COLUMBIA RIVER TREATY

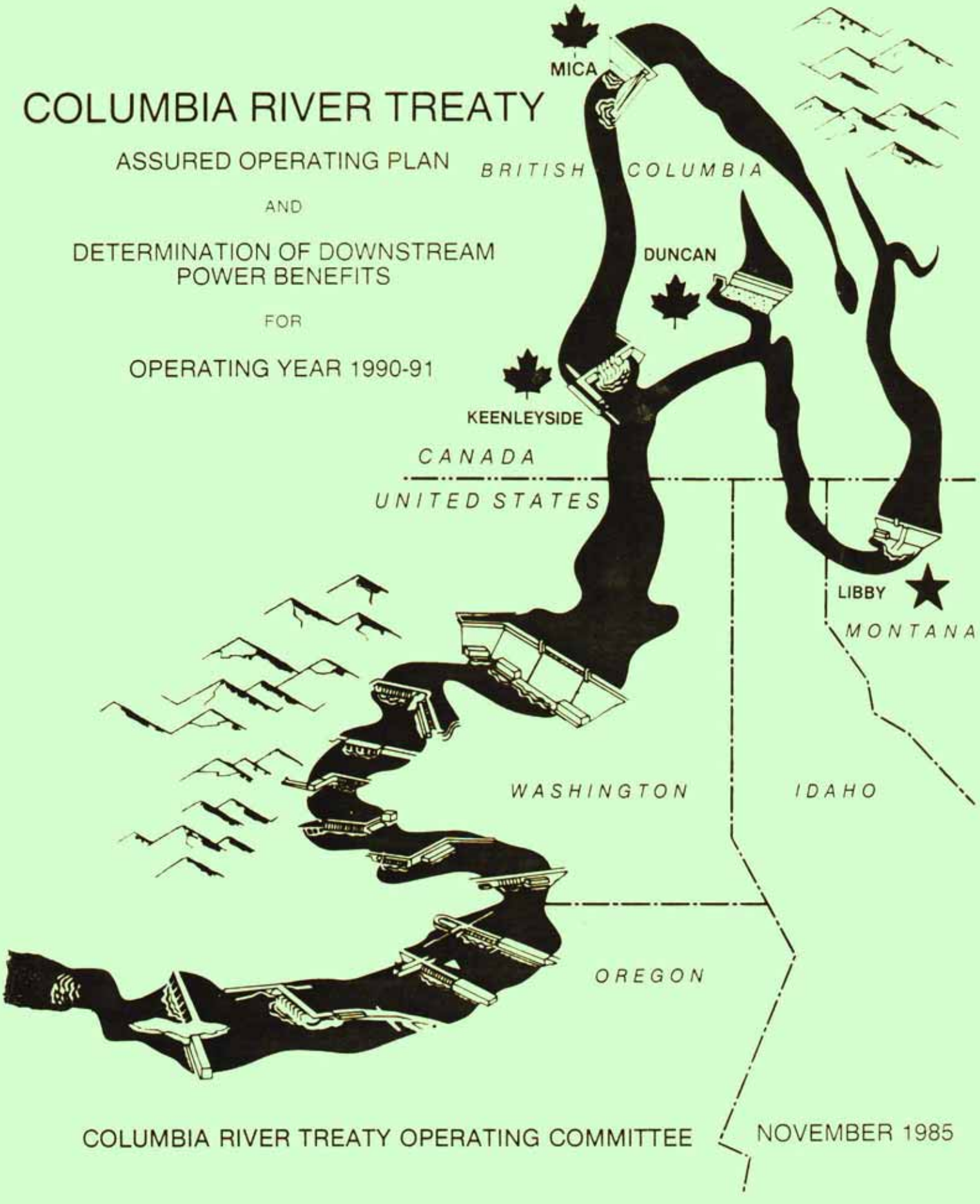
ASSURED OPERATING PLAN

AND

DETERMINATION OF DOWNSTREAM POWER BENEFITS

FOR

OPERATING YEAR 1990-91



COLUMBIA RIVER TREATY OPERATING COMMITTEE

NOVEMBER 1985

DETERMINATION OF DOWNSTREAM POWER BENEFITS RESULTING FROM CANADIAN STORAGE FOR OPERATING YEAR 1990-91

DETERMINATION OF DOWNSTREAM POWER BENEFITS

RESULTING FROM CANADIAN TREATY STORAGE

FOR OPERATING YEAR 1990-91

November 1985

Introduction

The Columbia River 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 1990-91 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" (POP), dated May 1983.

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 1990-91, 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.

Study Results

The Canadian Entitlement to the downstream power benefits in the United States of America attributable to operation in accordance with Treaty Annex A, Paragraph 7, for optimum generation in the Canada and the United States of America, which is one-half the total computed downstream power benefits, was computed to be:

Dependable Capacity	=	1,447.5 MW
Average Annual Energy	=	580.6 MW

In accordance with Part III, Paragraph 15c(2) of POP, the computation for the Canadian share of the minimum permitted downstream power benefits for the 1990-91 operating year are based on the formula X - (Y - Z), where the quantities X, Y, and Z are defined in POP. The quantities X and Y are derived from the downstream power benefit computations set out in the 1989-90 agreement 1/. The quantity Z, which is computed from 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:

Dependable Capacity	=	1,424.2 MW
Average Annual Energy	=	573.7 MW

The computation of the formula X - (Y - Z) is as follows:

Dependable Capacity	=	1,341.8	- (1,341.8 -	1,424.2)	=	1,424.2 MW
Average Annual Energy	=	566.4	- (569.8 -	573.7)	=	570.2 MW

The computed downstream power benefits exceed these amounts.

Effect on Sale of Canadian Entitlement

The Canadian Entitlement to downstream power benefits for operating year 1990-91 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 1990-91 Assured Operating Plan for this condition would have been:

Dependable Capacity	=	1,447.5 MW
Average Annual Energy	=	583.3 MW

Since the 1990-91 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." A comparison with the Canadian Entitlement to downstream power benefits computed in Section II(a) indicates a reduction in Canadian Entitlement of 2.7 average megawatts of average annual usable energy, but no reduction in dependable capacity.

The Entities are agreed that the United States Entity is entitled to receive during the period 1 April 1990 through 31 March 1991, from B.C. Hydro & Power Authority, 2.7 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement dated 13 August 1964.

Computation of Entitlement

The following Tables and Chart summarize the study results:

Table 1. Computation of Canadian Entitlement From 1990-91 Assured Operating Plan For:

A. Optimum Generation in Canada and the U.S.
B. Optimum Generation in the U.S. Only
C. Optimum Generation in the U.S. and a 1/2 Million Acre-Feet Reduction in Total Canadian Treaty Storage

The essential elements used in the computation of the Canadian Entitlement as provided in Annex A and 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 0.98831 and 0.96021, 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).

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

This chart shows duration curves of the secondary energy for Steps II and III studies. 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	5831 2/
Less Minimum Thermal Generation - MW	1894
Potential Thermal Displacement - MW	3937

1/ X = Difference between last year's AOP studies 90-42 and 90-13.
Y = Difference between last year's AOP studies 90-12 and 90-13.

2/ This value decreased by 1398 MW from last year mainly due to a decrease in the load forecast and the delay of the WNP #3 nuclear plant in-service date to beyond 1991. Also, last year's study required 632 MW of added thermal requirement to balance loads and resources compared to this years 492 MW firm surplus. 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. The annual plant factors include deductions for energy reserves and scheduled maintenance.

TABLE 1

COMPUTATION OF CANADIAN ENTITLEMENT FROM 1990-91 ASSURED OPERATING PLAN FOR:

A. Optimum Generation in Canada and the U.S.
B. Optimum Generation in the U.S. Only
C. Optimum Generation in the U.S. and a 1/2 Million Acre-Feet Reduction in Total Canadian Treaty Storage

Determination of Dependable Capacity Credited to Canadian Storage

	A	B	C
Step II - Critical Period Ave. Generation 1/	8,944.9	8,944.9	8,913.0
Step III - Critical Period Ave. Generation 2/	6,960.7	6,960.7	6,960.7
Gain Due to Canadian Storage	1,984.2	1,984.2	1,952.3
Average Critical Period Load Factor in % 3/	68.54	68.54	68.54
Dependable Capacity Gain 4/	2,895.0	2,895.0	2,848.4
Canadian Share of Dependable Capacity 5/	1,447.5	1,447.5	1,424.2

Determination of Increase in Average Annual Usable Energy

Step II (with Canadian Storage) 1/	A	B	C
Annual Firm Hydro Energy 3/	8,773.1	8,773.1	8,741.4
Thermal Replacement Energy 6/	1,701.0	1,709.6	1,715.5
Other Usable Secondary Energy 7/	403.1	400.0	406.5
System Annual Average Usable Energy	10,877.2	10,882.7	10,863.5
Step III (without Canadian Storage) 2/			
Annual Firm Hydro Energy 3/	6,452.2	6,452.2	6,452.2
Thermal Replacement Energy 6/	2,402.3	2,402.3	2,402.3
Other Usable Secondary Energy 7/	861.6	861.6	861.6
System Annual Average Usable Energy	9,716.1	9,716.1	9,716.1
Average Annual Usable Energy Gain 8/	1,161.1	1,166.6	1,147.4
Canadian Share of Average Annual Energy Gain 5/	580.6	583.3	573.7

1/ Step II values were obtained from the AOP 91-42, 91-12, and 91-22 studies, respectively.
2/ Step III values were obtained from the AOP 91-13 study.
3/ From Table 3.
4/ Dependable capacity gain credited to Canadian storage equals gain in critical period average generation divided by the estimated average critical period load factor.
5/ One-half of Total Gain.
6/ Average secondary generation limited to Potential Thermal Displacement market.
7/ Forty percent (40%) of the remaining secondary energy.
8/ Difference between Step II and Step III System Annual Average Usable.

TABLE 2

SUMMARY OF POWER REGULATIONS
FROM 1990-91 ASSURED OPERATING PLAN
FOR THE COMPUTATION OF CANADIAN ENTITLEMENT
TO DOWNSTREAM BENEFITS

	BASIC DATA		STEP I			STEP II				STEP III			
Projects	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			7,000			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	298	97	3,008	193	114	104	3,008	255	199	103
Albeni Falls	3	49	1,155	24	26	1,155	24	24	24	1,155	23	26	24
Grand Coulee	24	6,684	5,185	6,382	2,025	5,072	6,356	1,765	2,361	5,072	5,991	1,226	2,272
Chief Joseph	27	2,687		2,687	1,119		2,687	1,030	1,369		2,687	730	1,311
Ice Harbor	6	693		693	209		693	217	298		693	169	297
McNary	14	1,127		1,127	628		1,124	581	746		1,124	423	702
John Day	16	2,484	535	2,484	923		2,484	927	1,257		2,484	694	1,225
The Dalles	22 + 2F	2,076		2,076	746		2,076	724	977		2,076	565	961
Bonneville	18 + 2F	1,147		1,147	626		1,147	609	754		1,147	480	723
Subtotal		17,275	10,036	16,918	6,399	9,235	16,784	5,991	7,890	9,235	16,480	4,512	7,618
BASE SYSTEM NON-FEDERAL													
Kootenay Lake (Canadian)			649			427				427			
Kerr	3	160	1,219	151	113	1,219	146	99	115	1,219	151	134	115
Thompson Falls	6	40		40	38		40	38	38		40	39	37
Noxon Rapids	5	554	231	536	147		553	139	208		553	156	208
Cabinet Gorge	4	227		227	103		227	91	119		227	101	119
Box Canyon	4	74		71	47		71	44	46		71	50	47
Coeur d'Alene			223			223				223			
Wells	10	820		820	393		820	370	451		820	265	421
Chelan	2	54	677	51	39	676	51	38	45	676	51	49	45
Rocky Reach	11	1,267		1,267	565		1,267	534	679		1,267	383	640
Rock Island	18	544		544	274		544	260	322		544	182	297
Wanapum	10	986		986	520		986	493	605		986	348	553
Priest Rapids	10	912		912	513		912	486	578		912	356	526
Brownlee	5	675	975	675	201	974	675	256	272	974	675	272	270
Oxbow	4	220		220	82		220	106	112		220	114	112
Subtotal		6,533	3,974	6,500	3,035	3,519	6,512	2,954	3,592	3,519	6,517	2,449	3,390
TOTAL BASE SYSTEM HYDRO		23,808	29,510	23,418	9,434	28,254	23,296	8,945	11,482	12,754	22,997	6,961	11,008
ADDITIONAL STEP I PROJECTS													
Libby	5	604	4,980	485	186								
Boundary	6	1055		655	368								
Spokane River Plants	24	157	104	155	91								
Hells Canyon	3	450		393	161								
Dworshak	3	460	2,015	460	179								
Lower Granite	6	930		930	211								
Little Goose	6	930		930	208								
Lower Monumental	6	930		930	208								
Pelton, Rereg., and Round Butte	7	413	274	408	126								
Subtotal		5,929	7,373	5,346	1,741								
Other Coordinated Hydro		3,186	5,625	2,709	1,035								
Independent Hydro Resources		1,710	4,400	1,359	763								
Estimated Hydro Maintenance				-1,769	-50								
TOTAL HYDRO RESOURCES		34,633	46,908	31,063	12,923								
TOTAL IMPORTS				375	52								
MISCELLANEOUS CONTRACTS				216	217								
THERMAL RESOURCES 1/													
Small Existing Thermal Plants				1,721	227								
Centralia #1 & #2				1,280	1,027								
Jim Bridger #1, #2, #3, & #4				1,986	1,412								
Colstrip #1 & #2				330	250								
Trojan				1,080	787								
Boardman				530	406								
Valmy				242	193								
WNP #2				1,100	792								
Colstrip #3 & #4				980	737								
TOTAL THERMAL RESOURCES				9,249	5,831		9,249	5,831			9,249	5,831	
TOTAL RESOURCES				40,903	19,023		32,545	14,776			32,246	12,792	
RESERVES 2/				-2,451	0		-1,942	0			-1,633	0	
RESOURCES AVAILABLE FOR LOAD				38,452	19,023		30,603	14,776			30,613	12,792	
ESTIMATED LOAD PACIFIC NORTHWEST AREA				30,638	18,531		24,269	14,776			20,413	12,792	
SURPLUS				7,814	492		6,334	0			10,200	0	
CRITICAL PERIOD													
Starts:				September 1, 1928			September 1, 1943				September 16, 1936		
Ends:				February 29, 1932			April 30, 1945				April 15, 1937		
Length (Months):				42 Months			20 Months				7 Months		
Study Identification				91-41			91-42				91-13		

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.

(WP-PRC-2030G)

TABLE 3

DETERMINATION OF LOAD SHAPE FOR STEPS II AND III
1990-91 CANADIAN ENTITLEMENT COMPUTATIONS

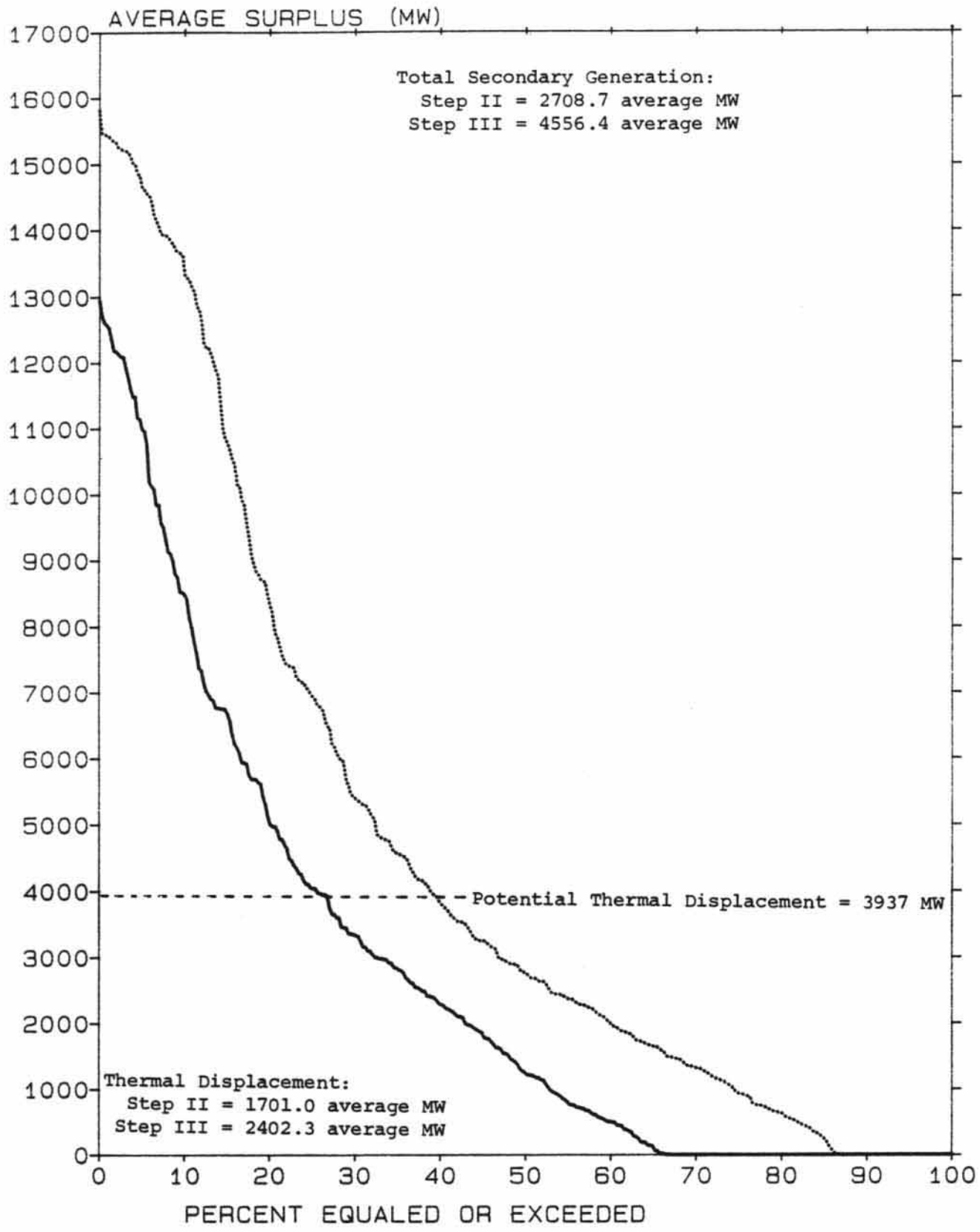
Pacific Northwest Area Load				Step II			Step III		
	Peak 1/	Avg.	Load Factor %	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load
Aug 1-15	24,052	17,045	70.87	13,501	5,831	7,670	11,336	5,831	5,505
Aug 16-31	23,959	16,984	70.89	13,453	5,831	7,622	11,336	5,831	5,505
Sep 1-15	24,428	16,733	68.50	13,254	5,831	7,423	11,148	5,831	5,317
Sep 16-30	24,383	16,693	68.46	13,223	5,831	7,392	11,122	5,831	5,291
October	26,599	17,549	65.98	13,901	5,831	8,070	11,692	5,831	5,861
November	28,073	19,091	68.00	15,122	5,831	9,291	12,719	5,831	6,888
December	29,323	20,169	68.78	15,976	5,831	10,145	13,438	5,831	7,607
January	30,638	21,006	68.56	16,639	5,831	10,808	13,995	5,831	8,164
February	29,464	20,064	68.10	15,893	5,831	10,062	13,368	5,831	7,537
March	27,734	19,089	68.83	15,121	5,831	9,290	12,718	5,831	6,887
Apr 1-15	26,607	18,217	68.47	14,430	5,831	8,599	12,137	5,831	6,306
Apr 16-30	26,607	18,079	67.95	14,321	5,831	8,490	12,045	5,831	6,214
May	25,810	17,565	68.06	13,913	5,831	8,082	11,703	5,831	5,872
June	24,741	17,359	70.16	13,750	5,831	7,919	11,565	5,831	5,734
July	25,247	17,545	69.49	13,897	5,831	8,066	11,689	5,831	5,858
Annual Average		18,436	68.63	14,604	5,831	8,773	12,283	5,831	6,452
Critical Period Ave.		18,531	68.54	14,776	5,831	8,945	12,792	5,831	6,961
Critical Period = 42 Months 9/1/28 - 2/29/32 Study 91-41				Critical Period = 20 Months 9/1/43 - 4/30/85 Study 91-42			Critical Period = 7 Months 9/16/36 - 4/15/37 Study 91-13		

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

1990-91 AOP SECONDARY ENERGY



1. ——— STEP II
2. ····· STEP III

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COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

ASSURED OPERATING PLAN
FOR OPERATING YEAR 1990-91

COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for
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COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for
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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 1990-91 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 1990-91.

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] 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, computed from the individual project Critical Rule Curves, Assured Refill Curves and 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 2.7 average downstream megawatts of average annual usable energy in the Canadian Entitlement of power benefits. This is within the limits specified by the Treaty.

System Regulation Studies for the Assured Operating Plan were based on 1990-91 estimated loads and resources in British Columbia and in the United States Pacific Northwest System. The Entities have agreed that the 1990-91 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 1990-91 conditions,[7] were used.

The Critical Rule Curve for these studies was determined from Bonneville Power Administration Study 91-41. The study indicated a 42-month critical period for the United States system resulting from the low flows during the period from 1 September 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) dependable peaking capability,

(c) average annual usable secondary energy.

In the studies for the 1990-91 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 1990-91 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 1990-91 Assured Operating Plan the three quantities would be assigned the following relative values:

Quantity	Relative Value
firm energy capability (Av. MW)	3
dependable 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 1990-91 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. 91-41	Study No. 91-11	Net Gain	Weight	Value
1. Firm Energy Capability (Av. MW)					
U.S. System1/	12,209	12,209	0		
Canada (Mica + Rev.)2/	1,595	1,569	+26		
Total (Av. MW)	13,804	13,778	+26	3	+78
2. Dependable Peaking Capacity (MW)					
U.S. System3/	31,471	31,469	+2		
Canada (Mica + Rev.)4/	3,536	3,537	-1		
Total (MW)	35,007	35,006	+1	1	+1
3. Average Annual Usable Secondary Energy (Av. MW)					
U.S. System5/	3,006	3,026	-20		
Canada (Mica + Rev.)6/	135	147	-12		
Total (Av. MW)	3,141	3,173	-32	2	-64
				Total Value =	+15

1/ U.S. System firm energy capability was determined over the U.S. system critical period beginning 1 September 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 dependable peaking capability was determined from January 1937.

4/ Canadian (Mica + Revelstoke) system dependable peaking capability was determined from December 1944.

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 Critical Rule Curves for Mica, Arrow and Duncan and 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 during the 30-year record for the period January through July as measured at The Dalles, Oregon. A tabulation of the Assured Refill Curves for Mica, Arrow and Duncan 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 Tables 3 - 5.

Variable Refill Curves for Mica, Arrow and Duncan for the 30 years of historical record are recorded in Tables 3 - 5. These illustrate the probable range of these curves based on historical conditions. In actual operation in 1990-91, 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 is developed for 1936-37 water conditions. Limiting Rule Curves for Mica, Arrow and Duncan are shown in Tables 3 - 5.

(d) Upper Rule Curve. The Upper Rule Curves[8] indicate the 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 Mica, Arrow and Duncan for the 30 year study period are shown on Tables 6 - 8; however, the tables do not reflect the constraint that the Upper Rule Curve not be lower than the Variable Refill Curve. Tables 7 and 8 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 9 to illustrate the probable future range of these curves based on historical conditions.

OPERATING RULES

The following rules, used in the 91-41 System Regulation Study, will apply to the operation of Canadian storage in the 1990-91 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 Composite Critical Rule Curve. The proportionate draft will be made, if necessary, first to

the first year Composite Critical Rule Curve, then between the first and second year Composite Critical Rule Curve, the second and third year Composite 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 Composite Critical Rule Curves, each shall be operated proportionately between its lowest Composite 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 and at Revelstoke 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 11. Mica monthly outflows will be increased above the values shown in the table in the months from October to June if required to avoid violation of the Upper Rule Curve.

Under this Assured Operating Plan, Mica storage releases in excess of 7 million acre-feet that are required to maintain the 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 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 11.

Revelstoke has been included in the 1990-91 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	2 700 - FULL 0 - 2 700	- 27 000	3 456.2	10 000
August 16-31	2 500 - FULL 0 - 2 500	- 27 000	3 529.2	10 000
September	2 500 - FULL 0 - 2 500	- 27 000	3 529.2	10 000
October	3 300 - FULL 0 - 3 300	10 000 27 000	-	10 000
November	3 200 - FULL 0 - 3 200	- 27 000	3 122.2	10 000
December	3 400 - FULL 3 200 - 3 400 0 - 3 200	23 000 27 000 34 000	-	15 000
January	2 200 - FULL 0 - 2 200	27 000 34 000	-	15 000
February	1 300 - FULL 0 - 1 300	24 000 27 000	-	15 000
March	100 - FULL 0 - 100	20 000 25 000	-	15 000
April 1-15	800 - FULL 0 - 800	15 000 20 000	-	15 000
April 16-30	0 - FULL	10 000	-	10 000
May	200 - FULL 0 - 200	10 000 20 000	-	10 000
June	0 - FULL	10 000	-	10 000
July	1 700 - FULL 0 - 1 700	- 25 000	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 1990-91 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 1990, 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 1990-91 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 1990-91 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 91-41, dated 24 October 1985.

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
CRITICAL RULE CURVES
END OF MONTH CONTENTS IN KSFD
1990-91 OPERATING YEAR

TABLE 1

MICA

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	3529.2	3529.2	3529.2	3428.4	3122.2	2537.0	1830.6	1238.9	715.3	446.2	350.0	581.9	1943.8	2936.7
2ND YR	3456.2	3529.2	3529.2	3428.4	2736.0	1772.0	1004.8	408.4	0.0	0.0	2.1	420.1	1776.0	3330.0
3RD YR	3529.2	3529.2	3529.2	3428.4	2769.3	1816.8	1066.7	468.8	0.0	0.0	0.0	303.1	1674.0	2406.5
4TH YR	2613.8	2748.4	2718.9	2205.4	1626.1	714.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ARROW

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	3579.6	3579.6	3579.6	3440.4	3453.6	3075.4	2472.7	1562.2	641.6	136.7	226.2	1333.0	3122.8	3579.6
2ND YR	3531.1	3519.9	3381.9	3057.0	3074.4	2526.7	1850.5	1447.1	520.6	451.9	464.8	909.5	2257.9	2955.6
3RD YR	3247.5	3414.8	3380.5	3053.8	3038.0	2465.8	1599.2	855.5	171.7	176.5	4.7	548.2	1693.1	2337.9
4TH YR	2421.4	2275.0.	2022.1	2007.8	1357.9	442.6	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DUNCAN

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	705.8	705.8	705.5	700.5	632.3	504.1	260.9	76.1	0.1	0.0	11.3	127.8	401.4	539.2
2ND YR	586.5	629.6	588.7	472.7	240.9	191.9	24.1	0.1	0.1	0.1	1.0	11.5	126.3	339.9
3RD YR	412.0	466.5	532.0	471.3	239.7	43.1	1.2	0.1	0.1	0.1	0.0	9.7	31.1	16.6
4TH YR	3.3	0.1	0.7	0.8	3.2	4.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

COMPOSITE

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	7814.6	7814.6	7814.3	7569.3	7208.1	6116.5	4564.2	2877.2	1357.0	582.9	587.5	2042.7	5468.0	7055.5
2ND YR	7573.8	7678.7	7499.8	6958.1	6051.3	4490.6	2879.4	1855.6	520.7	452.0	467.9	1341.1	4160.2	6625.5
3RD YR	7188.7	7410.5	7441.7	6953.5	6047.0	4325.7	2667.1	1324.4	171.8	176.6	4.7	861.0	3398.2	4761.0
4TH YR	5038.5	5023.5	4741.7	4214.0	2987.2	1160.9	99.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

COLUMBIA RIVER TREATY
ASSURED REFILL CURVES
END OF MONTH CONTENTS IN KSFD
1990-91 OPERATING YEAR

TABLE 2

MICA

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
0.0	27.6	636.9	811.5	872.5	881.0	874.8	864.9	870.8	754.8	671.4	1151.3	2474.3	3529.2

ARROW

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
0.0	0.0	0.0	0.0	0.0	0.0	552.3	1167.7	1621.2	1589.0	1624.1	2273.2	3416.2	3579.6

DUNCAN

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
37.8	98.4	165.3	196.0	213.5	224.7	234.8	244.0	258.1	244.6	236.6	343.8	532.8	705.8

DUNCAN VARIABLE REFILL CURVE (KSFD)
1990-91 OPERATING YEAR

TABLE 3

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							460.7	417.6	421.1	415.5	431.2	424.5	574.3	705.8
1929-30							458.7	415.6	418.8	412.9	435.6	445.6	585.9	,,
1930-31							405.0	361.4	368.1	368.8	393.6	393.5	574.3	,,
1931-32							13.9	20.0	1.6	0.0	22.3	106.9	436.2	,,
1932-33							,,	,,	,,	,,	0.0	0.0	300.6	,,
1933-34							,,	,,	,,	,,	49.4	168.2	494.6	,,
1934-35							148.0	103.1	119.9	135.4	181.0	217.8	464.7	,,
1935-36							114.4	69.1	75.6	88.7	137.4	200.0	504.2	,,
1936-37							408.9	365.4	370.6	366.5	388.4	385.8	556.3	,,
1937-38							16.3	20.0	1.6	18.1	85.4	163.8	460.9	,,
1938-39							263.6	219.0	227.7	232.3	274.1	303.7	557.0	,,
1939-40							252.5	207.8	223.8	237.8	281.6	305.9	545.5	,,
1940-41							330.6	286.5	298.5	311.3	358.1	384.6	569.4	,,
1941-42							255.2	211.1	223.4	236.6	278.0	314.6	530.4	,,
1942-43							141.6	97.6	107.5	133.2	193.6	276.9	494.2	,,
1943-44							482.1	439.0	447.4	442.9	461.4	458.2	604.7	,,
1944-45							405.4	361.9	371.0	369.1	390.6	385.7	562.4	,,
1945-46							13.9	20.0	1.6	0.0	0.0	51.5	429.4	,,
1946-47							,,	,,	,,	,,	2.0	95.4	442.3	,,
1947-48							,,	,,	,,	,,	36.0	112.9	452.7	,,
1948-49							192.9	149.3	155.7	177.1	226.8	290.4	555.5	,,
1949-50							13.9	20.0	1.6	0.0	55.0	121.7	396.3	,,
1950-51							,,	,,	,,	,,	3.9	86.8	427.7	,,
1951-52							29.4	,,	,,	25.5	87.5	173.4	473.2	,,
1952-53							28.4	,,	,,	24.4	86.3	151.2	439.1	,,
1953-54							13.9	,,	,,	0.0	0.0	12.6	369.2	,,
1954-55							,,	,,	,,	,,	61.1	117.9	382.1	,,
1955-56							,,	,,	,,	,,	0.0	59.9	425.4	,,
1956-57							,,	,,	,,	,,	39.7	114.5	490.3	,,
1957-58							,,	,,	,,	,,	0.0	50.6	441.7	,,
ECC LOWER LIMIT							13.9	20.0	1.6					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	100	100	100	1700	1700	1700	1700	1700
FOR JANUARY THROUGH JULY						90 MAF--	100	100	100	900	900	900	900	900
VOLUME RUNOFF AT THE DALLES						95 MAF--	100	100	100	100	100	100	100	100

ARROW VARIABLE REFILL CURVE (KSFD)
1990-91 OPERATING YEAR

TABLE 4

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							3482.4	3533.6	3579.6	3579.6	3579.6	3484.2	3579.6	3579.6
1929-30							2522.0	2244.8	2321.9	2435.1	3147.6	2875.7	,,	,,
1930-31							2473.9	2369.9	2679.4	2770.1	3307.4	2701.6	,,	,,
1931-32							277.5	88.0	21.0	0.0	0.0	697.0	2514.6	,,
1932-33							,,	,,	,,	,,	266.3	894.8	2476.2	,,
1933-34							,,	,,	,,	,,	0.0	1304.9	2961.0	,,
1934-35							1389.6	1130.0	1246.6	1321.2	1717.6	1980.1	3076.2	,,
1935-36							1462.6	1179.3	1153.3	1169.9	1594.9	1987.6	3395.7	,,
1936-37							3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	,,
1937-38							277.5	88.0	74.0	364.5	986.8	1527.9	2864.1	,,
1938-39							2562.8	2286.3	2491.7	2587.6	3188.5	2797.1	3579.6	,,
1939-40							2211.8	1931.0	2079.0	2294.3	2966.9	2570.2	,,	,,
1940-41							2994.7	3043.4	3392.2	3568.5	3579.6	3579.6	,,	,,
1941-42							2658.4	2385.6	2403.6	2384.2	2820.8	2867.7	3560.4	,,
1942-43							1625.0	1353.9	1349.4	1349.8	1930.8	2220.1	3034.3	,,
1943-44							3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	,,
1944-45							,,	,,	,,	,,	,,	,,	,,	,,
1945-46							277.5	88.0	21.0	0.0	157.2	1018.7	2738.4	,,
1946-47							,,	,,	,,	,,	786.7	1570.4	2896.7	,,
1947-48							,,	,,	,,	,,	387.3	1223.4	2807.2	,,
1948-49							891.3	617.8	659.4	959.6	1752.0	2001.0	3368.6	,,
1949-50							277.5	88.0	21.0	0.0	669.5	1161.6	2481.0	,,
1950-51							,,	,,	,,	197.7	970.3	1459.0	2948.0	,,
1951-52							362.6	210.4	274.1	438.4	896.1	1502.6	2893.1	,,
1952-53							961.0	686.0	710.9	802.0	1205.9	1625.5	2883.7	,,
1953-54							277.5	88.0	21.0	0.0	49.9	818.5	2485.8	,,
1954-55							588.9	440.7	555.9	711.6	1155.6	1541.1	2639.3	,,
1955-56							277.5	88.0	21.0	0.0	495.2	1284.1	2838.2	,,
1956-57							,,	,,	,,	,,	461.1	1000.8	2912.4	,,
1957-58							,,	,,	,,	,,	353.9	985.1	2790.8	,,
ECC LOWER LIMIT							277.5	88.0	21.0					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	5000	5000	5000	22000	22000	31000	31000	48000
FOR JANUARY THROUGH JULY						90 MAF--	5000	5000	5000	9600	9600	9600	26500	29000
VOLUME RUNOFF AT THE DALLES						95 MAF--	5000	5000	5000	5000	5000	5000	14000	14000

MICA VARIABLE REFILL CURVE (KSFD)
1990-91 OPERATING YEAR

TABLE 5

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							2238.9	1969.9	1921.3	1897.2	1962.1	1856.4	2739.2	3529.2
1929-30							1214.9	943.3	892.2	911.1	1132.4	1252.4	2462.8	,,
1930-31							1681.5	1411.1	1357.6	1348.6	1477.4	1439.8	2632.9	,,
1931-32							487.5	85.9	0.0	0.0	22.8	352.2	2057.1	,,
1932-33							,,	,,	,,	,,	0.0	249.7	1891.0	,,
1933-34							,,	,,	,,	,,	,,	0.0	2127.9	,,
1934-35							,,	195.3	180.3	294.1	529.4	711.8	2120.8	,,
1935-36							537.6	262.8	225.2	296.3	532.6	787.0	2437.9	,,
1936-37							2205.5	1936.4	1871.7	1866.5	1969.2	1878.1	2775.6	,,
1937-38							487.5	85.9	0.0	0.0	153.0	464.8	2071.9	,,
1938-39							1394.0	1122.9	1072.2	1088.3	1255.6	1312.8	2760.6	,,
1939-40							1267.2	992.8	962.9	984.1	1169.0	1213.3	2594.8	,,
1940-41							1857.0	1587.0	1537.0	1539.6	1727.2	1764.7	2819.1	,,
1941-42							821.8	551.4	510.3	592.5	814.9	1009.4	2370.9	,,
1942-43							708.4	438.4	390.1	535.4	849.0	1184.1	2366.3	,,
1943-44							2396.5	2124.9	2075.4	2040.4	2115.2	2043.3	2943.0	,,
1944-45							2306.3	2037.5	1987.9	1963.8	2029.4	1921.1	2832.8	,,
1945-46							487.5	85.9	0.0	0.0	0.0	87.6	2057.5	,,
1946-47							,,	,,	,,	,,	,,	216.7	2063.8	,,
1947-48							,,	,,	,,	,,	,,	3.5	1949.0	,,
1948-49							1209.7	941.0	881.2	977.0	1200.3	1416.8	2726.1	,,
1949-50							487.5	85.9	0.0	0.0	0.0	231.6	1759.5	,,
1950-51							,,	,,	,,	,,	69.4	355.0	2123.7	,,
1951-52							,,	,,	,,	44.9	325.6	654.8	2271.3	,,
1952-53							554.5	284.2	243.0	357.9	600.5	814.3	2237.5	,,
1953-54							487.5	85.9	0.0	0.0	0.0	0.0	1731.4	,,
1954-55							,,	,,	,,	61.3	345.4	581.5	1927.0	,,
1955-56							,,	,,	,,	0.0	0.0	250.6	2038.2	,,
1956-57							,,	,,	,,	,,	57.2	339.2	2370.3	,,
1957-58							,,	,,	,,	,,	0.0	235.5	2132.4	,,
ECC LOWER LIMIT							487.5	85.9	0.0					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	3000	3000	3000	11600	11600	11600	11600	14600
FOR JANUARY THROUGH JULY						90 MAF--	3000	3000	3000	3000	3000	3000	3000	3000
VOLUME RUNOFF AT THE DALLES						95 MAF--	3000	3000	3000	3000	3000	3000	3000	3000

DUNCAN
FLOOD CONTROL STORAGE RESERVATION CURVES
1990-91 OPERATING YEAR
KSFD

TABLE 6

	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	397.3	303.0	303.0	311.0	324.7	416.4	560.6	705.8
1929-30	,,	,,	,,	,,	,,	,,	385.7	281.3	281.3	289.9	304.0	400.8	553.0	,,
1930-31	,,	,,	,,	,,	,,	,,	368.5	248.0	248.0	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	191.6	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	219.8	219.8	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	,,	,,	,,	,,	,,	,,	,,	,,	,,	82.7	107.4	385.7	705.8	,,
1939-40	,,	,,	,,	,,	,,	,,	,,	,,	,,	78.1	103.8	,,	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	321.1	156.3	156.3	167.4	186.0	311.0	508.2	,,
1941-42	,,	,,	,,	,,	,,	,,	302.0	121.0	121.0	131.1	155.3	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	300.5	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	240.0	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	,,

ARROW

FLOOD CONTROL STORAGE RESERVATION CURVES

1990-91 OPERATING YEAR

KSFD

TABLE 7

	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	1008.4	1015.9	1126.8	2224.4	,,	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	1008.4	1036.6	1761.6	3034.6	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1784.8	2327.2	3579.6	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1008.4	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	1008.4	1083.0	1278.1	1831.2	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	1008.4	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	,,	,,	,,	,,	,,	,,	2641.9	2251.6	1818.0	1842.7	1908.3	2477.0	3368.4	,,
1945-46	,,	,,	,,	,,	,,	,,	2364.6	1719.2	1008.4	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	1008.4	1077.9	1224.1	2651.4	3579.6	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	1046.7	1190.9	2242.6	,,	,,

MICA
FLOOD CONTROL STORAGE RESERVATION CURVES
1990-91 OPERATING YEAR
KSFD

TABLE 8

	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	3387.0	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	,,	,,	,,	,,	,,	3025.0	2067.1	1058.8	100.9	100.9	100.9	803.7	2363.6	,,
1956-57	,,	,,	,,	,,	,,	3428.4	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
1990-91 OPERATING YEAR

TABLE 9

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	7814.6	7814.6	7814.3	7569.3	7208.1	6116.5	4564.2	3045.1	2750.1	2588.4	2532.1	3768.3	6423.3	7814.6
1929-30	,,	,,	,,	,,	,,	,,	3948.5	2749.5	,,	,,	,,	,,	6411.8	,,
1930-31	,,	,,	,,	,,	,,	,,	4415.1	3045.1	,,	,,	,,	,,	6423.3	,,
1931-32	,,	,,	,,	,,	,,	,,	778.9	193.9	22.6	0.0	45.1	1156.1	5007.9	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	266.3	1144.5	4667.8	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	49.4	1473.1	5583.5	,,
1934-35	,,	,,	,,	,,	,,	,,	2025.1	1428.4	1546.8	1750.7	2334.5	2909.7	5661.7	,,
1935-36	,,	,,	,,	,,	,,	,,	2114.6	1511.2	1454.1	1554.9	2264.9	2974.6	6337.8	,,
1936-37	,,	,,	,,	,,	,,	,,	4564.2	3045.1	2750.1	2588.4	2532.1	3768.3	6423.3	,,
1937-38	,,	,,	,,	,,	,,	,,	781.3	193.9	75.6	382.6	1225.2	2156.5	5396.9	,,
1938-39	,,	,,	,,	,,	,,	,,	4127.6	2904.1	2719.7	2576.1	2532.1	3728.2	6423.3	,,
1939-40	,,	,,	,,	,,	,,	,,	3731.5	2762.8	2715.8	2581.6	,,	3730.4	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	4564.2	3045.1	2750.1	2588.4	,,	3768.3	,,	,,
1941-42	,,	,,	,,	,,	,,	,,	3549.7	2324.7	2354.9	2418.1	,,	3597.2	6317.5	,,
1942-43	,,	,,	,,	,,	,,	,,	2475.0	1889.9	1847.0	2018.4	2489.1	3648.3	5894.8	,,
1943-44	,,	,,	,,	,,	,,	,,	4564.2	3045.1	2750.1	2588.4	2532.1	3768.3	6423.3	,,
1944-45	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1945-46	,,	,,	,,	,,	,,	,,	778.9	193.9	22.6	0.0	157.2	1157.8	5225.3	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	788.7	1882.5	5402.8	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	423.3	1339.8	5208.9	,,
1948-49	,,	,,	,,	,,	,,	,,	2293.9	1708.1	1685.9	1891.5	2522.3	3442.7	6375.7	,,
1949-50	,,	,,	,,	,,	,,	,,	778.9	193.9	22.6	0.0	724.5	1514.9	4636.8	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	197.7	1043.6	1900.8	5499.4	,,
1951-52	,,	,,	,,	,,	,,	,,	879.5	316.3	275.7	508.8	1309.2	2330.8	5637.6	,,
1952-53	,,	,,	,,	,,	,,	,,	1543.9	990.2	955.5	1184.3	1892.7	2591.0	5560.3	,,
1953-54	,,	,,	,,	,,	,,	,,	778.9	193.9	22.6	0.0	49.9	831.1	4586.4	,,
1954-55	,,	,,	,,	,,	,,	,,	1090.3	546.6	557.5	772.9	1562.1	2240.5	4948.4	,,
1955-56	,,	,,	,,	,,	,,	,,	778.9	193.9	1.6	0.0	289.9	1594.6	5227.0	,,
1956-57	,,	,,	,,	,,	,,	,,	,,	,,	22.6	,,	558.0	1454.5	5773.0	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	353.9	1271.2	5364.9	,,