	13,093	7,265	5,828
Apr. 16-30	26,136	19,578	74.91	15,508	7,265	8,243	13,129	7,265	5,864
May	25,423	18,789	73.91	14,883	7,265	7,618	12,600	7,265	5,335
June	24,979	18,933	75.80	14,997	7,265	7,732	12,697	7,265	5,432
July	24,048	18,853	78.40	14,933	7,265	7,668	12,643	7,265	5,378
Annual Average		20,198		15,998	7,265	8,733	13,545	7,265	6,280
Critical Period Avg.		20,315	75.66	16,234	7,265	8,969	14,235	7,265	6,970

January Peak 32,442

Step I Critical Per.	Critical Per.	Critical Per.
42 1/2 Months	20 Months	7 months
Aug 16, 1928 - Feb 1932	Sep 1943 - Apr 1945	Sep 16, 1936 - Apr 15, 1937
Study 89-41	Study 89-42	Study 89-13

1/ Figures in this column are peak megawatts. All other figures are monthly or semi-monthly energy in average megawatts.

2/ 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.

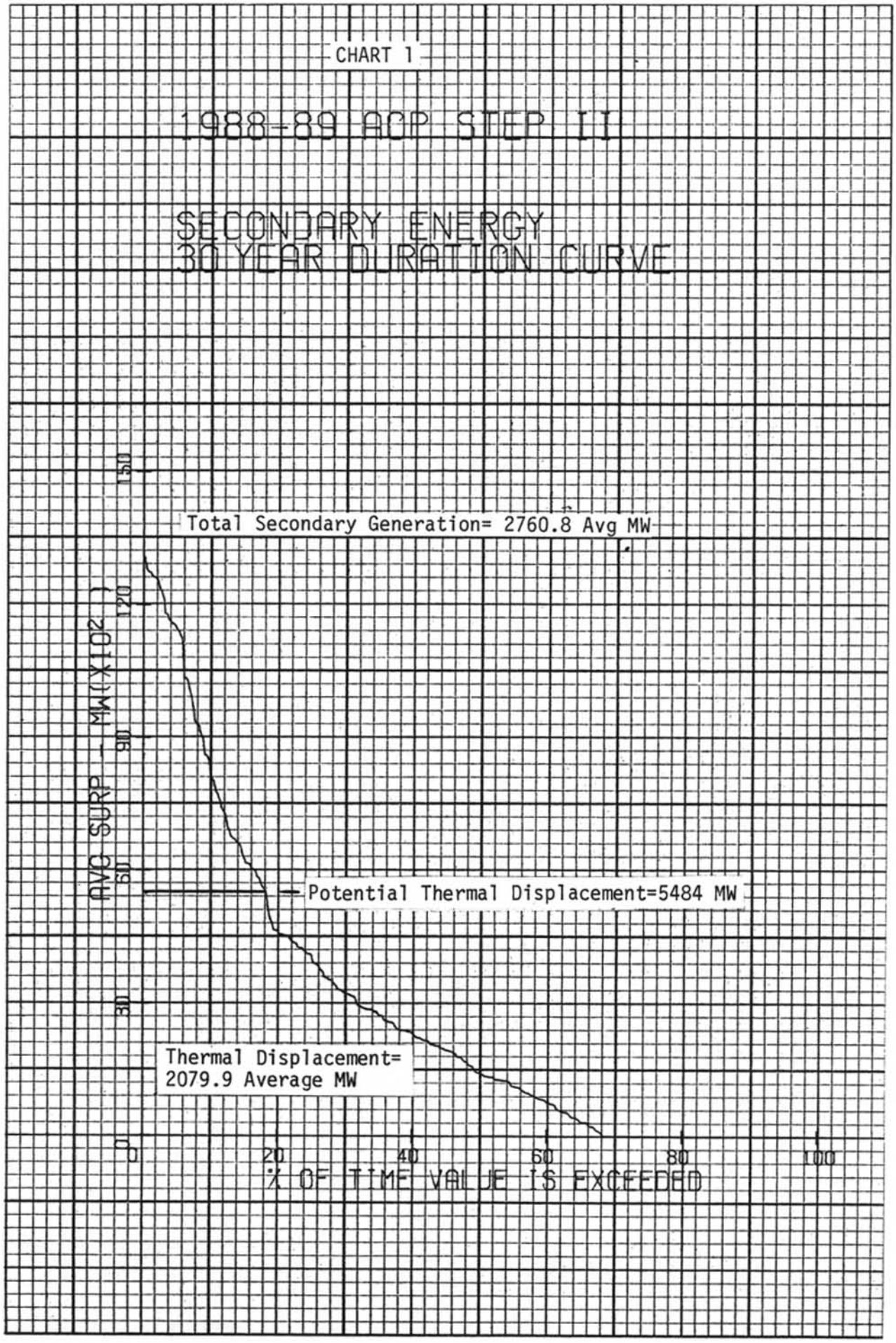
CHART 1
1988-89 ACP STEP II
SECONDARY ENERGY
30 YEAR DURATION CURVE
Total Secondary Generation= 2760.8 Avg MW
Potential Thermal Displacement=5484 MW
Thermal Displacement=
2079.9 Average MW
AVG SURP - MW(X10^2)
150
120
90
60
30
0
20
40
60
80
100
% OF TIME VALUE IS EXCEEDED

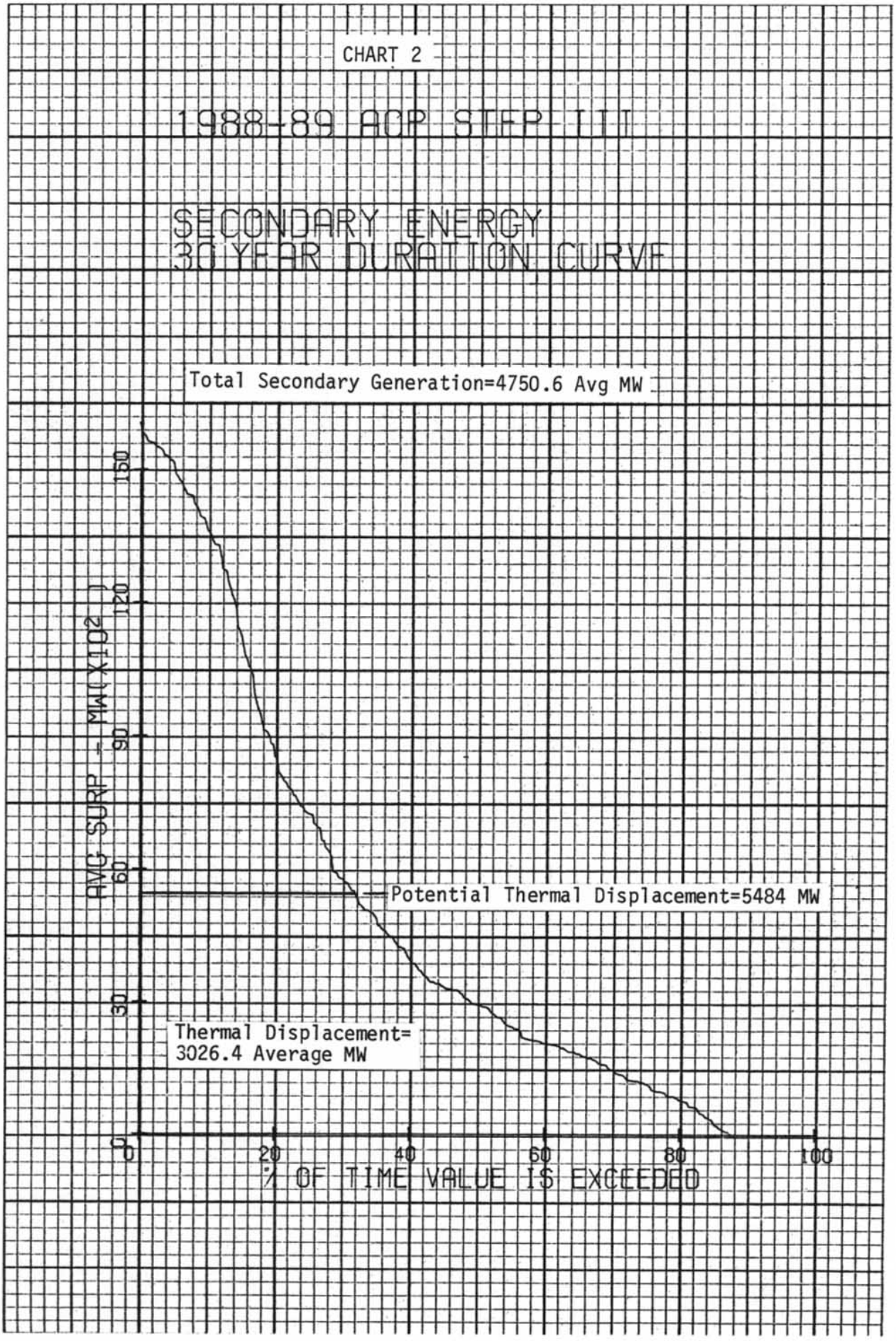
CHART 2
1988-89 ACP STEP III
SECONDARY ENERGY
30 YEAR DURATION CURVE
Total Secondary Generation=4750.6 Avg MW
AVG SURP - MW(X10^2)
150
120
90
60
30
0
Potential Thermal Displacement=5484 MW
Thermal Displacement=
3026.4 Average MW
20
40
60
80
100
% OF TIME VALUE IS EXCEEDED