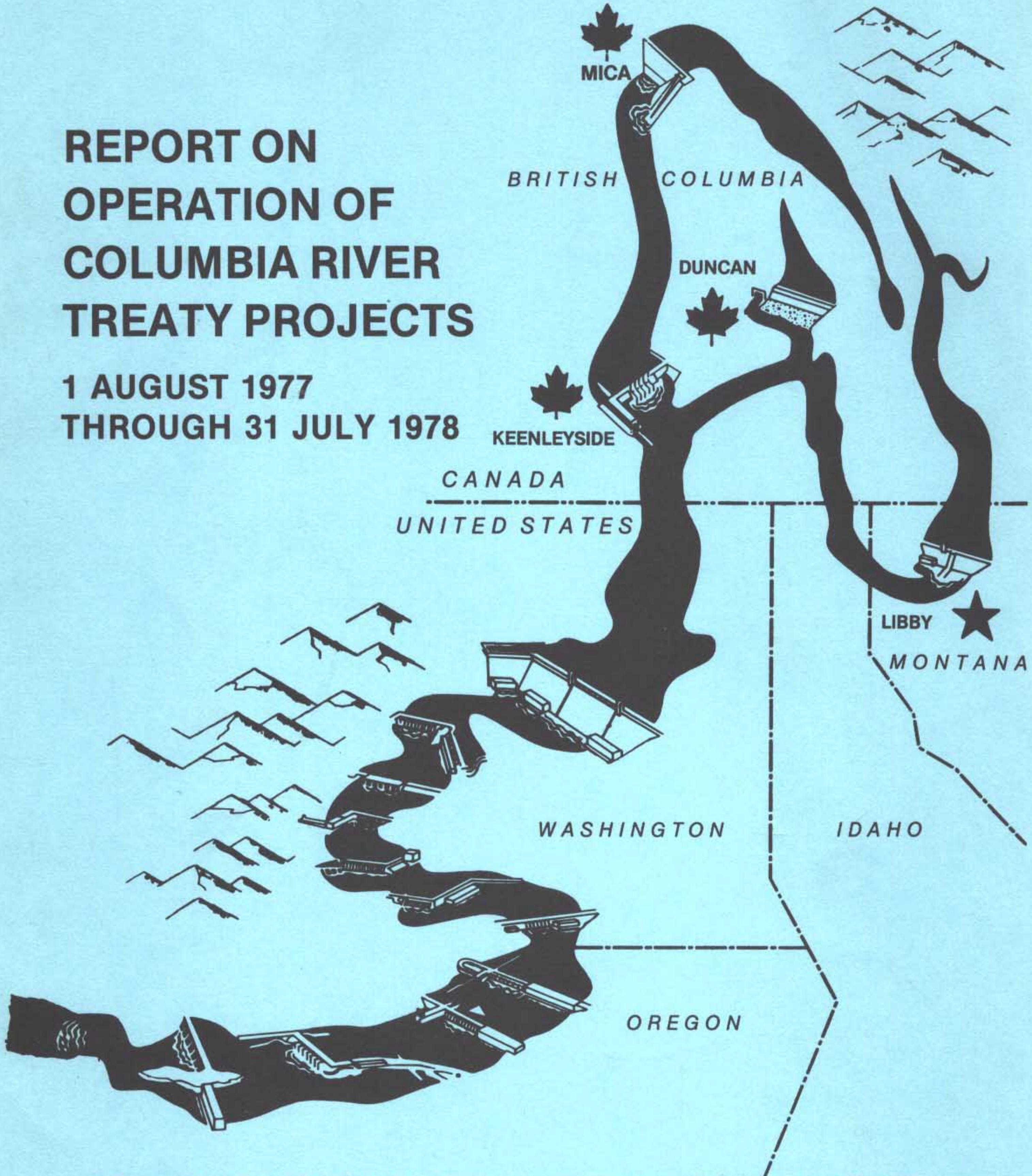
REPORT ON OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1977 THROUGH 31 JULY 1978



COLUMBIA RIVER TREATY OPERATING COMMITTEE

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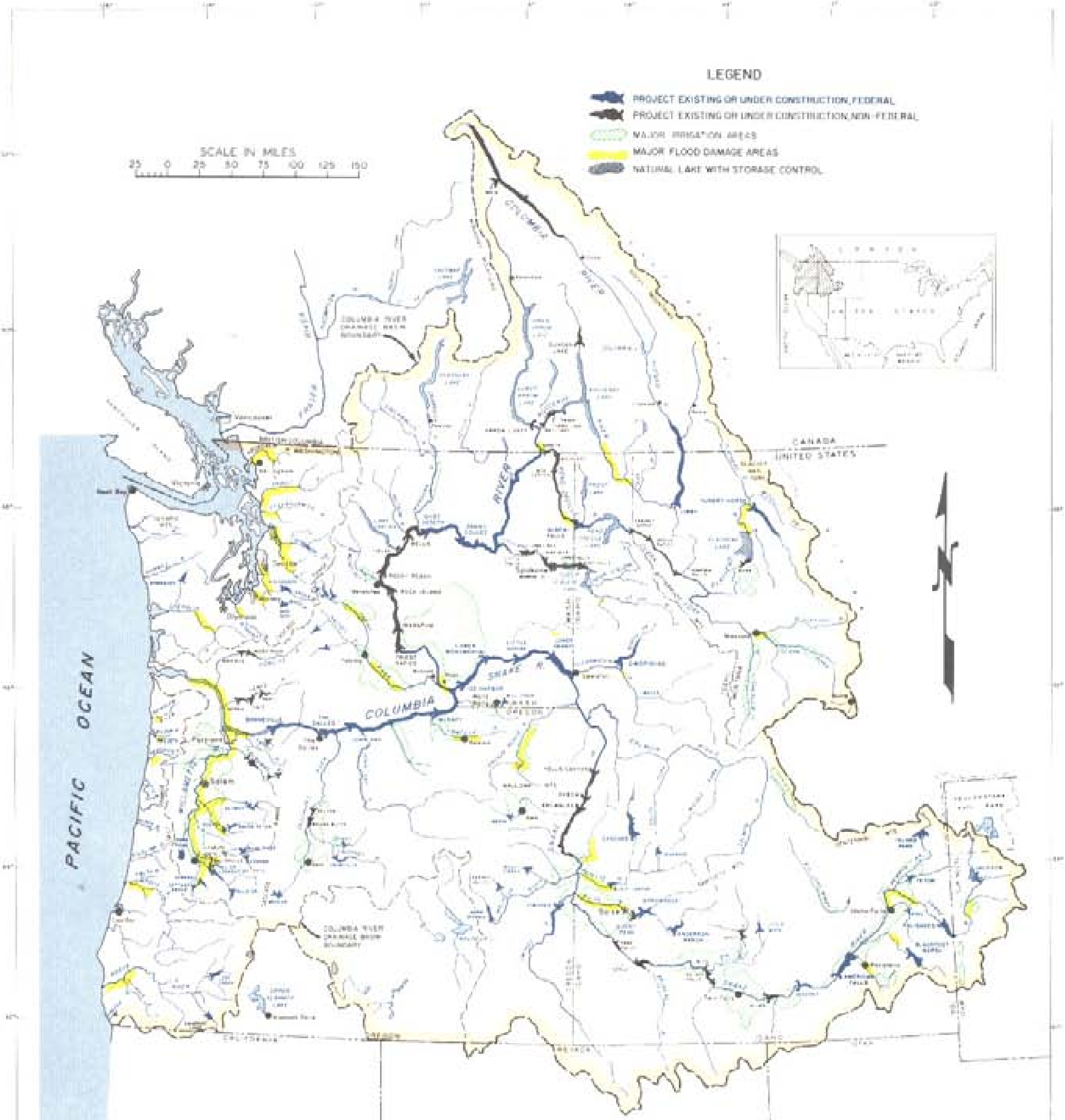


REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1977 THROUGH 31 JULY 1978

I. INTRODUCTION

A. AUTHORITY

Duncan, Arrow, and Mica reservoirs in Canada and Libby reservoir in the United States of America were constructed under the provisions of the Columbia River Treaty of January 1961. Treaty Storage is required to be operated for the purpose of increasing hydroelectric power generation and flood control in the United States of America and in Canada. In 1964, the Canadian and United States governments each designated an Entity to formulate and carry out the operating arrangements necessary to implement the Treaty. The Canadian Entity is British Columbia Hydro and Power Authority; the United States Entity is the Administrator, Bonneville Power Administration and the Division Engineer, North Pacific Division, Corps of Engineers.

The Columbia River Treaty Operating Committee, established in September 1968 by the Entities, is responsible for preparing and implementing operating plans as required by the Columbia River Treaty. This report records and reviews the operation of Mica, Arrow, Duncan and Libby reservoirs for power and flood control during the period 1 August 1977 through 31 July 1978, including the major effects downstream in Canada and in the United States of America.

B. OPERATING PROCEDURE

Throughout the period covered by this report, storage operations were implemented by the Operating Committee in accordance with the Detailed Operating Plan for Columbia River Treaty Storage, dated September 1977. During the drawdown season from mid August 1977 to late April 1978 the regulation of the Canadian Treaty storage content was normally determined by the Operating Committee on a weekly basis. From 31 May 1978 through 18 June 1978 during the 1978 Flood Control Refill Period, project outflows were determined on a daily basis. During the remainder of the refill period storage operations were determined on a weekly basis.

II. WEATHER AND STREAMFLOW

A. WEATHER

Precipitation in July, August and September 1977 was slightly above average but was not enough to alleviate the drought caused by the exceptionally dry conditions experienced during the period 1 October 1976 to 1 July 1977. Precipitation during October was below average but wet weather starting in late November brought streamflows back to normal, finally putting an end to the drought conditions. During the winter months, precipitation ranged from above average in December to below average in February and March. Through the spring and summer, the only month with below average precipitation was June, while July was near average and the remainder of the months had above average precipitation.

The total October 1977 - September 1978 precipitation was 96 percent of average for the Columbia Basin above Grand Coulee and 106 percent of average for the Columbia Basin above The Dalles.

The geographical distribution of the accumulated October through April precipitation for the basin, expressed as a percentage of the 1958-72 average, is shown on Chart 1. This chart shows the October through April precipitation to be the lowest (less than 80 percent of average) in the Big Bend region north of Revelstoke and Donald; from 80 to 120 percent in the Kootenay basin, and in the Columbia basin above Donald and below Revelstoke in British Columbia. In the U. S. portion of the basin the October through April precipitation was above 150 percent of average in extreme Southeastern Idaho and in the Owyhee basin in Southwestern Idaho and Southeastern Oregon. The remainder of the U. S. portion varied from 90 to 150 percent with heavier amounts in Southern Idaho and lighter amounts in Western Oregon and Western Washington.

Chart 2 depicts the sequence of precipitation and temperatures that occurred throughout the winter, as measured by index stations in the basin. The heavy precipitation in November and December made up a significant part of the winter precipitation, and the colder than normal temperatures caused much of this precipitation to fall as snow. Warm temperatures in March melted snowpacks at low and mid-elevations. The combined effects of dry and warm weather reduced the snowpack, basin-wide, from 98 percent of average on 1 March to 86 percent on 1 April. The 1 May snowpack remained 85 percent of average, because heavy precipitation and warm temperatures combined to produce a near average reduction in the snowpack during April.

The pattern of temperature and precipitation throughout the April - August season is shown on Charts 3 and 4. Chart 3 applies to the Columbia River Basin above The Dalles, Oregon and Chart 4 applies to the upper Columbia and Kootenay River Basins in Canada. Since the major portion of the runoff which occurs during this season is produced by snowmelt, the temperatures shown are of special significance to system reservoir regulation in that they largely influence the pattern of streamflow.

B. STREAMFLOW

River flows were considerably below normal in August 1977, as a result of the record drought. Above average precipitation in

August and September increased streamflows to near normal in September, October, and November and then the heavy rain in late November and December increased streamflows to 144 percent of average for the month of December. There were no extremes in weather during the period January through August 1978; the streamflows returned to average in January and remained near average for the remainder of the water year.

The Water Year 1978 monthly modified streamflows and average monthly flows for the period 1926-1978 are shown in the following table for the Columbia River at Grand Coulee and for the Columbia River at The Dalles. These modified flows are corrected for storage in lakes and reservoirs so as to exclude the effects of regulation, and are adjusted to the 1970 level of development for irrigation.

Monthly Mean Modified Streamflow in CFS

	Columbia River at Grand Coulee		Columbia River at The Dalles	
MONTH	Water Year 1978	Average 1926-78	Water Year 1978	Average 1926-78
OCT	36440	51340	62090	89150
NOV	37610	46680	71210	91900
DEC	53080	43470	138000	95920
JAN	36120	38390	91180	92210
FEB	37420	40950	98040	103200
MAR	62640	47950	148500	118500
APR	132200	115000	255600	218200
MAY	238600	264900	388200	415500
JUN	306300	316500	465100	470900
JUL	205500	188100	280200	254000
AUG	96300	98000	129600	134500
SEP	96160	59870	130200	92490
YEAR	111800	109500	188400	181600

The maximum month, June, was 97 percent and 99 percent of the long-term average at Grand Coulee and at The Dalles respectively. Regulation by upstream reservoirs resulted in an actual recorded average June flow at The Dalles of 236,800 cubic feet per second (cfs).

The maximum observed mean daily flow in the Columbia River at The Dalles was 313,000 cfs on 10 June 1978.

Maximum observed mean daily inflow for Mica was 77,500 cfs on 10 July; for Arrow 88,400 cfs on 6 June; for Duncan 14,600 cfs on 6 June; and for Libby 61,000 cfs on 6 June. The natural streamflow patterns for the year are shown on the inflow hydrographs for the Treaty reservoirs, Charts 5, 6, 7, and 8. Observed and computed unregulated hydrographs for Kootenay Lake, Columbia River at Birchbank, Grand Coulee Dam, and The Dalles are shown on Charts 9, 10, 11, and 12, respectively.

C. SEASONAL RUNOFF VOLUMES

The volume and distribution of runoff during the snowmelt season are of great importance because the reservoir regulation plans are determined in part by the expected runoff volume. Runoff volume forecasts, based on precipitation and snowpack data, were prepared for a large number of locations in the Columbia River Basin and updated each month as the season advanced. Table 1 lists the seasonal volume inflow forecasts for Mica, Arrow, Duncan, and Libby projects and the unregulated runoff of the Columbia River at The Dalles. The forecasts for Mica, Arrow, and Duncan inflow were prepared by B. C. Hydro and Power Authority and those for the Lower Columbia River and Libby inflow were prepared by the United States Columbia River Forecasting Service. Also shown on Table 1 are the actual volumes for these five locations. Observed April-August runoff volumes, adjusted for upstream storage effects so as to exclude the effects of regulation, are listed for eight locations in the following tabulation:

Streamflow and Location	Thousands of Acre-Feet	Percent of 1958-72 Average
Libby Reservoir Inflow	6,345	90
Duncan Reservoir Inflow	1,941	89
Mica Reservoir Inflow	10,660	88
Arrow Reservoir Inflow	21,586	90
Columbia River at Birchbank	39,158	91
Grand Coulee (FDR) Reservoir Inflow	60,684	93
Snake River at Lower Granite Dam	24,422	103
Columbia River at The Dalles	92,924	94

III. RESERVOIR OPERATION

A. MICA RESERVOIR

Storage Evacuation Period - As indicated in Chart 5, Mica reservoir (McNaughton Lake) was at elevation 2446.5 feet on 31 July 1977, approximately 28 feet below full pool elevation 2475.0 feet. Out of a total live storage of 4628.5 thousand second-foot-days (ksfd) on that day, 2169.3 ksfd was Treaty live storage and 2459.2 ksfd was B. C. Hydro live storage (72.7 ksfd of B. C. Hydro live storage had previously been transferred to Arrow Lakes). There was a Treaty storage deficit at Mica of 1359.9 ksfd of which 442.4 ksfd was the Emergency Draft carried over from the 1976-77 operating year.

With near average August streamflows and three units discharging a total of 26,000 cfs at best gate, the lake continued to fill reaching an elevation of 2455.5 feet on 31 August. During October and November, Mica discharges averaged 17,000 cfs except for the period 15 October through 20 October when unit #4 went into commercial operation and Mica discharges increased to 26,000 cfs to meet Canadian power requirements.

The Emergency Draft was transferred into Arrow Lakes during January and February so that the actual Mica outflows varied from 8,000 cfs to 26,000 cfs for the period January through April; drafting the reservoir to elevation 2400.3 feet on 31 March and to elevation 2398.0 feet on 26 April.

<u>Refill Period</u> - An agreement was reached between Bonneville Power Administration (BPA) and B. C. Hydro for BPA to store energy at Mica to enhance refill. Between 27 April and 8 June, BPA delivered energy to B. C. Hydro in lieu of Treaty storage releases at Mica. During this period, Mica outflows were significantly reduced below Detailed Operating Plan releases except for a three day period beginning 12 May when the outflows were increased to 17,000 cfs to serve system load. The reservoir began to rise on 28 April and was at elevation 2421.4 feet on 8 June.

During the "log drive", 9 June through 23 June, Mica operated with alternate periods of high and low discharge. High discharges up to 30,000 cfs were required to supplement the Mica to Revelstoke local streamflow in order to move log bundles from a point on the Columbia River 32 miles upstream of the City of Revelstoke into the Arrow Lakes. Periods of zero discharge were required to lower the water level allowing stranded log bundles to be bulldozed off sandbars and shallow shorelines. The final result was that a total of over 4,000 log bundles were floated past Revelstoke into the Arrow Lakes, with a success rate of almost 100 percent, and no spilling at Mica.

After the "log drive", BPA resumed energy deliveries to B. C. Hydro for storage at Mica until 14 July. It was understood that some of the energy stored at Mica under the BPA storage account was energy from other U.S. utilities. In early July, B. C. Hydro advised BPA that some of the energy stored at Mica would probably be spilled when McNaughton Lake reached full pool. On 31 July, the reservoir was at elevation 2469.6 feet and it reached full pool on 4 September.

B. ARROW RESERVOIR

Storage Evacuation Period - As indicated in Chart 6, due to the exceptionally low runoff in Summer 1977, Arrow reservoir only filled to a maximum elevation of 1410.9 feet on 27 June 1977, approximately 33 feet below the full pool elevation 1444.0 feet. During July and August as Mica and Duncan reservoirs continued to fill, Treaty storage was drafted out of Arrow to meet U.S. power requirements. Between 9 July and 13 September 1977, B. C. Hydro delivered energy to BPA in lieu of Arrow Treaty storage releases to hold the Arrow Lakes elevation relatively constant throughout the summer season. The reservoir was held at elevation 1398 feet for three weeks between late September and early October before it was filled to elevation 1399.7 feet on 22 October as a result of higher Mica discharges.

During December 1977, heavy rains caused high streamflows in the lower Columbia basin, and for several periods of up to 10 days, discharges were reduced to the 5,000 cfs minimum to reduce downstream spilling in the U.S. As a result of these reductions, Arrow

2 September and 25 September, Duncan discharged 10,000 cfs with a total storage draft of approximately 149.7 ksfd. This allowed Kootenay Lake to be raised to the level specified by the International Joint Commission (IJC). During October and November 1977, Duncan outflow varied from a minimum of 100 cfs to 8,000 cfs depending upon the Libby project outflow. During periods of high Libby discharges, Duncan discharges were kept to the minimum necessary to control the level of Kootenay Lake and to reduce spilling at the Brilliant project. Wherever Libby discharge was reduced, higher Duncan outflows were required to supplement local inflow and keep Brilliant generating at full load. From December 1977 through February 1978, Duncan reservoir was drafted heavily to meet U.S. power requirements. The 1 February snow survey indicated that Duncan would have a better than 95 percent confidence of refill. Consequently all Treaty storage was drafted from Duncan reservoir prior to the 1978 spring freshet and it reached its minimum pool elevation of 1794.2 feet on 20 February.

Refill Period - Subsequent to the drawdown, Duncan discharged inflow until 12 March 1978. Between 13 March and 27 April, the outflow was maintained at 200 cfs for fish trapping downstream of the project by the B. C. Government Fish and Wildlife Branch. With well above average steamflow during the fish trapping period, Duncan had accumulated 58.7 ksfd in storage. The outflow was subsequently reduced to 100 cfs and the reservoir continued to fill, reaching full pool elevation 1892.0 feet on 23 July.

D. LIBBY RESERVOIR

Storage Evacuation Period - As a result of the 1977 drought, Libby reservoir (Lake Koocanusa) failed to fill and only reached elevation 2415 feet (44 feet below full pool) on 6 July 1977. During August the lake was drafted about 6 feet to meet U.S. power requirements, but during September it was refilled to elevation 2414 feet. During the fall the outflow was maintained at special levels to permit preliminary work required for stilling basin repairs. The repairs began in early December 1977 and were completed by late May 1978.

The outflow fluctuations from Libby are of concern to the many people who use the river between the project and Kootenay Lake as well as to West Kootenay Power & Light and B. C. Hydro who are interested in the inflow to Kootenay Lake. In order to notify some of the river users of expected stage fluctuations, the project issued a standing order (Libby No. 12) on 21 December 1977 to call the Kootenai Valley Reclamation Association each Monday with a forecast of expected stage fluctuations for the coming week. The project would also call if there were any significant changes in this forecast. The Kootenai Valley Reclamation Association would provide the information to radio station KBFI in Bonners Ferry, Idaho.

On 1 January 1978 the lake was at elevation 2367 feet, 43 feet below the flood control requirement but 21 feet above the 31 January Variable Refill Curve (VRC). During January and February the lake was drafted as additional water was available for power and more space was required for flood control.

The large drop in the runoff forecast between 1 March and 1 April caused the VRC to rise above the actual lake elevation. On 20 March the lake reached its lowest level, elevation 2329.6 feet.

Refill Period - From 4 March to 1 June Libby outflows were maintained between 3,000 and 4,000 cfs to improve the probability of refill. The inflow to the lake peaked at 61,000 cfs on 6 June. The lake continued to fill during the summer and on 30 July the powerhouse outflow was adjusted to equal inflow as the lake was within 0.3 feet of full pool.

E. KOOTENAY LAKE

Storage Evacuation Period - As indicated in Chart 9, Kootenay Lake elevation was maintained about 1743.3 feet during July and August 1977. During September, Kootenay Lake discharges were reduced to an average of 16,000 - 17,000 cfs to keep the Brilliant plant operating at full load without spill. With high discharges out of Duncan, Kootenay Lake gradually filled to elevation 1745.0 feet on 19 October, approximately 0.3 feet below the IJC rule curve. The elevation was held about 1745.0 feet through the end of December. Average discharge from Kootenay Lake during November and December was 22,000 cfs, with 5,000 cfs normally discharged through the West Kootenay projects and the remainder diverted through B. C. Hydro's canal project. During the period January 1978 through March 1978, Kootenay Lake was drafted in accordance with the IJC rule curve. It reached its lowest elevation 1739.1 feet on 23 March.

Refill Period - High steamflows in early April raised the lake to elevation 1740.0 feet but the level dropped to 1739.0 feet as the streamflows receded to normal towards the end of April. The lake rose rapidly in May and June reaching a peak elevation of 1747.6 feet on 11 June. As the streamflows receded, the lake gradually dropped to elevation 1744.0 feet by 31 July and it reached elevation 1743.3 feet by 14 August.

IV. DOWNSTREAM EFFECTS OF STORAGE OPERATION

A. POWER

General - During the period covered by this report, the Treaty storage was operated in accordance with the 1977-78 Detailed Operating Plan designed to achieve optimum power generation in Canada and in the United States of America in accordance with paragraph 7, Annex A of the Treaty. In 1964 the Canadian Entitlement to downstream power benefits for the 1977-78 Operating Year was purchased by Columbia Storage Power Exchange (CSPE) and exchanged with BPA for specified amounts of power and energy. Deliveries of power and energy specified under the Canadian Entitlement Exchange Agreements and attributable to Arrow, Duncan, and Mica under the provisions of these agreements were made during the 1977-78 Operating Year. In a report dated 6 November 1972, "Downstream Power Benefit Computations for 1977-78 Operating Year", the Entities agreed that the United States Entity is entitled to receive during the period 1 April 1977 through 31 March 1978, from B. C. Hydro and Power Authority, 1.5 megawatts of capacity and 5.5 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement, dated 13 August 1964. Scheduling of this capacity and energy from B. C. Hydro and Power Authority terminated on 31 March 1978.

The generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement was 689 average megawatts at rates up to 1362 megawatts from 1 August 1977 through 31 March 1978 and 658 average megawatts at rates up to 1350 megawatts, from 1 April 1978 through 31 July 1978. During the period 1 April 1977 through 31 March 1978, the CSPE participants assigned 154 average megawatts at rates up to 300 megawatts to Pacific Southwest utilities. Beginning 1 April 1978 the assignment was 74 average megawatts at rates up to 150 megawatts. CSPE power not assigned to Pacific Southwest utilities was used in Pacific Northwest loads.

Review of 1977-78 Operations - The January through July 1977 volume runoff of the Columbia River measured at The Dalles, Oregon was 54.0 million acre-feet which was less than the previously recorded low flow of 60.6 million acre-feet for the same period. This resulted in a storage deficit of 12.7 million acre-feet (approximately 14 billion kilowatt-hours) on 31 July 1977. Estimates of 1977-78 Coordinated System loads and resources indicated that reservoirs would empty by late winter 1978 and firm loads could not be served through April 1978 with a repetition of the lowest historical August through April runoff conditions (1936-37) in the 40-year period 1928-29 through 1967-68. These estimates assumed that firm loads would not substantially deviate from the estimates and that major thermal plants would operate as planned.

The total runoff of the Columbia River at The Dalles from 1 August 1977 through November 1977 was equivalent to that runoff which occurred in 1936 (19.4 million acre-feet) and was only 0.6 million acre-feet higher than the lowest August-November runoff recorded in 1929. Even so, reservoir storage energy deficiencies, compared to normal drawdown levels, remained near 14 billion kilowatt-hours throughout the period as loads continued to underrun operating program levels as a result of energy conservation efforts.

Above average precipitation during the last four months of 1977, particularly in November and December (124 and 161 percent of normal amounts, respectively), caused the reservoir storage energy deficiency to drop to 9.6 billion kilowatt-hours by 31 December 1977.

On 11 January 1978, BPA restored secondary energy deliveries to all of its Pacific Northwest customers. Curtailment of secondary energy deliveries to private utilities and BPA industrial customers had been in effect since 1 November 1976. Favourable volume runoff forecasts for major storage projects enabled lowering of the 31 January 1978 reservoir operating rule curves and restoration of secondary energy deliveries without jeopardy to firm power commitments or reservoir refill. In addition, BPA made 1.2 billion kilowatt-hours of energy available for sale from the Hanford plant. This energy had been withdrawn from BPA's industrial customers due to the extreme drought conditions that existed during 1976-77. On 31 March 1978, BPA began marketing surplus energy to California. No surplus energy had been delivered outside the Pacific Northwest since 13 September 1976.

BPA surplus energy sales to California were curtailed 19 June 1978. At the same time, secondary energy sales to Pacific Northwest utilities increased to displace thermal generation that was being exported to Pacific Southwest utilities. BPA surplus sales to California were resumed 1 July 1978 for about 2½ weeks as reservoirs approached their normal full elevations.

All major reservoirs were full on 31 July 1978, except Mica which filled by 4 September.

B. FLOOD CONTROL

Lower Columbia River Regulation - Without regulation by upstream reservoirs, the 1978 high water season would have produced an April through August runoff volume of 94 maf compared to the 1958-72 average of 99 maf. The computed unregulated peak discharge at The Dalles was 573,000 cfs on 10 June; the actual peak was 313,900 cfs on 10 June. At Vancouver, Washington, a key gauging station for evaluating flooding on the Lower Columbia River, the maximum stage during the spring freshet was 9.8 feet observed on 19 May as compared to a computed unregulated stage of 19.9 feet. Bankfull stage at Vancouver is 16 feet and major flood stage is 26 feet at this gauge.

Chart 12 shows the 1977-78 flows at The Dalles, both as observed and as they would have been under unregulated conditions. These hydrographs are shown compared with the summary hydrograph of previously observed flows at The Dalles. Chart 13 shows the flow at The Dalles for the spring flood period in 1978. On this chart the effects of regulation by Mica, Arrow, Duncan, and Libby projects are separated from those of all other major storage projects in the Columbia River Basin.

The flood control regulation of the Lower Columbia River is significantly affected by the operation of Grand Coulee project. Chart 11 shows the regulation by Grand Coulee reservoir during the period 1 July 1977 - 31 July 1978. The observed peak inflow to Roosevelt Lake at Grand Coulee Dam was 199,000 cfs on 22 May 1978, when the outflow was 140,000 cfs. The computed unregulated peak inflow was 318,000 cfs on 11 and 12 June. The basis for the computation of the Initial Controlled Flow of 320,000 cfs for the Columbia River at The Dalles, Oregon, is shown on Table 6.

Chart 14 documents the relative filling of Arrow and Grand Coulee during the principal filling period, and compares the coordinated regulation of the two reservoirs to guidelines in the Flood Control Operating Plan.

Local Regulation - No significant local flood control problems were encountered in 1978. Unregulated discharges at Bonners Ferry, Idaho would have caused stages approximately 0.7 feet over bankfull stage. This is about 8 feet below the top of the levees. The operation at Libby reservoir reduced the Kootenay River flow to a non-damaging stage, permitting use of roads and lands that are normally inundated. The combined operation of Libby and Duncan reservoirs in controlling inflows to Kootenay Lake improved the seasonal operation of the lake and reduced the peak stage of Kootenay Lake by about 6 feet as indicated on Chart 9.

The operation of Mica and Arrow projects not only contributed to the reduction of flows in the lower Columbia River to non-damaging flows but regulated the flow of the Columbia River in Canada to well below bankfull levels. As shown on Chart 10 the peak discharge of the Columbia River at Birchbank was 110,000 cfs on 19 July which is well below the bankful level as measured at Trail, B. C. The computed unregulated maximum flow at Birchbank was 204,000 cfs.

C. SPECIAL OPERATING ARRANGEMENTS

Storage in Arrow Lakes by B. C. Hydro - On 18 July 1977, B. C. Hydro and BPA entered into an agreement, Contract No. 14-03-79156, whereby B. C. Hydro would deliver energy to BPA in lieu of releases from Arrow Lakes and thereby provide for the storage of additional water in Arrow Lakes. During the period from 7 July to 13 September 1977, B. C. Hydro delivered energy to BPA in lieu of Arrow Treaty storage releases at rates of up to 20,000 MWh per day. Total energy delivered during the period was 559,178 MWh; equivalent to 386.5 ksfd of storage at Arrow. The energy was returned 29 October - 15 December 1977, and B. C. Hydro paid BPA 1.5 mills for each killowatt-hour of storage energy returned. The United States and Canadian Entities were satisfied that the operations adopted by the parties were not in conflict with the Columbia River Treaty operations and the Canadian Entitlement Purchase Agreement. The

Operating Committee was instructed to ensure that any filling or drafting of the additional Arrow storage did not conflict with the implementation of the Treaty operating plans.

Emergency Draft Arrangement - During the 1976-77 Operating Year, BPA and B. C. Hydro entered into the "Emergency Draft Agreement" to mitigate energy shortages in the U.S. The agreement allowed for the drafting of an additional 442.4 ksfd of storage from Arrow and Duncan reservoirs. A compensating draft of 442.4 ksfd was made at Mica later in the 1976-77 Operating Year to restore the Arrow and Duncan reservoir levels. This left a 442.4 ksfd reduction in Mica Treaty storage at the beginning of the 1977-78 Operating Year.

On 22 December 1977, it was agreed that it would be beneficial to both Canadian and U.S. interests in the operation of the Columbia River Treaty projects to transfer the Emergency Draft from Mc-Naughton Lake back into Arrow Lakes. Beginning on 1 January 1978, the transfer took place at an average rate of about 10 ksfd per day. This was accomplished by reducing the Mica Treaty storage releases below that stipulated in the 1977-78 Detailed Operating Plan.

The transfer of the total Emergency Draft of 442.4 ksfd was completed 18 February and thereafter the Mica head loss computation and corresponding energy deliveries were discontinued. The total head loss at Mica incurred during the period 3 May 1977 - 18 February 1978 was 88,333 Mwh which was delivered by BPA to B. C. Hydro during the period.

On 31 March, it was recognized that had the Emergency Draft not been completely restored, the Treaty storage at Arrow reservoir would have exceeded the flood control drawdown requirement by 272.2 ksfd. It was then agreed that effective 1 April, the Emergency Draft would be reduced by 272.2 ksfd to 170.2 ksfd. Treaty storage continued to accumulate in early April and Arrow reservoir reached elevation 1400.0 feet on 15 April, the maximum elevation allowable for flood control. Therefore, the Emergency Draft was deemed fully restored and the Emergency Draft Agreement effectively ended on that date.

Agreement to Enhance Filling of Mica Reservoir - Forecasts of inflow to McNaughton Lake during the April through July 1978 period indicated that the Mica Reservoir had substantially less probability of refilling during the summer of 1978 (while meeting the 1977-78 Detailed Operating Plan target releases) than did other reservoirs affecting the Federal Columbia River Power System. The probability of refilling McNaughton Lake could be enhanced be permitting BPA to deliver electric energy to B. C. Hydro for storage in Mica Reservoir. An agreement to allow this would be advantageous to both BPA and B. C. Hydro. In addition to Mica refill considerations, B. C. Hydro could gain flexibility in the operation of its system by delivering electric energy to BPA for storage in the Mica and Arrow Lakes Reservoirs.

Discussions between representatives of BPA and B. C. Hydro resulted in the development of a mutually beneficial proposal whereby each party may deliver energy to the other for storage in reservoirs. The agreement between BPA and B. C. Hydro, Contract No. EW-78-Y-83-0069, became effective 26 April 1978 and will continue in effect until 31 July 1979.

During the period 27 April through 8 June, BPA delivered a total of 326,589 MWh of energy to B. C. Hydro in lieu of Treaty storage releases; equivalent to 327.8 ksfd of storage in McNaughton Lake. From 23 June until 14 July, BPA delivered additional energy for storage in McNaughton Lake (161.9 ksfd) for a total of 498,031 MWh (489.7 ksfd). Due to the probability of spilling some of this energy, small amounts were returned to BPA during the last half of July so that on 31 July the BPA storage in McNaughton Lake amounted to 426.8 ksfd.

V. OPERATING CRITERIA

A. GENERAL

The Columbia River Treaty requires that the reservoirs constructed in Canada be operated pursuant to flood control and hydroelectric operating plans developed thereunder. Annex A of the Treaty stipulates that the United States Entity will submit flood control operating plans and that the Canadian Entity will operate in accordance with flood control storage diagrams or any variation which the Entities agree will not be adverse to the desired aim of the flood control plan. Annex A also provides for the development of hydroelectric operating plans five years in advance to furnish the Entities with an Assured Operating Plan for Canadian Storage. In addition, Article XIV.2.k of the Treaty provides that a Detailed Operating Plan may be developed to produce more advantageous results through use of current estimates of loads and resources. The Protocol to the Treaty provides further detail and clarification of the principles and requirements of Annex A. The Principles and Procedures of 25 July 1967, together with the Columbia River Treaty Flood Control Operating Plan dated October 1972, both developed by special task forces, establish the general criteria of operations.

The Assured Operating Plan dated 16 October 1972 established Operating Rule Curves for Duncan, Arrow and Mica during the 1977-78 operating year. The Operating Rule Curves provided guidelines for refill levels as well as drawdown levels. They were derived from Critical Rule Curves, Assured Refill Curves, and simulated Variable Refill Curves, consistent with flood control requirements, as described in the Principles and Procedures. The Flood Control Storage Reservation Curves were established to conform to the Flood Control Operating Plan.

The Detailed Operating Plan dated September 1977 established data and criteria for determining the Operating Rule Curves for use in actual operations. At the request of the Canadian Entity these criteria included the Critical Rule Curves for Duncan, Arrow, and Mica agreed in the 1977-78 Assured Operating Plan. The Variable Refill Curves and flood control requirements subsequent to 1 January 1978, were determined on the basis of seasonal volume runoff forecasts during actual operation.

B. POWER OPERATION

Prior to the 1976-77 operating year, each Detailed Operating Plan was designed to achieve optimum generation downstream in the United States. However, with the existence of generators at Mica, the Detailed Operating Plan dated September 1977 was designed to achieve optimum power generation at site in Canada and downstream in Canada and the United States, consistent with project operating limits and flood control requirements.

The power facilities in the United States which are downstream from the Treaty storage projects are all operated under the Pacific Northwest Coordination Agreement dated September 1964. Optimum generation in the United States was assured by the adoption, in the Assured and Detailed Operating Plans, of criteria and operating guides designed to coordinate the operation of Treaty projects with the projects operating under the Agreement. Optimum operation of Treaty reservoirs was accomplished, for the actual water condition experienced, by operating with reference to the Critical Rule Curves, Assured Refill Curves, Variable Refill Curves, Flood Control Storage Reservation Curves and related criteria determined in accordance with the Detailed Operating Plan.

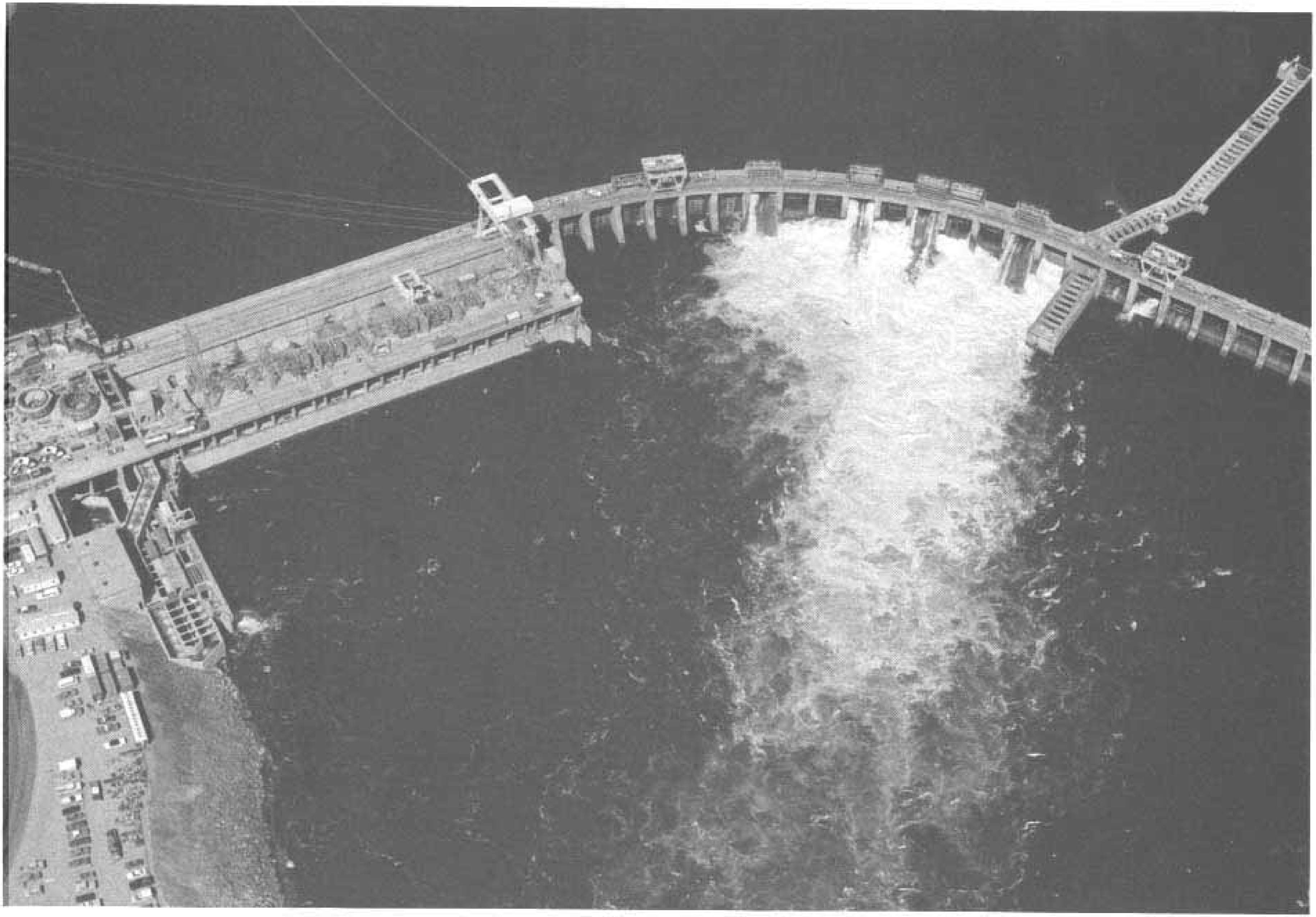
C. FLOOD CONTROL OPERATION

The Flood Control Operating Plan was designed to minimize flood damage both in Canada and in the United States. The flood control operation during the drawdown period consisted of evacuating and holding available storage space, consistent with refill criteria, sufficient to control the maximum flood that could occur under forecast conditions. Runoff volume forecasts determined the volume of storage space required.

Flood control operation of the Columbia River Treaty projects during the refill period was controlled in part by the computed Initial Controlled Flow of the Columbia River at The Dalles. Other

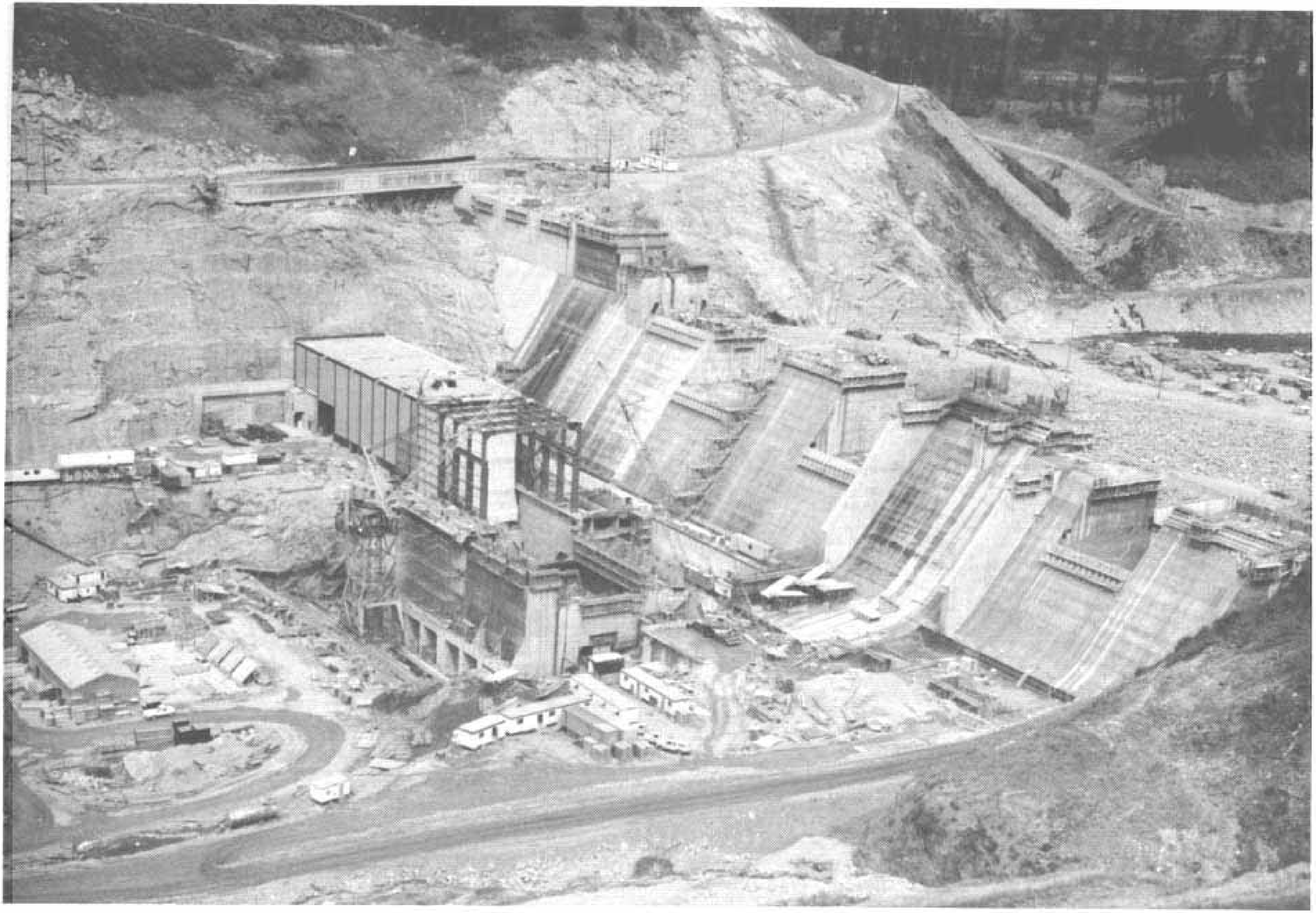
A view from inside the Mica Dam powerhouse of the formal dedication ceremonies which took place on 13 October 1977. As of 15 October 1977 there were four generating units in commercial operation; each rated at 434 MW. The powerhouse will ultimately have six units with a total installed capacity of 2704 MW.

B.C. Hydro and Power Authority Photograph



An aerial view looking upstream showing construction of the second powerhouse at Public Utility District No. 1 of Chelan County's Rock Island Project. Eight Alstrom-Nypric axial flow turbine-generator units are being installed with each generator rated at 54 MVA.

Chelan County Public Utility District No. 1 Photograph



A view from the left bank showing construction of the Seven-Mile Project as of 30 August 1978. The first of four 202 megawatt units is scheduled to come on-line in April 1980.

B.C. Hydro and Power Authority Photograph

TABLE 1

UNREGULATED RUNOFF VOLUME FORECASTS
MILLIONS OF ACRE-FEET
1978

	DUNCAN	ARROW	MICA	LIBBY	UNREGULATED RUNOFF COLUMBIA RIVER AT THE DALLES, OREGON
Forecast Date - 1st of	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Jan - 31 Jul
January	2.04	21.28	10.58	6.83	120.0
February	2.05	21.13	10.63	6.81	114.0
March	2.00	20.09	10.25	6.30	108.0
April	1.94	20.03	10.21	5.88	101.0
May	2.02	21.02	10.44	6.10	104.0
June	2.06	20.49	10.19	7.00	105.0
Actual	1.94	21.59	10.66	6.34	105.2

NOTE: These data are as used in actual operations. Subsequent revisions have been made in some cases.

MICA RESERVOIR COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1978

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUNE 1
1. PROBABLE FEB. 1-JULY 31 INFLOW, KSFD 1/		4429.7	4463.1	4294.6	4294.3	4392.1	4275.1
2. 95% FORECAST ERROR, KSFD		727.4	535.6	453.7	457.3	455.8	444.7
3. 95% CONFIDENCE FEB. 1-JULY 31 INFLOW, KSFD 2/		3702.3	3927.5	3840.9	3837.0	3936.3	3830.4
4. OBSERVED FEB. 1-DATE INFLOW, KSFD		0.0	0.0	94.9	206.8	450.6	1091.3
5. 95% CONFIDENCE DATE-JULY 31, INFLOW, KSFD 3/		3702.3	3927.5	3746.0	3630.2	3485.7	2739.1
ASSUMED FEB. 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB. 1-JULY 31 INFLOW, KSFD 4/		3702.3					
MIN. FEB. 1-JULY 31 OUTFLOW, KSFD		2180.0					
MIN. JAN. 31 RESERVOIR CONTENT, KSFD 5/		2006.9					
MIN. JAN. 31 RESERVOIR ELEV., FT. 6/	2440.2	2444.7					
JAN. 31 VARIABLE REFILL CURVE, FT. 7/		2440.2					
ASSUMED MAR. 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
ASSUMED MAR. 1-JULY 31 INFLOW, KSFD 4/		3624.6	3845.0				
MIN. MAR. 1-JULY 31 OUTFLOW, KSFD		1760.0	1760.0				
MIN. FEB. 28 RESERVOIR CONTENT, KSFD 5/		1664.6	1444.2				
MIN. FEB. 28 RESERVOIR ELEV., FT. 6/	2426.3	2437.6	2432.9				
FEB. 28 VARIABLE REFILL CURVE, FT. 7/		2426.3	2426.3				
ASSUMED APR. 1-JULY 31 INFLOW, % VOLUME		95.6	95.6	97.6			
ASSUMED APR. 1-JULY 31 INFLOW, KSFD 4/		3539.4	3754.7	3656.1			
MIN. APR. 1-JULY 31 OUTFLOW, KSFD		1295.0	1295.0	1295.0			
MIN. MAR. 31 RESERVOIR CONTENT, KSFD 5/		1284.8	1069.5	1168.1			
MIN. MAR. 31 RESERVOIR ELEV., FT. 6/	2414.9	2429.5	2424.7	2426.9			
MAR. 31 VARIABLE REFILL CURVE, FT. 7/		2414.9	2414.9	2414.9			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		91.4	91.4	93.3	95.6		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		3383.9	3589.7	3495.0	3470.5		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		920.0	920.0	920.0	920.0		
MIN. APR. 30 RESERVOIR CONTENT, KSFD 5/		1065.3	859.5	954.2	978.7		
MIN. APR. 30 RESERVOIR ELEV., FT. 6/	2409.6	2424.7	2420.1	2422.2	2422.7		
APR. 30 VARIABLE REFILL CURVE, FT. 7/		2409.6	2409.6	2409.6	2409.6		
ASSUMED JUN. 1-JULY 31 INFLOW, % VOLUME		74.2	74.2	75.8	77.6	81.2	
ASSUMED JUN. 1-JULY 31 INFLOW, KSFD 4/		2747.1	2914.2	2839.5	2817.0	2830.4	
MIN. JUN. 1-JULY 31 OUTFLOW, KSFD		610.0	610.0	610.0	610.0	610.0	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		1392.1	1225.0	1299.7	1322.2	1308.8	
MIN. MAY 31 RESERVOIR ELEV., FT. 6/	2421.8	2431.8	2428.2	2429.8	2430.3	2430.0	
MAY 31 VARIABLE REFILL CURVE, FT. 7/		2421.8	2421.8	2421.8	2421.8	2421.8	
ASSUMED JUL. 1-JULY 31 INFLOW, % VOLUME		36.0	36.0	36.8	37.6	39.4	48.5
ASSUMED JUL. 1-JULY 31 INFLOW, KSFD 4/		1332.8	1413.9	1378.5	1365.0	1373.4	1328.5
MIN. JUL. 1-JULY 31 OUTFLOW, KSFD		310.0	310.0	310.0	310.0	310.0	310.0
MIN. JUNE 30 RESERVOIR CONTENT, KSFD 5/		2506.4	2425.3	2460.7	2474.2	2465.8	2510.7
MIN. JUNE 30 RESERVOIR ELEV., FT. 6/	2451.0	2454.8	2453.2	2453.9	2454.2	2454.0	2454.9
JUNE 30 VARIABLE REFILL CURVE, FT. 7/		2451.0	2451.0	2451.0	2451.0	2451.0	2451.0
JULY 31 VARIABLE REFILL CURVE, FT. 7/	2474.5	2474.5	2474.5	2474.5	2474.5	2474.5	2474.5
NOTE - ACCUMULATED DEAD STORAGE, KSFD		6565.1	6565.1	6565.1	6565.1	6565.1	6565.1

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1 - LINE 2
3/ LINE 3 - LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (3529.2) PLUS PRECEDING LINE LESS LINE PRECEDING THAT (USABLE STORAGE).
6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED MARCH 25, 1974 (FOOTNOTE 5 PLUS ACCUMULATED DEAD STORAGE).
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED BY ADDING DEAD STORAGE TO INITIAL CONTENTS.

ARROW LAKES RESERVOIR COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1978

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUNE 1
1. PROBABLE FEB. 1-JULY 31 INFLOW, KSFD 1/		9355.5	9336.7	8773.3	4714.7+	5079.7+	4961.7+
2. 95% FORECAST ERROR, KSFD		1680.9	1281.3	1160.3	579.1	523.1	508.5
3. 95% CONFIDENCE FEB. 1-JULY 31 INFLOW, KSFD 2/		7674.6	8055.4	7613.0	4135.6	4556.6	4453.2
4. OBSERVED FEB. 1-DATE INFLOW, KSFD		0.0	0.0	165.8	450.9	1010.0	2116.0
5. 95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		7674.6	8055.4	7447.2	3684.7	3546.6	2337.2
ASSUMED FEB. 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB. 1-JULY 31 INFLOW, KSFD 4/		7674.6					
MIN. FEB. 1-JULY 31 OUTFLOW, KSFD		905.0					
MICA REFILL REQUIREMENTS, KSFD 5/		1738.1					
MIN. JAN. 31 CONTENTS, KSFD 6/		683.6*					
MIN. JAN. 31 ELEVATION, FT. 7/	1416.9	1393.3					
JAN. 31 VARIABLE REFILL CURVE, FT. 8/		1393.3					
ASSUMED MAR. 1-JULY 31 INFLOW, % VOLUME		97.4	97.4				
ASSUMED MAR. 1-JULY 31 INFLOW, KSFD 4/		7475.1	7846.0				
MIN. MAR. 1-JULY 31 OUTFLOW, KSFD		765.0	765.0				
MICA REFILL REQUIREMENTS, KSFD 5/		2389.0	2389.0				
MIN. FEB. 28 CONTENTS, KSFD 6/		353.1*	353.1*				
MIN. FEB. 28 ELEVATION, FT. 7/	1405.6	1386.2	1386.2				
FEB. 28 VARIABLE REFILL CURVE, FT. 8/		1386.2	1386.2				
ASSUMED APR. 1-JULY 31 INFLOW, % VOLUME		94.3	94.3	96.8			
ASSUMED APR. 1-JULY 31 INFLOW, KSFD 4/		7237.1	7596.2	7208.9			
MIN. APR. 1-JULY 31 OUTFLOW, KSFD		610.0	610.0	610.0			
MICA REFILL REQUIREMENTS, KSFD 5/		2899.1	2899.1	2899.1			
MIN. MAR. 31 CONTENTS, KSFD 6/		89.9*	89.9*	89.9*			
MIN. MAR. 31 ELEVATION, FT. 7/	1404.5	1380.1	1380.1	1380.1			
MAR. 31 VARIABLE REFILL CURVE, FT. 8/		1380.1	1380.1	1380.1			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		87.3	87.3	89.6	92.6		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		6699.9	7032.4	6672.7	3412.0		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		460.0	460.0	460.0	460.0		
MICA REFILL REQUIREMENTS, KSFD 5/		3127.4	3127.4	3127.4	N/A		
MICA DOP RELEASE		N/A	N/A	N/A	920.0		
MIN. APR. 30 CONTENTS, KSFD 6/		467.1	134.6	494.3	0.0		
MIN. APR. 30 ELEVATION, FT. 7/	1391.8	1388.8	1381.2	1389.4	1377.9		
APR. 30 VARIABLE REFILL CURVE, FT. 8/		1388.8	1381.2	1389.4	1377.9		
ASSUMED JUN. 1-JULY 31 INFLOW, % VOLUME		63.4	63.4	65.1	67.3	72.6	
ASSUMED JUN. 1-JULY 31 INFLOW, KSFD 4/		4865.7	5107.1	4848.1	2479.8	2574.8	
MIN. JUN. 1-JULY 31 OUTFLOW, KSFD		305.0	305.0	305.0	305.0	305.0	
MICA REFILL REQUIREMENTS, KSFD 5/		2593.6	2593.6	2593.6	N/A	N/A	
MICA DOP RELEASE		N/A	N/A	N/A	610.0	610.0	
MIN. MAY 31 CONTENTS, KSFD 6/		1612.5	1371.1	1630.1	794.8	699.8	
MIN. MAY 31 ELEVATION, FT. 7/	1412.3	1411.4	1406.9	1411.7	1395.6	1393.7	
MAY 31 VARIABLE REFILL CURVE, FT. 8/		1411.4	1406.9	1411.7	1395.6	1393.7	
ASSUMED JUL. 1-JULY 31 INFLOW, % VOLUME		26.3	26.3	27.0	27.9	30.1	41.4
ASSUMED JUL. 1-JULY 31 INFLOW, KSFD 4/		2018.4	2118.6	2010.7	1028.0	1067.5	967.6
MIN. JUL. 1-JULY 31 OUTFLOW, KSFD		155.0	155.0	155.0	155.0	155.0	155.0
MICA REFILL REQUIREMENTS, KSFD 5/		1212.1	1212.1	1212.1	N/A	N/A	N/A
MICA DOP RELEASE		N/A	N/A	N/A	310.0	310.0	310.0
MIN. JUN. 30 CONTENTS, KSFD 6/		2928.3	2828.1	2936.0	2396.6	2357.1	2457.0
MIN. JUN. 30 ELEVATION, FT. 7/	1442.5	1433.8	1432.2	1433.9	1425.1	1424.4	1426.1
JUN. 30 VARIABLE REFILL CURVE, FT. 8/		1433.8	1432.2	1433.9	1425.1	1424.4	1426.1
JULY 31 VARIABLE REFILL CURVE, FT. 8/	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1 - LINE 2
3/ LINE 3 - LINE 4
4/ PRECEDING LINE X LINE 5
5/ MICA FULL CONTENT - VARIABLE REFILL CURVE FROM MICA VRC COMPUTATION FORM
6/ FULL CONTENT (3579.6 KSFD) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT
7/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED FEBRUARY 28, 1974
8/ LOWER OF THE ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)
* LOWER LIMIT, BASED ON 1936-37 HYDRO CONDITIONS
\+ 95% CONFIDENCE FORECAST AND CORRESPONDING VRC BASED ON ARROW LOCAL FORECAST AND RELEASES FROM MICA AS GIVEN BY THE DETAILED OPERATING PLAN (DOP)

DUNCAN RESERVOIR COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1978

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUNE 1
1. PROBABLE FEB. 1-JULY 31 INFLOW, KSFD 1/		891.2	895.1	861.9	846.5	881.5	896.5
2. 95% FORECAST ERROR, KSFD		154.2	120.9	111.4	105.6	96.2	94.8
3. 95% CONFIDENCE FEB. 1-JULY 31 INFLOW, KSFD 2/		737.0	774.2	750.5	740.9	785.3	801.7
4. OBSERVED FEB. 1-DATE INFLOW, KSFD		0.0	0.0	10.8	38.8	102.7	251.5
5. 95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		737.0	774.2	739.7	702.1	682.6	550.2
ASSUMED FEB. 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB. 1-JULY 31 INFLOW, KSFD 4/		737.0					
MIN. FEB. 1-JULY 31 OUTFLOW, KSFD		18.1					
MIN. JAN. 31 RESERVOIR CONTENT, KSFD 5/		139.8*					
MIN. JAN. 31 RESERVOIR ELEVATION, FT. 6/	1835.8	1820.0					
JAN. 31 VARIABLE REFILL CURVE, FT. 7/		1820.0					
ASSUMED MAR. 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
ASSUMED MAR. 1-JULY 31 INFLOW, KSFD 4/		721.5	757.9				
MIN. MAR. 1-JULY 31 OUTFLOW, KSFD		15.3	15.3				
MIN. FEB. 28 RESERVOIR CONTENT, KSFD 5/		72.6*	72.6*				
MIN. FEB. 28 RESERVOIR ELEVATION, FT. 6/	1835.3	1809.0	1809.0				
FEB. 28 VARIABLE REFILL CURVE, FT. 7/		1809.0	1809.0				
ASSUMED APR. 1-JULY 31 INFLOW, % VOLUME		95.5	95.5	97.5			
ASSUMED APR. 1-JULY 31 INFLOW, KSFD 4/		703.8	739.4	721.2			
MIN. APR. 1-JULY 31 OUTFLOW, KSFD		12.2	12.2	12.2			
MIN. APR. 30 RESERVOIR CONTENT, KSFD 5/		20.2*	20.2*	20.2*			
MIN. MAR. 31 RESERVOIR CONTENT, FT. 6/	1837.2	1799.0	1799.0	1799.0			
MAR. 31 VARIABLE REFILL CURVE, FT. 7/		1799.0	1799.0	1799.0			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		90.4	90.4	92.3	94.7		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		666.3	699.9	682.7	664.9		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		9.2	9.2	9.2	9.2		
MIN. APR. 30 RESERVOIR CONTENT, KSFD 5/		48.7	15.1	32.3	50.1		
MIN. APR. 30 RESERVOIR CONTENT, FT. 6/	1834.2	1804.7	1797.9	1801.5	1804.9		
APR. 30 VARIABLE REFILL CURVE, FT. 7/		1804.7	1797.9	1801.5	1804.9		
ASSUMED JUNE 1-JULY 31 INFLOW, % VOLUME		71.4	71.4	72.9	74.8	79.0	
ASSUMED JUNE 1-JULY 31 INFLOW, KSFD 4/		526.2	552.8	539.2	525.2	539.3	
MIN. JUNE 1-JULY 31 OUTFLOW, KSFD		6.1	6.1	6.1	6.1	6.1	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		185.7	159.1	172.7	186.7	172.6	
MIN. MAY 31 RESERVOIR CONTENT, FT. 6/	1848.6	1826.9	1823.0	1825.0	1827.1	1825.0	
MAY 31 VARIABLE REFILL CURVE, FT. 7/		1826.9	1823.0	1825.0	1827.1	1825.0	
ASSUMED JULY 1-JULY 31 INFLOW, % VOLUME		32.5	32.5	33.1	34.0	35.9	45.5
ASSUMED JULY 1-JULY 31 INFLOW, KSFD 4/		239.5	251.6	244.8	238.7	245.1	250.3
MIN. JULY 1-JULY 31 OUTFLOW, KSFD		3.1	3.1	3.1	3.1	3.1	3.1
MIN. JUNE 30 RESERVOIR CONTENT, KSFD 5/		469.4	457.3	464.1	470.2	463.8	458.6
MIN. JUNE 30 RESERVOIR CONTENT, FT. 6/	1872.0	1864.4	1862.9	1863.8	1864.5	1863.7	1863.1
JUNE 30 VARIABLE REFILL CURVE, FT. 7/		1864.4	1862.9	1863.8	1864.5	1863.7	1863.1
JULY 31 VARIABLE REFILL CURVE, FT.	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1-LINE 2
3/ LINE 3-LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (705.8) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
6/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED JUNE 20, 1974
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)
* LOWER LIMIT, BASED ON 1936-37 HYDRO CONDITIONS

LIBBY COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1978

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUN. 1
1. 95% CONFIDENCE JAN 1 - JULY 31 INFLOW, KSFD 1/		2575.3	2743.2	2452.8	2201.7	2144.7	1615.4
2. OBSERVED JAN 1 - DATE INFLOW, KSFD		0.0					
3. RESIDUAL 95% DATE - JULY 31 INFLOW, KSFD 2/		2575.3	2743.2	2452.8	2201.7	2144.7	1615.4
ASSUMED FEB 1 - JUL 31 INFLOW, % VOLUME		96.94					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD 3/		2496.5					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD		543.0					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 4/		548.1*					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 5/		2345.8					
JAN 31 VARIABLE REFILL CURVE, FT. 6/	2403.6	2345.8					
ASSUMED MAR 1 - JUL 31 INFLOW, % VOLUME		94.17	97.14				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD 3/		2425.2	2664.7				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD		459.0	459.0				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 4/		521.1	342.2 *				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 5/		2343.6	2326.5				
FEB 28 VARIABLE REFILL CURVE, FT. 6/	2402.2	2343.6	2326.5				
ASSUMED APR 1 - JUL 31 INFLOW, % VOLUME		90.79	93.66	96.42			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD 3/		2338.1	2569.3	2365.0			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD		366.0	366.0	366.0			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 4/		515.2	284.0	488.3			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 5/		2342.9	2320.5	2340.5			
MAR 31 VARIABLE REFILL CURVE, FT. 6/	2400.9	2342.9	2320.5	2340.5			
ASSUMED MAY 1 - JUL 31 INFLOW, % VOLUME		81.71	84.29	86.77	90.00		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD 3/		2104.3	2312.2	2128.3	1981.5		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD		276.0	276.0	276.0	276.0		
MIN. APR 30 RESERVOIR CONTENT, KSFD 4/		659.0	451.1	635.0	781.8		
MIN. APR 30 RESERVOIR ELEVATION, FT. 5/		2355.3	2337.1	2353.3	2364.9		
APR 30 VARIABLE REFILL CURVE, FT. 6/	2399.4	2355.3	2337.1	2353.3	2364.9		
ASSUMED JUN 1 - JUL 31 INFLOW, % VOLUME		52.75	54.42	56.02	58.10	64.56	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD 3/		1358.5	1492.8	1374.1	1279.2	1384.6	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD		183.0	183.0	183.0	183.0	183.0	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 4/		1311.8	1177.5	1296.2	1391.1	1285.7	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 5/		2400.2	2392.1	2399.3	2404.9	2398.7	
MAY 31 VARIABLE REFILL CURVE, FT. 6/	2423.9	2400.2	2392.1	2399.3	2404.9	2398.7	
ASSUMED JUL 1 - JUL 31 INFLOW, % VOLUME		18.97	19.57	20.15	20.90	23.22	35.97
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD 3/		488.5	536.8	494.2	460.2	498.0	581.1
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD		93.0	93.0	93.0	93.0	93.0	93.0
MIN. JUN 30 RESERVOIR CONTENT, KSFD 4/		2091.8	2043.5	2086.1	2120.1	2082.3	1999.2
MIN. JUN 30 RESERVOIR ELEVATION, FT. 5/		2441.3	2439.0	2441.1	2442.7	2440.9	2436.9
JUN 30 VARIABLE REFILL CURVE, FT. 6/	2454.5	2441.3	2439.0	2441.1	2442.7	2440.9	2436.9
JULY 31 VARIABLE REFILL CURVE, FT.		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0

1/ .50417 TIMES SUM OF TWO SUB-BASIN 95% INFLOW FORECASTS, (KAF)
2/ LINE 1 MINUS LINE 2
3/ PRECEDING LINE X LINE 3
4/ FULL CONTENT (2487.3 KSFD) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
5/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED MARCH 17, 1972
6/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR, BUT NOT LESS THAN THE LOWEST RULE CURVE
*LOWER LIMIT, BASED ON 1936 - 37 HYDRO CONDITIONS

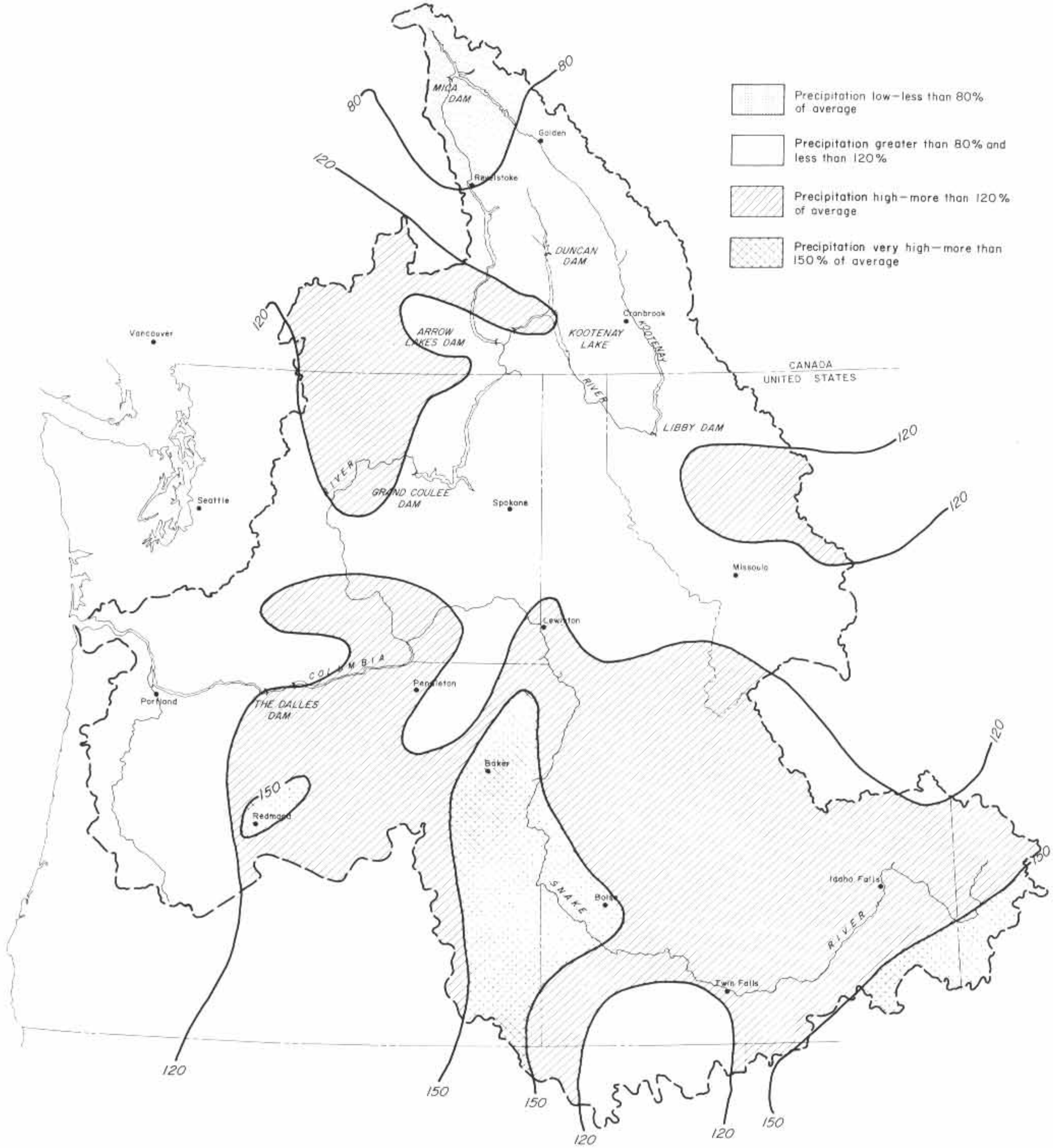
COMPUTATION OF INITIAL CONTROLLED FLOW
COLUMBIA RIVER AT THE DALLES, OREGON
1 MAY 1978

1 May Forecast of May - August Unregulated Runoff Volume, MAF		76.5
Less Estimated Depletions, MAF		1.5
Less Upstream Storage Corrections, MAF		
Mica	5.9	
Arrow	5.0	
Libby	3.8	
Duncan	1.2	
Hungry Horse	1.6	
Flathead Lake	.5	
Noxon	.1	
Pend Oreille Lake	.5	
Grand Coulee	4.3	
Brownlee	.3	
Dworshak	1.0	
John Day	.2	
TOTAL	24.4	24.4
Forecast of Adjusted Residual Runoff Volume, MAF		50.6
Computed Initial Controlled Flow (From Chart 1, of Interim Flood Control Plan), KCFS		320.0

COLUMBIA RIVER BASIN

OCTOBER 77 - APRIL 78 PRECIPITATION
PERCENT OF 1958-72 AVERAGE

CHART 1
SEASONAL PRECIPITATION



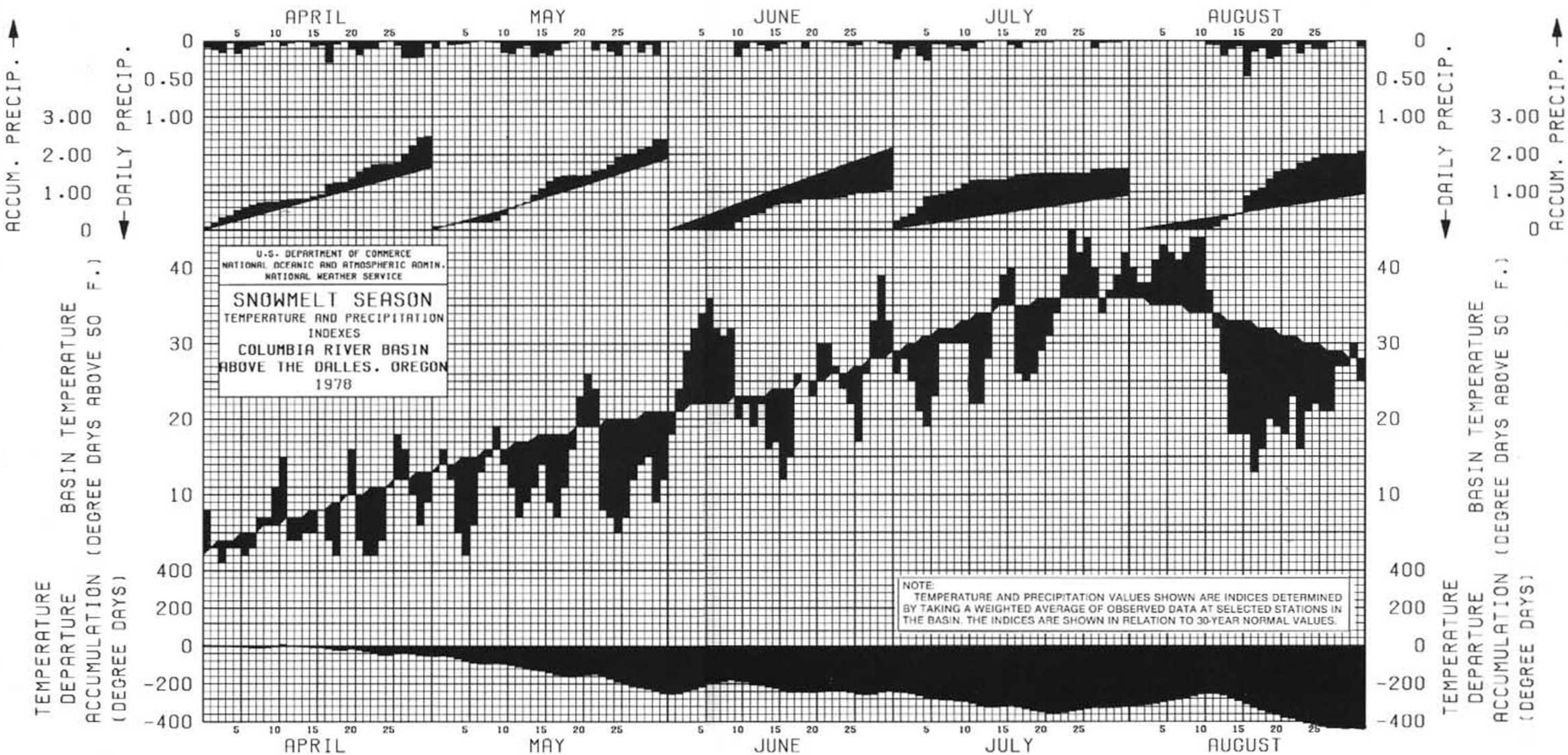
Lakes filled to elevation 1404.5 feet on 5 January 1978. An elevation of about 1405.0 feet was held through 20 February before the reservoir was heavily drafted for four weeks to meet U.S. power requirements.

Refill Period - Arrow reservoir gradually filled in April and May 1978 with rising streamflows. Discharges were adjusted to control the inflow into Grand Coulee reservoir (F.D. Roosevelt Lake). During part of April and also early May, discharges at Arrow were kept to the 5,000 cfs minimum to help keep Grand Coulee reservoir down for boat ramp repairs and archaeology studies. High discharges up to 40,000 cfs were maintained towards the end of May and in early June to help fill Grand Coulee reservoir to the target elevation necessary for the Gibson tests. Beginning 7 June, the outflow was reduced to 5,000 cfs and the reservoir filled rapidly so that all Treaty storage space in Arrow was filled on 14 July.

C. DUNCAN RESERVOIR

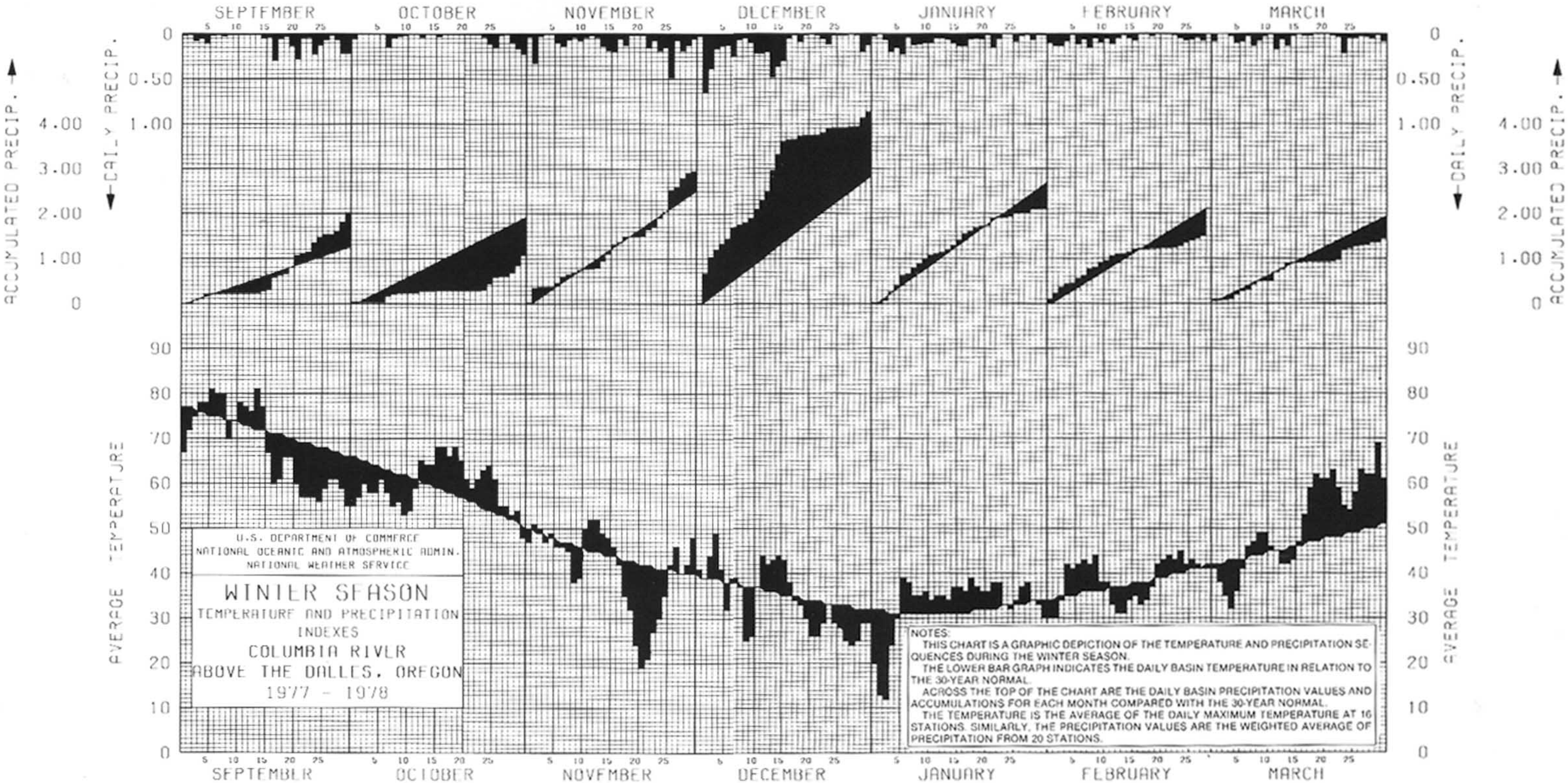
Storage Evacuation Period - As indicated in Chart 7, Duncan reservoir was at elevation 1885.4 feet on 31 July 1977. The project continued to discharge the 100 cfs minimum in early August and with near normal streamflow, it was filled to its normal full pool elevation 1892.0 feet on 15 August 1977. The reservoir was then maintained at full pool throughout the remainder of August. Between operating rules and local criteria were utilized to prepare day-to-day streamflow forecasts for key points in Canada and the United States and to establish the operations of the flood control storage. These forecasts were prepared daily during the snowmelt season by the Columbia River Forecasting Service for periods of 30 to 45 days using both moderate and severe snowmelt sequences.

CHART 3



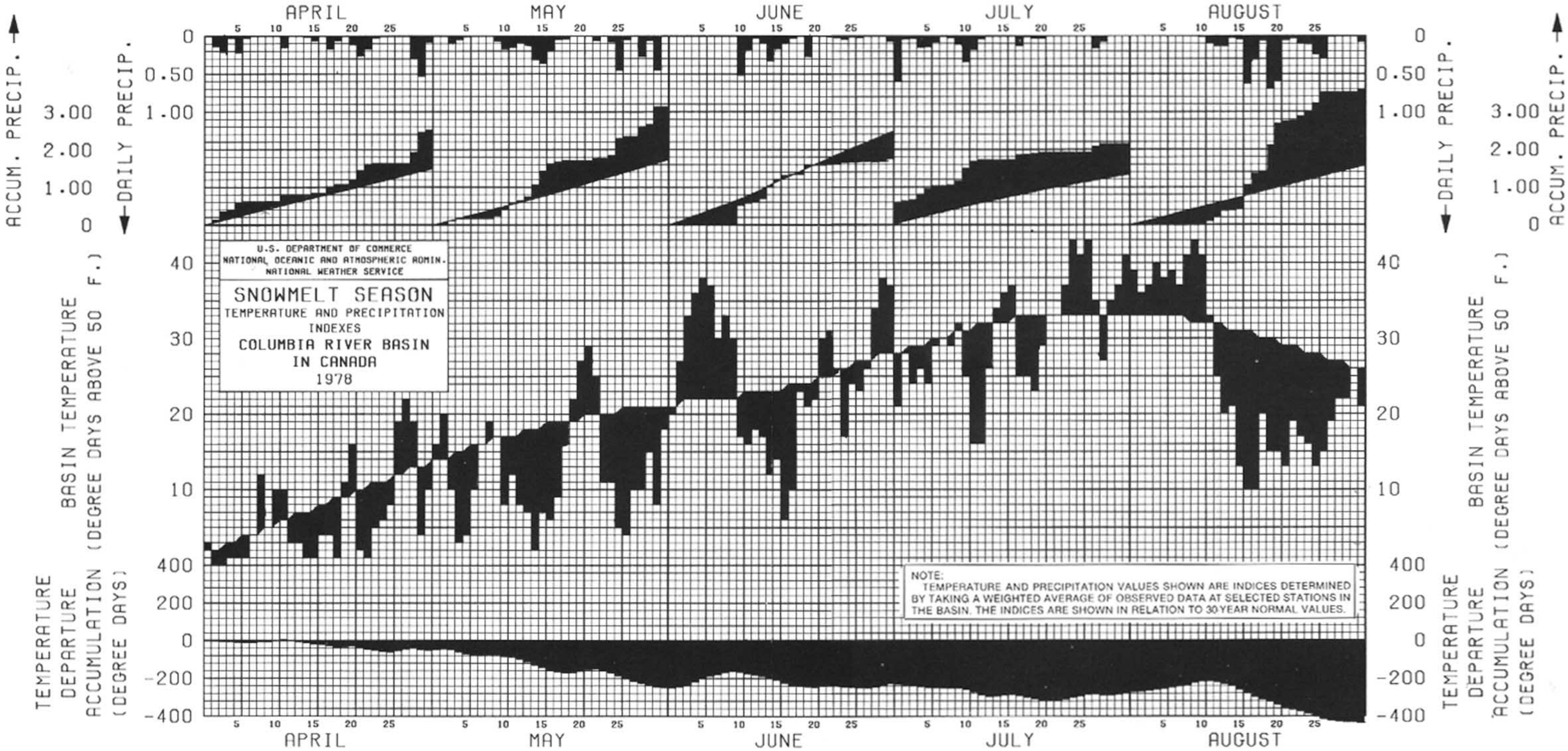
APRIL
MAY
JUNE
JULY
AUGUST
ACCUM. PRECIP.
DAILY PRECIP.
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50 F.)
TEMPERATURE DEPARTURE ACCUMULATION (DEGREE DAYS)
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN
ABOVE THE DALLES, OREGON
1978
NOTE:
TEMPERATURE AND PRECIPITATION VALUES SHOWN ARE INDICES DETERMINED BY TAKING A WEIGHTED AVERAGE OF OBSERVED DATA AT SELECTED STATIONS IN THE BASIN. THE INDICES ARE SHOWN IN RELATION TO 30-YEAR NORMAL VALUES.

CHART 2



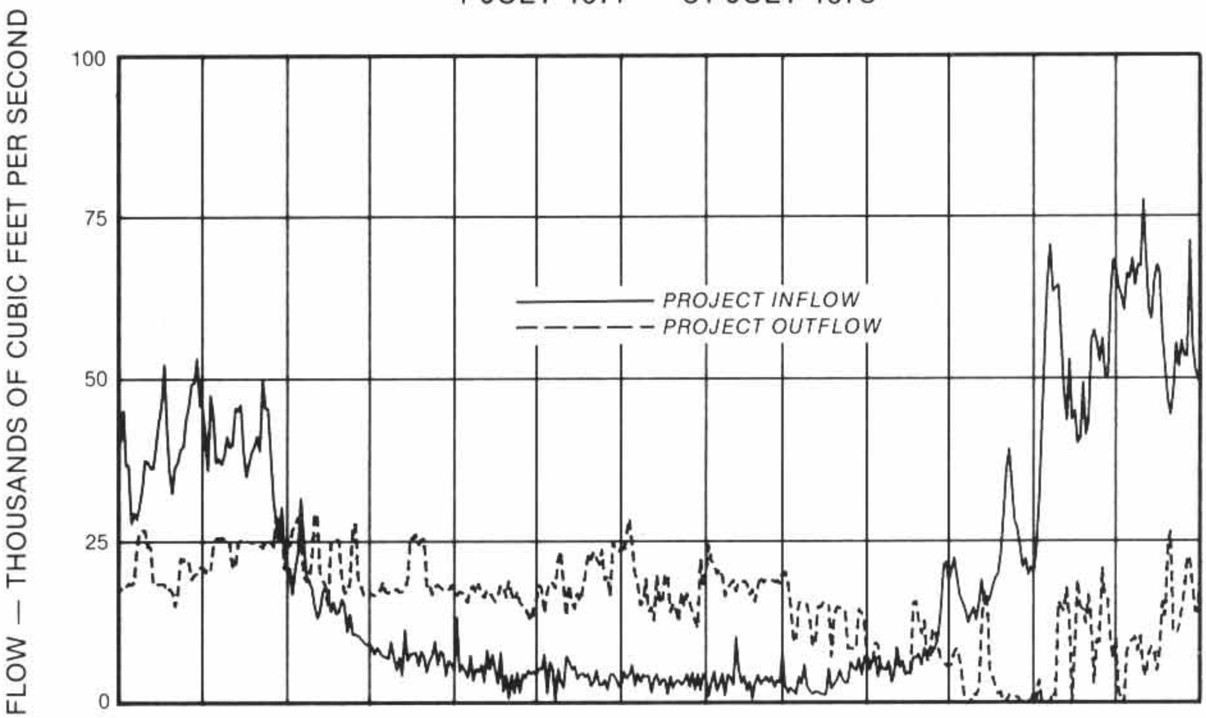
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
ACCUMULATED PRECIP.
DAILY PRECIP.
AVERAGE TEMPERATURE
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDEXES
COLUMBIA RIVER
ABOVE THE DALLES, OREGON
1977 - 1978
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURE AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON.
THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL.
ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL.
THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS. SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS.

CHART 4



APRIL
MAY
JUNE
JULY
AUGUST
ACCUM. PRECIP.
DAILY PRECIP.
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.
NATIONAL WEATHER SERVICE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN IN CANADA
1978
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50 F.)
TEMPERATURE DEPARTURE ACCUMULATION (DEGREE DAYS)
NOTE:
TEMPERATURE AND PRECIPITATION VALUES SHOWN ARE INDICES DETERMINED BY TAKING A WEIGHTED AVERAGE OF OBSERVED DATA AT SELECTED STATIONS IN THE BASIN. THE INDICES ARE SHOWN IN RELATION TO 30 YEAR NORMAL VALUES.

REGULATION OF MICA
1 JULY 1977 — 31 JULY 1978



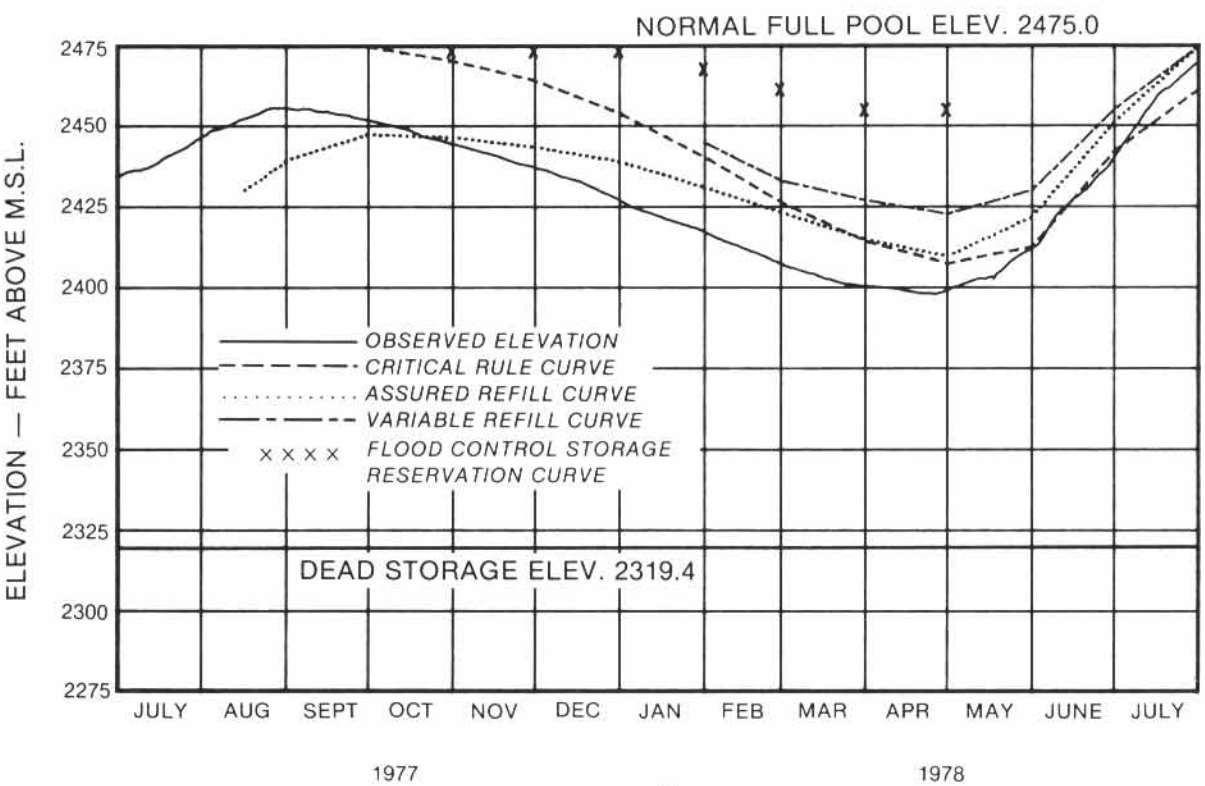
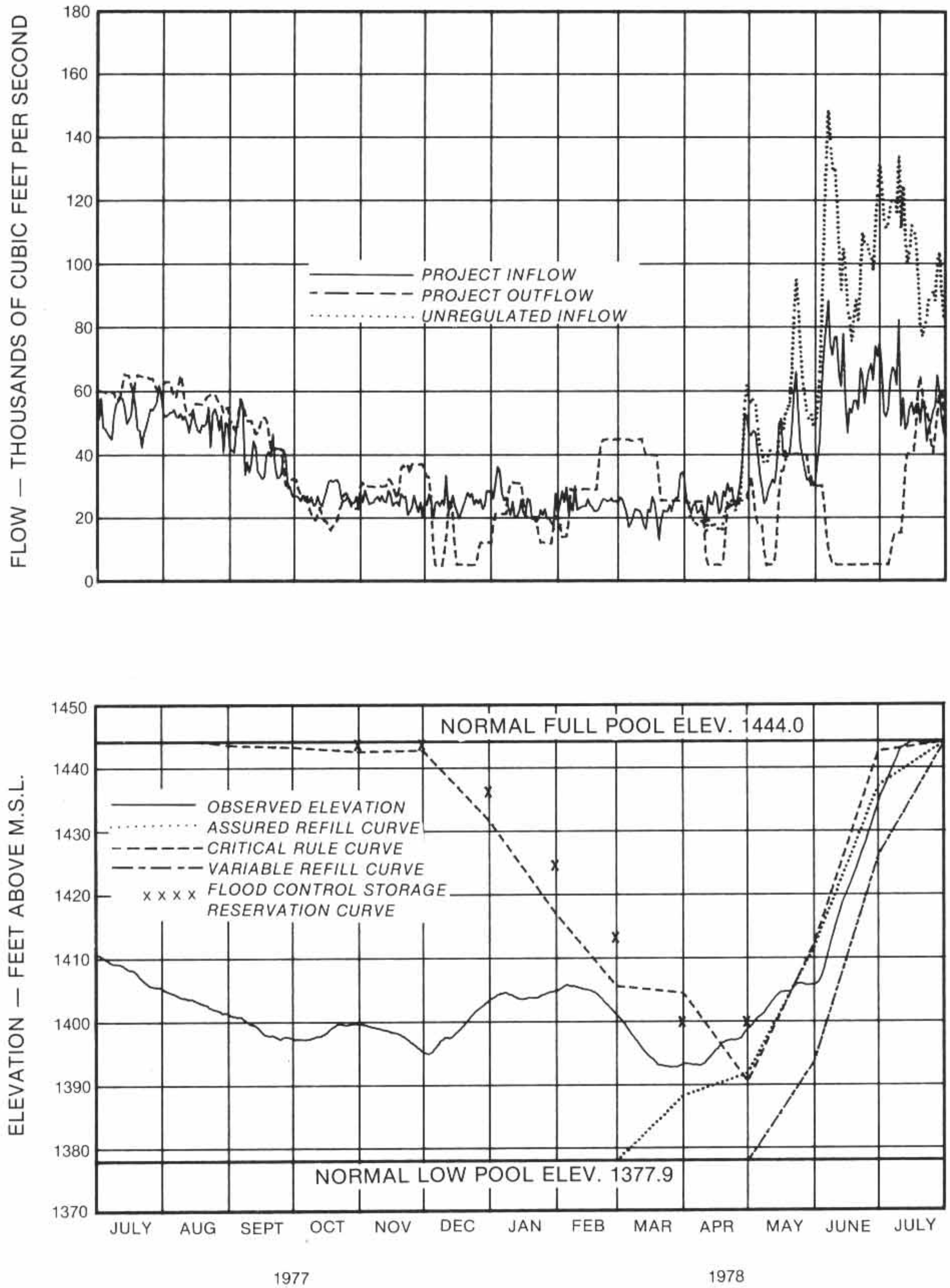


CHART 6
ARROW

REGULATION OF ARROW
1 JULY 1977 — 31 JULY 1978



REGULATION OF DUNCAN
1 JULY 1977 — 31 JULY 1978

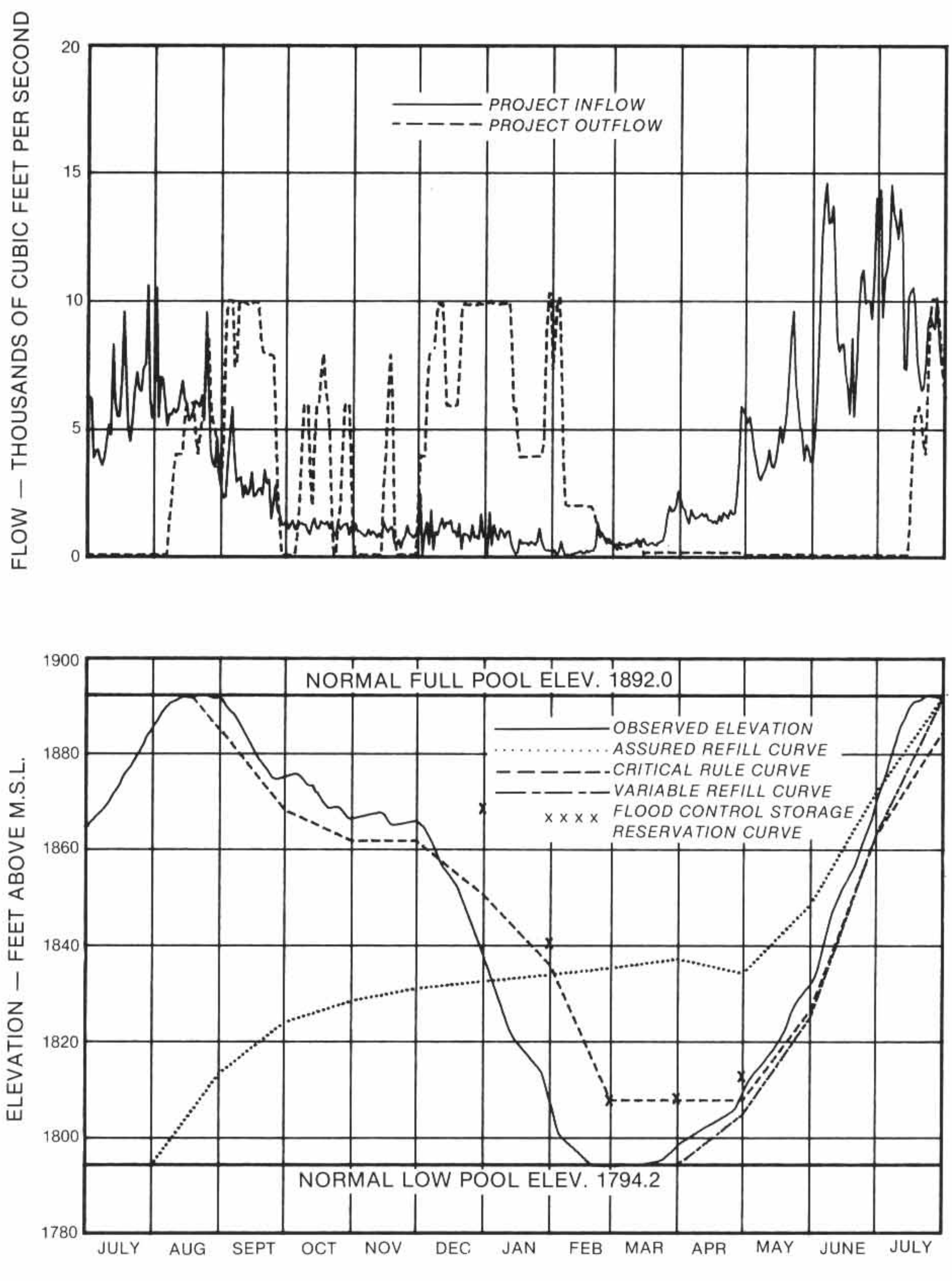
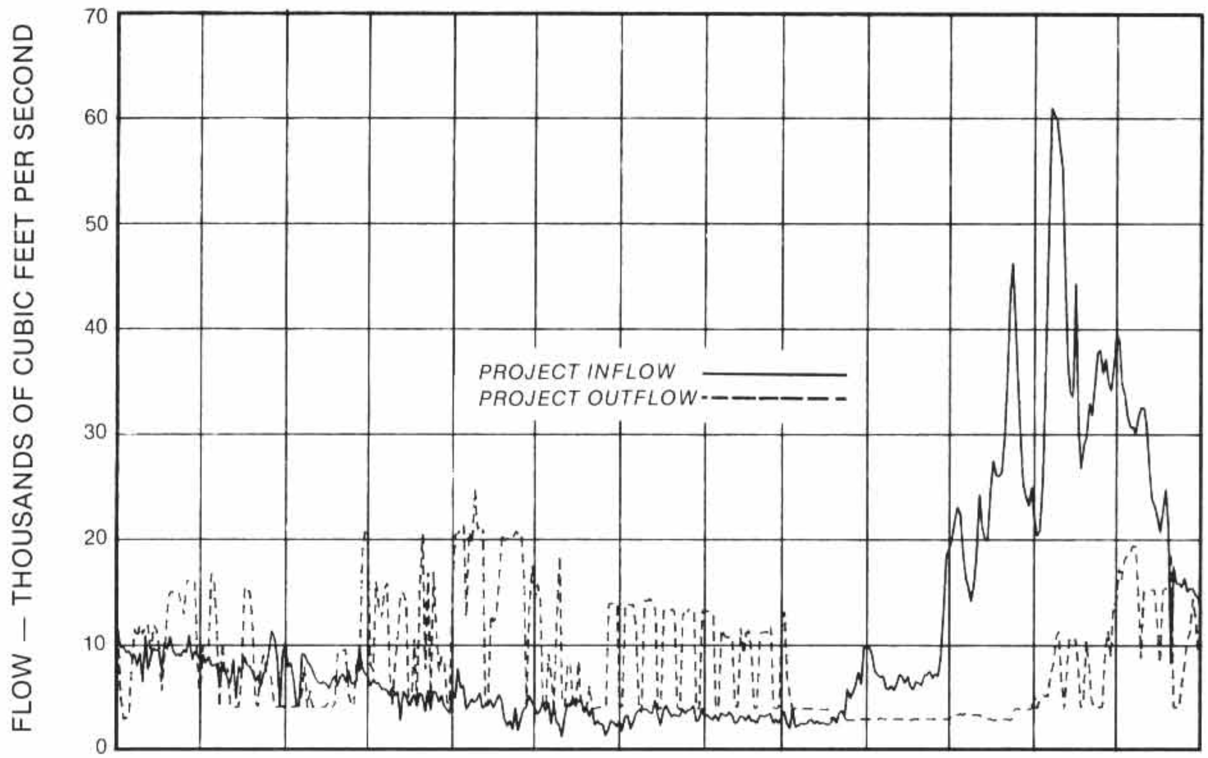


CHART 8
LIBBY

REGULATION OF LIBBY
1 JULY 1977 — 31 JULY 1978



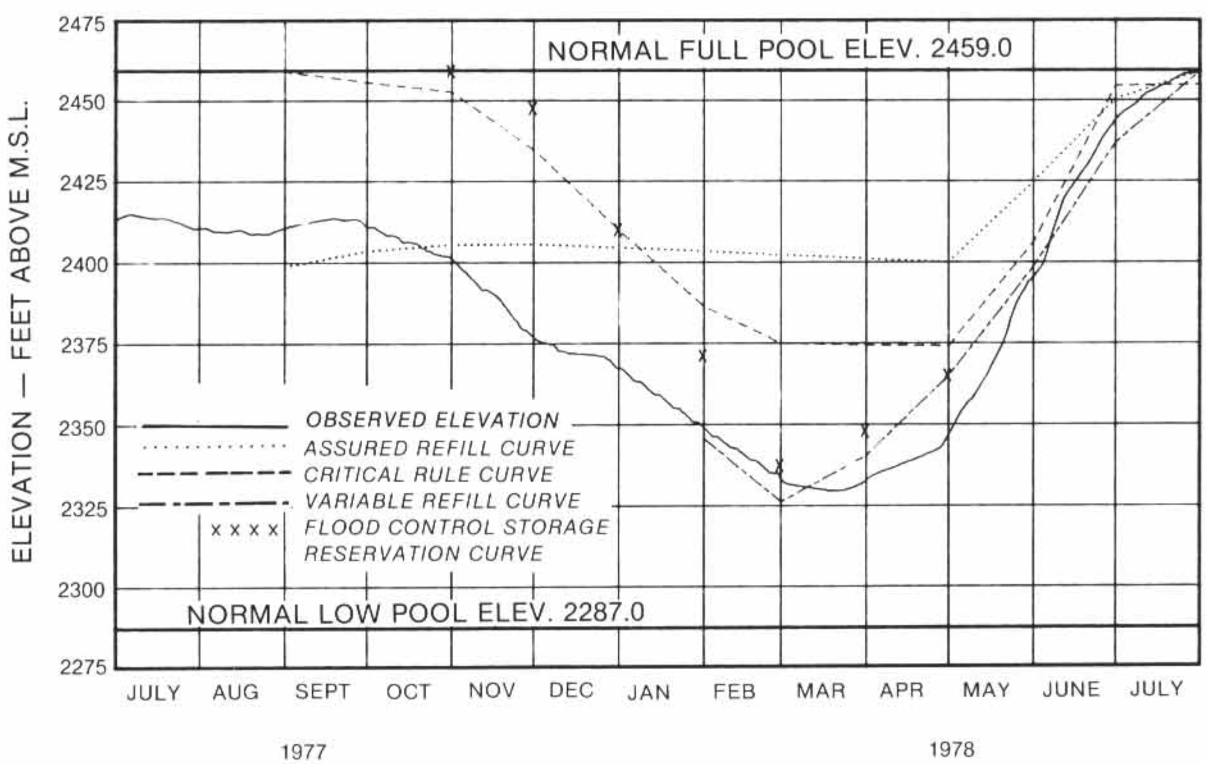
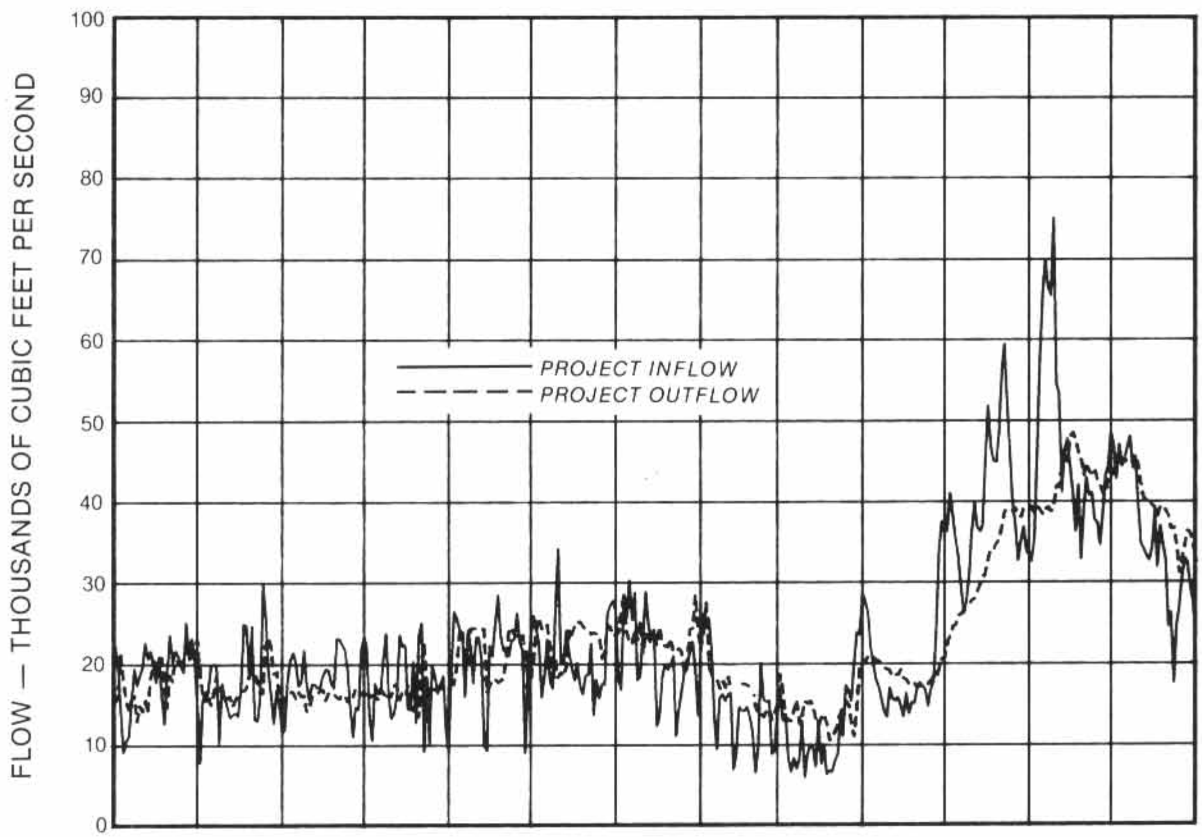


CHART 9
KOOTENAY LAKE

REGULATION OF KOOTENAY LAKE
1 JULY 1977 — 31 JULY 1978



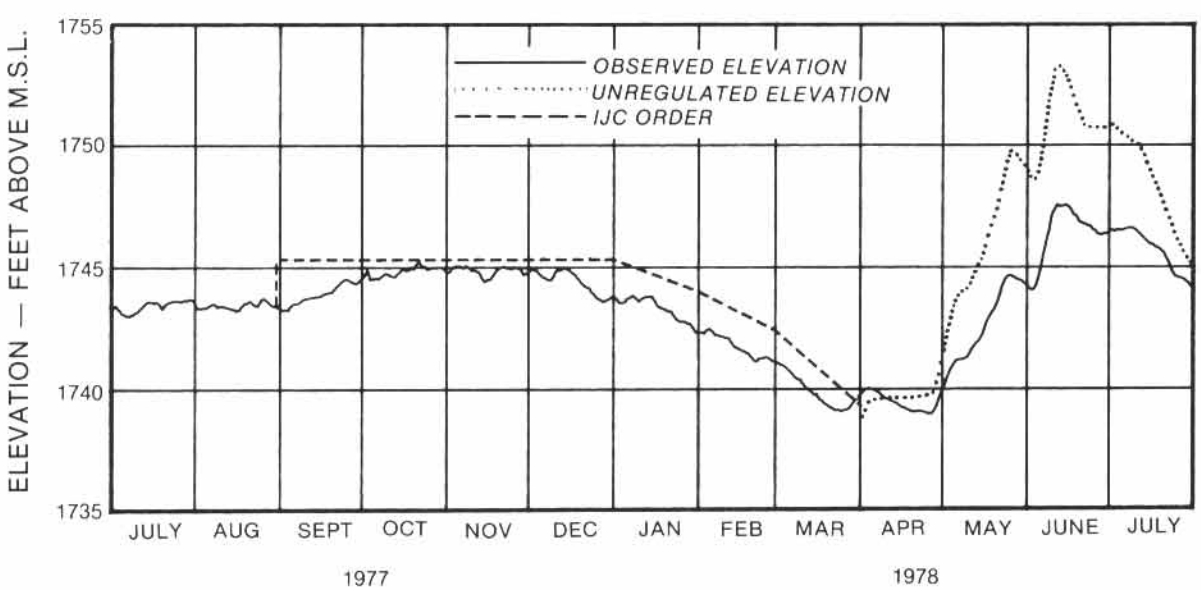


CHART 10
BIRCHBANK

COLUMBIA RIVER AT BIRCHBANK
1 JULY 1977 — 31 JULY 1978

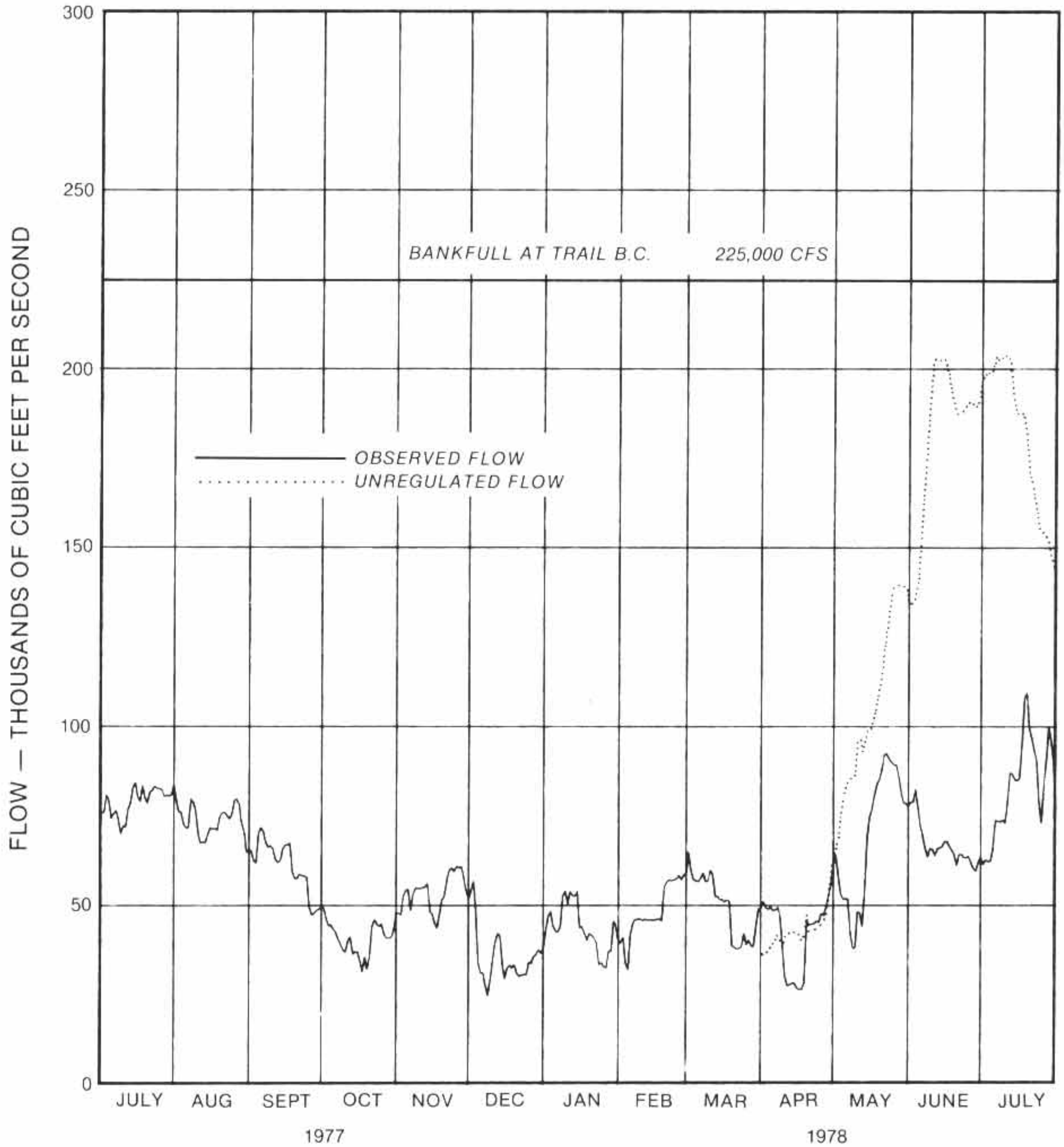
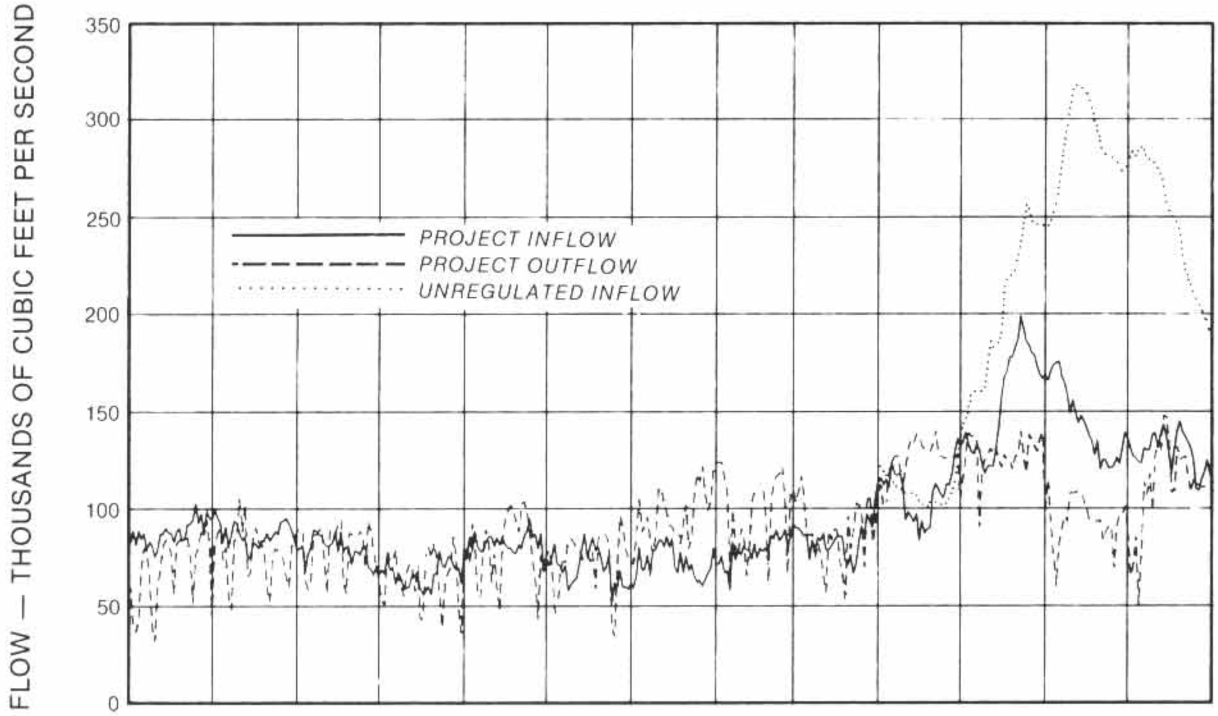
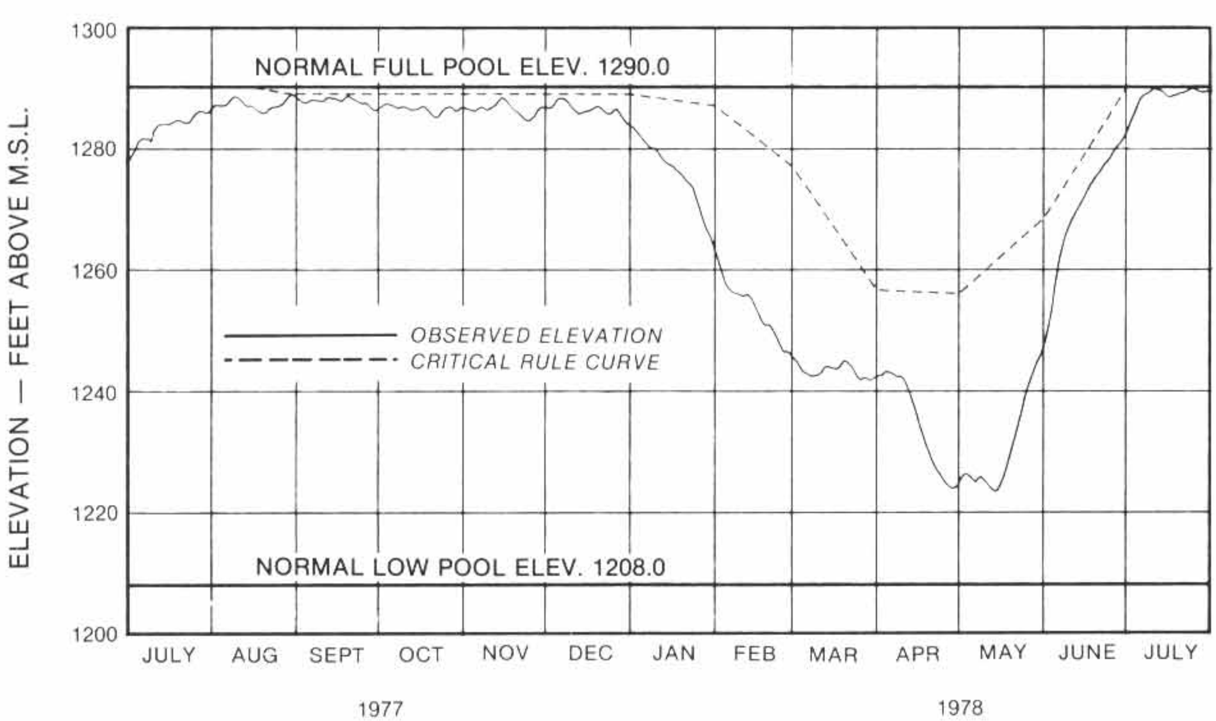
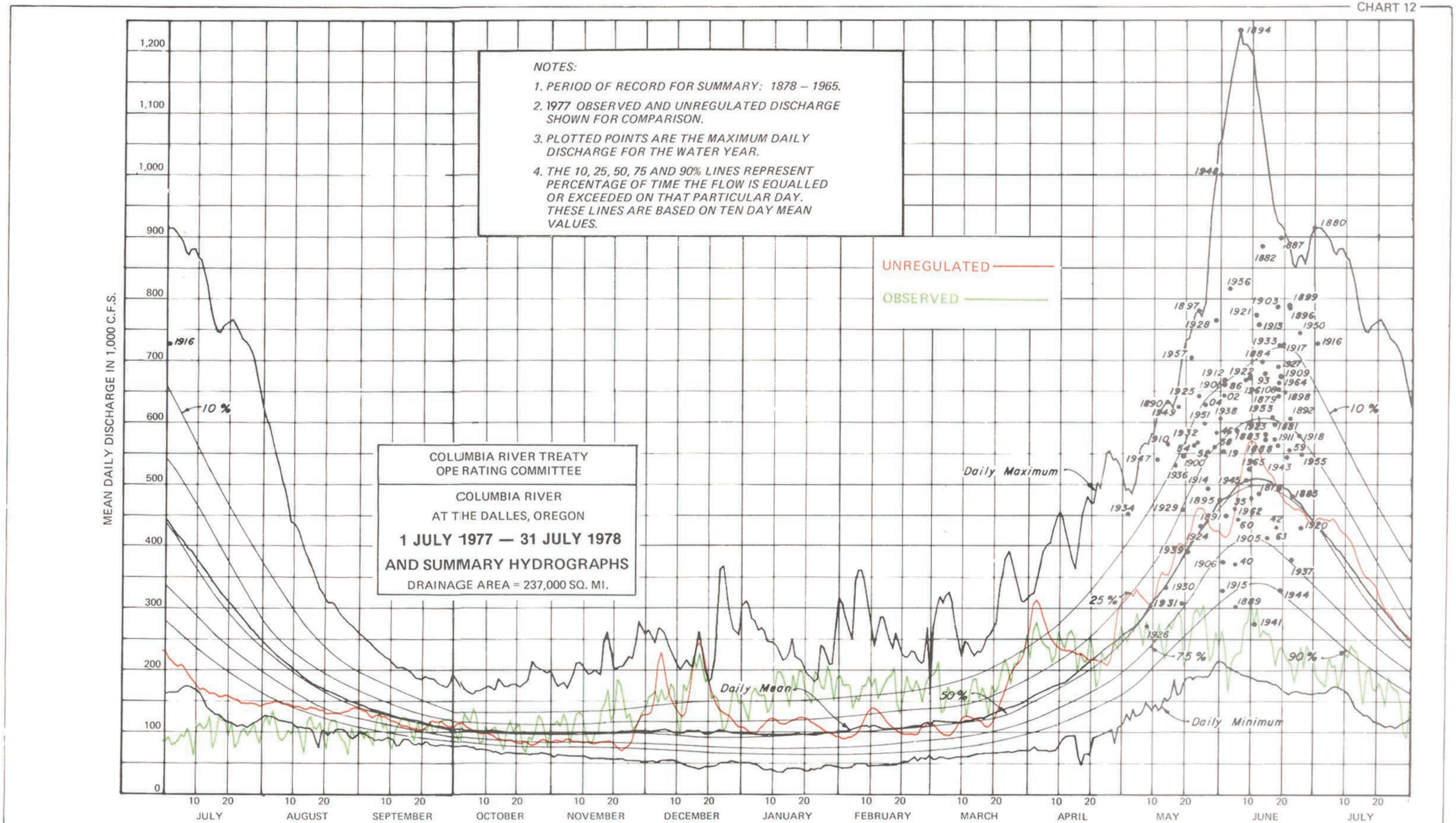


CHART 11
GRAND COULEE

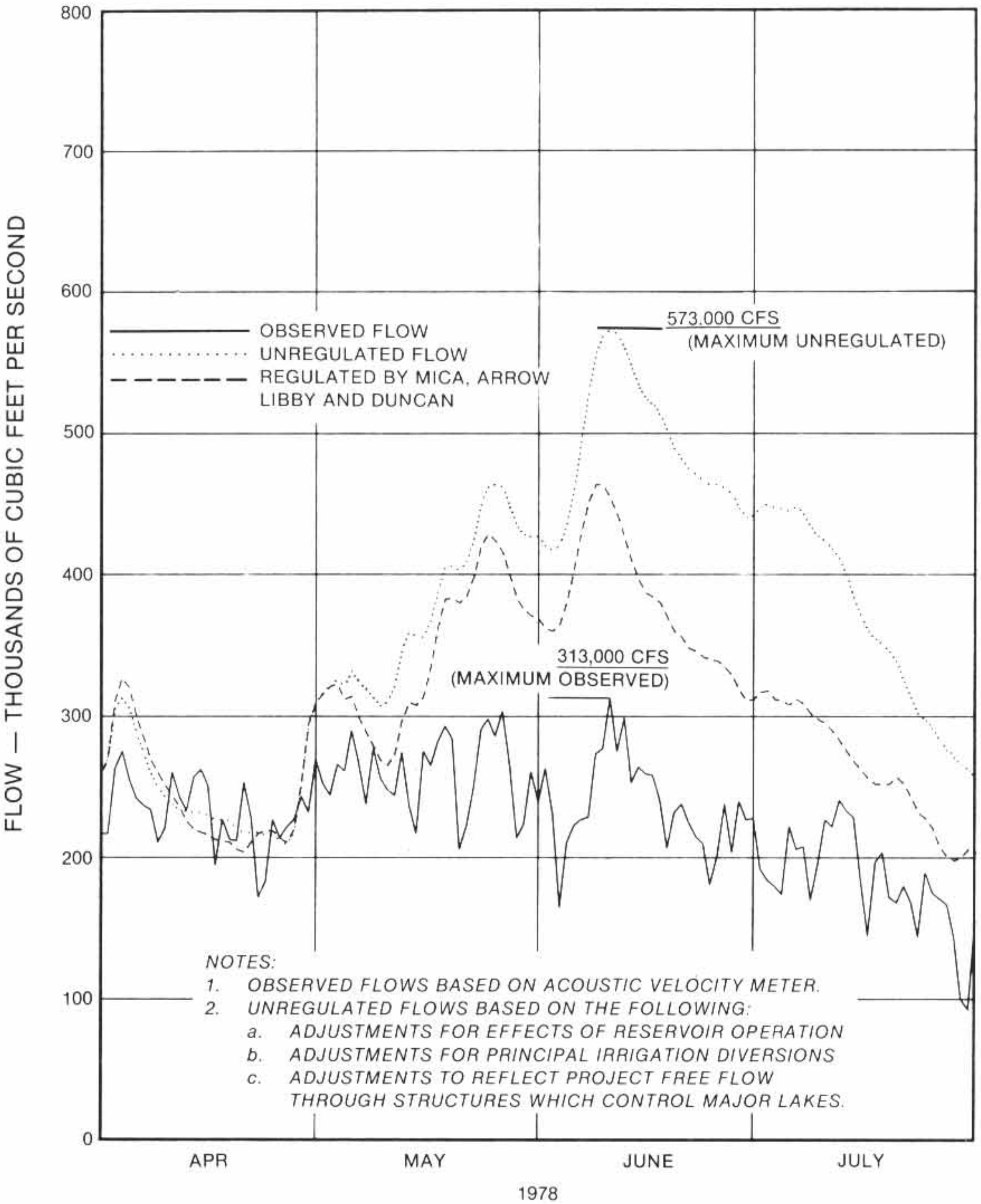
REGULATION OF GRAND COULEE
1 JULY 1977 — 31 JULY 1978



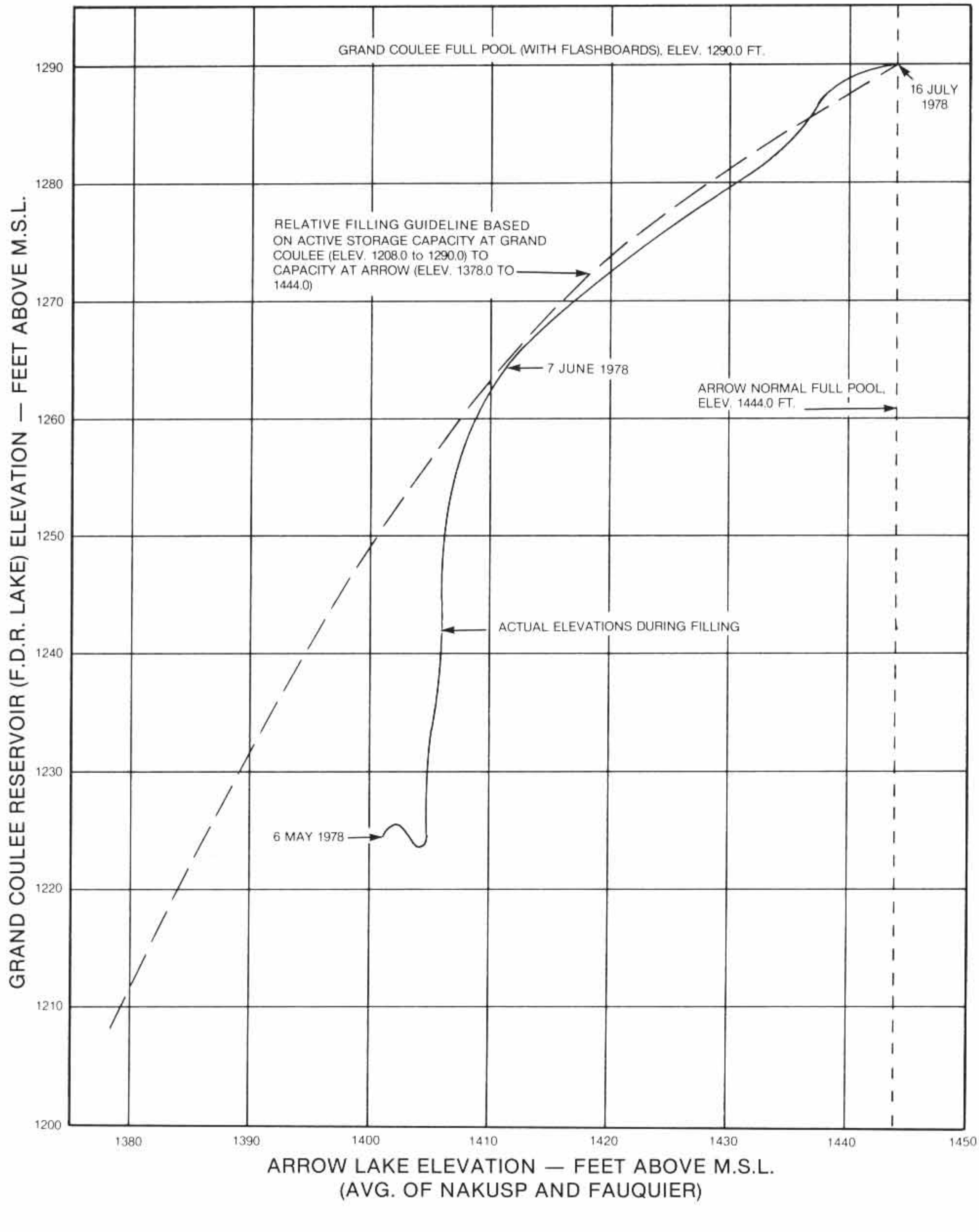



NOTES:
1. PERIOD OF RECORD FOR SUMMARY: 1878 – 1965.
2. 1977 OBSERVED AND UNREGULATED DISCHARGE SHOWN FOR COMPARISON.
3. PLOTTED POINTS ARE THE MAXIMUM DAILY DISCHARGE FOR THE WATER YEAR.
4. THE 10, 25, 50, 75 AND 90% LINES REPRESENT PERCENTAGE OF TIME THE FLOW IS EQUALLED OR EXCEEDED ON THAT PARTICULAR DAY. THESE LINES ARE BASED ON TEN DAY MEAN VALUES.
COLUMBIA RIVER TREATY
OPERATING COMMITTEE
COLUMBIA RIVER
AT THE DALLES, OREGON
1 JULY 1977 — 31 JULY 1978
AND SUMMARY HYDROGRAPHS
DRAINAGE AREA = 237,000 SQ. MI.
UNREGULATED
OBSERVED
MEAN DAILY DISCHARGE IN 1,000 C.F.S.
Daily Maximum
Daily Mean
Daily Minimum
10 %
25 %
50 %
75 %
90 %
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY

COLUMBIA RIVER AT THE DALLES
1 APRIL 1978 — 31 JULY 1978



RELATIVE FILLING
ARROW AND GRAND COULEE



REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period 1 August 1977 through 31 July 1978:

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

2. "Columbia River Treaty Hydroelectric Operating Plan for Canadian Storage, Operating Year 1977-78", dated 16 October 1972.

3. "Columbia River Treaty Detailed Operating Plan for Canadian Storage, 1 July 1977 through 31 July 1978", dated September 1977.

4. "Columbia River Treaty Flood Control Operating Plan", dated October 1972.