# Report on Operation of Columbia River Treaty Projects

**1 August 1979 through 31 July 1980**


COLUMBIA RIVER TREATY OPERATING COMMITTEE

**October 1980**

REPORT ON

OPERATION OF COLUMBIA RIVER

TREATY PROJECTS

1 AUGUST 1979 THROUGH 31 JULY 1980

COLUMBIA RIVER TREATY OPERATING COMMITTEE

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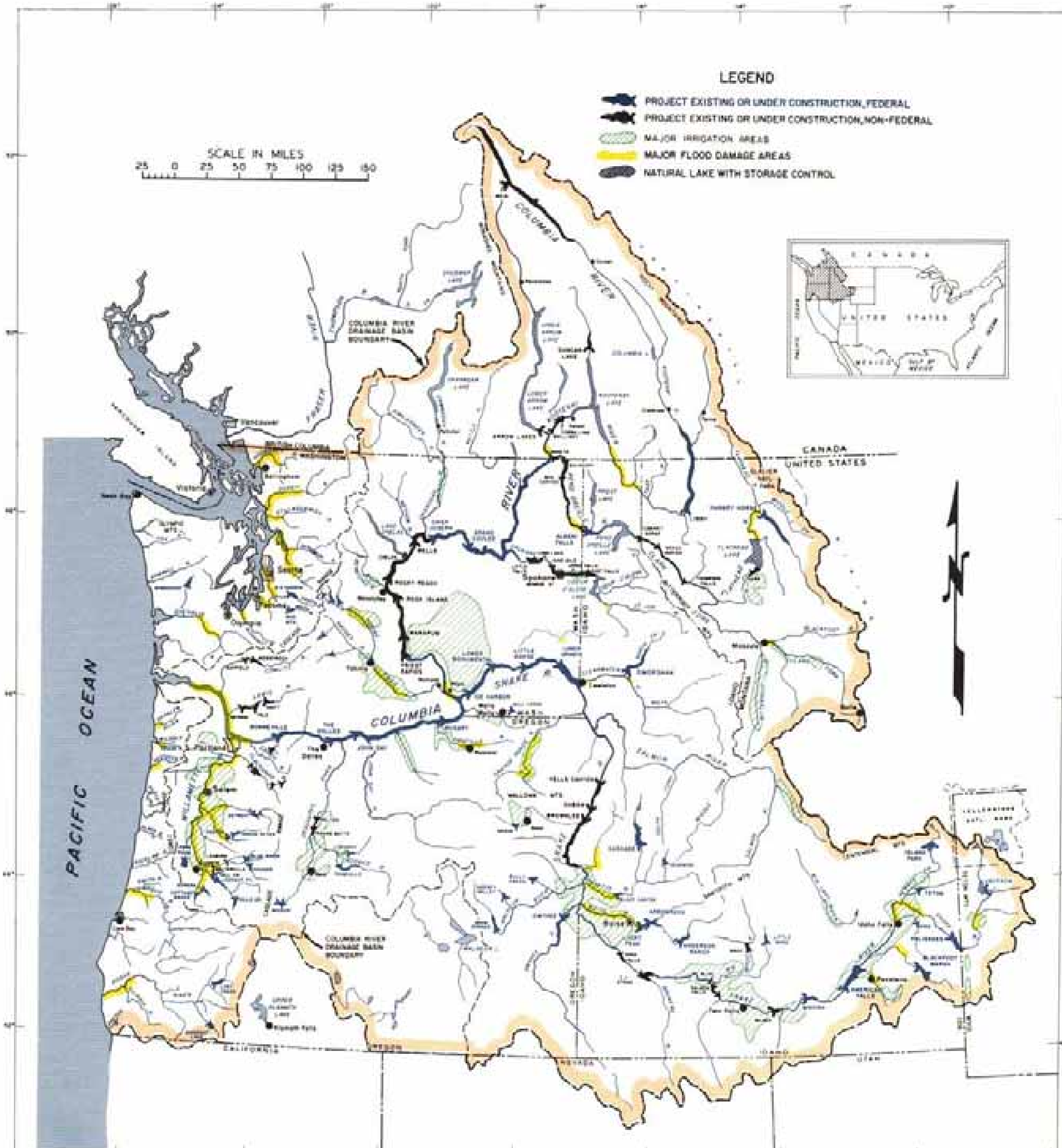


REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1979 THROUGH 31 JULY 1980

# 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 in Canada 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 (B.C. Hydro); the United States Entity is the Administrator, Bonneville Power Administration (BPA) and the Division Engineer, North Pacific Division, Corps of Engineers (USCE).

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 1979 through 31 July 1980, 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 (DOP) for Columbia River Treaty Storage, dated September 1979. The regulation of the Canadian storage content was normally determined by the Operating Committee on a weekly basis during the entire operating year.

## II. WEATHER AND STREAMFLOW

A. WEATHER.

A warm and damp August preceded near average to below average fall precipitation throughout most of the Pacific Northwest. September continued the warm trend with generally light rainfall. The Snake River and Clark Fork Basins recorded less than twenty percent of normal precipitation, with only the Similkameen and Okanogan drainages registering well above average. The fall rains finally started in mid-October with all but the northern and eastern-most basins receiving above normal rainfall. November temperatures turned cooler with below average precipitation in most watersheds across the entire Columbia River Basin. Temperature rose to above normal in early December. Western Washington and the Upper Columbia-Kootenay Basins experienced heavy mid-month precipitation, while the southeastern basins were once again below average for the month. Snowfall and low-elevation precipitation in January varied from better than twice the average accumulations in portions of the Upper Snake down to about two-thirds of normal in the Upper Columbia and Kootenay Basins in Canada. Twice during the month Arctic air invaded the Northwest and plunged temperatures as much as 16 to 25 degrees F below normal. October - January cumulative precipitation was 83 percent of the long term basin average.

Precipitation for February varied widely over the basin, ranging from 200 percent of average in central Washington to 71 percent in the Clark Fork drainage. Precipitation patterns for March saw above normal readings in the Upper Snake and below normal west of the Cascades. These patterns were reversed in April. Temperatures remained cool throughout March, warming to well above normal across the basin in late April. These warm temperatures, as high as 20 degrees above normal in the Snake and Upper Columbia-Kootenay, depleted most of the low and middle elevation snowpack, dropping the May 1 snowpack to roughly two-thirds of normal.

Most areas returned to cooler temperatures through May and June, with above normal precipitation reported over all eastside basins in May and the westside and northern basins in June. The total August 1979 - July 1980 precipitation was 98 percent of average for the Columbia Basin above Grand Coulee and also 98 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 15-year average, 1963-1977, is shown on Chart 1. This shows the October through April precipitation to be greater than 50% of average in all areas. The Clark Fork-Flathead River basins and the northernmost tip of the Canadian portion of the Columbia River Basin reported 50 to 80 percent of average.

The vast majority of stations reported near average (between 80 and 120 percent of average) precipitation. Large areas of central Oregon and central Washington and the extreme southeastern edge of the Snake Basin received in excess of 120 percent of the 15-year average.

Chart 2 depicts the winter season precipitation and temperature sequences that occurred throughout the basin, as measured by index stations in the basin. Light October-November rainfall and warm termperatures in December held the February 1 snow accumulation to 83 percent of average. Seasonal temperatures and precipitation brought the April 1 basin-wide index to 89 percent, but the late April warming trend accelerated the snowmelt, reducing the May 1 snow accumulation to only 67 percent of normal.

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 seasonal runoff 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

Streamflow in August was slightly below to well below average throughout the Columbia River Basin, with the exception of the Owyhee River Basin which reported record high flows. Deficient flows continued through September, October and November with most stations reporting flows at 50 to 80 percent of the 15-year average. Record low values were recorded at several stations. Heavy rains in western Washington in mid-December were the cause of near record flooding in that area, while new record minimum daily flows were reported in the Flathead and Priest River basins. Monthly mean discharges remained well below average for the remaining areas through January except for near average flows in Oregon. Streamflow was significantly below average during February in the upper Columbia River basin in British Columbia and in the Flathead and Kootenai Rivers in western Montana. March saw the return of near average flows at most Pacific Northwest stations. Warm temperatures in mid-April brought above average flows to the northern basins and near average flows elsewhere. The same pattern persisted through May. The spring snowmelt pattern came to an abrupt halt in June. Streamflow in the northern portion of the Columbia River basin was significantly less than average and most other stations reported below average flows, except for high flows on the Owyhee and John Day Rivers.

The 1979-1980 monthly modified streamflows and average monthly flows for the period 1926-1980 are shown in the following table for the Columbia River at Grand Coulee and The Dalles. These modified flows are corrected for storage in lakes and reservoirs to exclude the effects of regulation, and are adjusted to the 1970 level of development for irrigation.

Monthly Mean Modified Streamflow, in CFS

| Month | Columbia River at Grand Coulee Year 1979-1980 | Columbia River at Grand Coulee Average 1926-1979 | Columbia River at The Dalles Year 1979-1980 | Columbia River at The Dalles Average 1926-1979 |
|---|---|---|---|---|
| AUG | 78900 | 97570 | 102100 | 133740 |
| SEP | 53100 | 60240 | 72340 | 92780 |
| OCT | 37740 | 51130 | 60550 | 88500 |
| NOV | 26610 | 46330 | 51470 | 90960 |
| DEC | 35960 | 43090 | 71720 | 94730 |
| JAN | 27850 | 38300 | 71770 | 91230 |
| FEB | 35560 | 41000 | 86960 | 102750 |
| MAR | 42420 | 48090 | 104200 | 118580 |
| APR | 144200 | 115090 | 244800 | 217760 |
| MAY | 325800 | 265890 | 493500 | 416790 |
| JUN | 242700 | 313770 | 384500 | 466590 |
| JUL | 132200 | 186300 | 185900 | 252320 |
| YEAR | 95590 | 108840 | 160820 | 180560 |

The maximum mean monthly adjusted streamflows occurred in May this year, and were 124 percent and 121 percent of the long-term averages for the Columbia River at Grand Coulee and The Dalles, respectively. During the usual maximum month, June, streamflows were down to 78 and 83 percent of normal at their respective locations.

Maximum observed mean daily inflows during the 1979-80 operating year were 68,200 cfs at Mica on 17 June, 78,700 cfs at Arrow on 29 April, 17,500 cfs at Duncan on 21 May, 50,700 cfs at Libby on 7 May. The maximum observed mean daily flow in the Columbia River at The Dalles was 338,100 cfs on 18 June 1980. The observed 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, 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 for the unregulated runoff of the Columbia River at The Dalles. The forecasts for Mica, Arrow, and Duncan inflows were prepared by B. C. Hydro 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 to exclude the effects of regulation, are listed for eight locations in the following tabulation:

| Streamflow and Location | Thousands of Acre-Feet | Percent of 1963-77 Average |
|---|---|---|
| Libby Reservoir Inflow | 5902 | 86 |
| Duncan Reservoir Inflow | 2061 | 99 |
| Mica Reservoir Inflow | 10728 | 91 |
| Arrow Reservoir Inflow | 22021 | 93 |
| Columbia River at Birchbank | 38656 | 91 |
| Grand Coulee Reservoir Inflow | 57907 | 90 |
| Snake River at Lower Granite Dam | 21601 | 88 |
| Columbia River at The Dalles | 86853 | 89 |

# III. RESERVOIR OPERATION

## A. MICA RESERVOIR

Storage Evacuation Period. As shown on Chart 5 Mica discharged full turbine capacity during the last week in July 1979, and Mica Reservoir filled to only 2456.6 feet on 31 July 1979, 13 feet below its effective full pool. The high discharge was a combination of Treaty storage release plus B. C. Hydro non-Treaty storage release from Mica Reservoir, and was required to maintain a reasonable lake level at Arrow Lake for summer recreation. The reservoir dropped slightly to 2455.3 feet by 31 August and maintained that level through September. During October, Mica generation was increased above the DOP target releases of 20,000 cfs to meet B. C. Hydro system electrical load demand. Consequently the reservoir was drawn down approximately 8 feet to 2446.9 feet by 31 October, creating an imbalance of 856,000 sfd (second foot days) in Treaty storage between Mica and Arrow Reservoirs.

During December 1979 and January 1980, Treaty storages in Mica and Arrow Reservoirs were brought back into balance by 18 January 1980, by operating Mica significantly below its DOP target releases. From February through the first part of April, Mica was used to generate heavily to meet B. C. Hydro load requirements, with outflow varying between 15,000 cfs and 40,000 cfs. During that period the reservoir was drawn down almost 40 feet to reach its lowest elevation of 2387.3 feet on 18 April.

Refill Period. The high streamflows in May and June enabled Mica Reservoir to fill rapidly, and it was at elevation 2437.8 feet by 12 June.

During the period from 13 to 16 June 34,300 sfd of water, surplus to U.S. requirements, was stored in Arrow and then transferred into B.C. Hydro Mica non-Treaty space. This water will remain stored in B.C. Hydro Mica non-Treaty space pending agreement between B. C. Hydro and BPA on its status and final disposition. On 17 June, B. C. Hydro accepted BPA surplus generation for storage into the Treaty space at Mica under the Agreement to Enhance Filling of Mica Reservoir (Contract No. DE-MS79-80BP97038). This delivery of energy continued through 6 July and totalled 112,894 sfd in the BPA Mica Surplus Storage Account. All the BPA Mica Surplus Storage (energy) was returned to BPA prior to 8 August. The Treaty space in Mica Reservoir continued to fill through July and on 31 July, it was approximately 300,000 sfd below full. The Mica Treaty space refilled completely by 5 August 1980.

B. ARROW RESERVOIR

Storage Evacuation Period. As shown on Chart 6 Arrow Reservoir was filled to a peak elevation of 1438.0 feet on 23 July 1979 before it was drafted to elevation 1436.9 feet, on 31 July. With high turbine discharge from Mica it was possible to maintain a relatively steady lake level for recreation through the remainder of the summer season. Project outflows averaged 75,000 cfs until 18 August when outflows were gradually reduced to 30,000 cfs by the first week of October. The reservoir was at elevation 1429.7 feet on 13 October. Anticipating a restriction in project outflow later in the month, Arrow increased its discharge to 50,000 cfs on 14 October. Arrow outflow was reduced to 5,000 cfs to facilitate installing a sewage pipe near Trail. Normal operation resumed on 3 November. During December 1979, Arrow Reservoir was drafted heavily to meet U.S. power requirements. The discharges were up to 80,000 cfs for several days and the reservoir was drawn down approximately 20 feet to elevation 1402.2 feet or slightly above its Second Year Critical Rule Curve by 31 December 1979.

Arrow Reservoir continued to draft through January and February 1980, reaching its lowest level of the drawdown period at elevation 1386.6 feet on 3 March 1980.

Refill Period. Arrow Reservoir began to fill in early March as inflow exceeded outflow and was approximately 12 feet above its Variable Refill Curve by 31 March. On 7 and 8 of April, the project discharge was reduced to 5,000 cfs during daytime to facilitate inspection of the navigation lock and removal of debris near its upstream approach. Beginning April, Arrow discharged 25,000 cfs for approximately four weeks before the outflow was reduced to 5,000 cfs to minimize spilling at downstream projects. Capturing the early streamflow, the reservoir filled rapidly during May and June and was effectively full on 16 June. The actual Arrow Reservoir elevation on 16 June was below 1444.0 feet since some Arrow Treaty storage was retained temporarily at Mica. During the period from 13 to 15 June, Arrow reservoir captured 34,300 sfd of water surplus to U.S. requirments under a special arrangement between BPA and B. C. Hydro operating staff. The water was immediately transferred into non-Treaty space at Mica and will stay there pending agreement between BPA and B. C.

Hydro on its status and disposition. Under the Arrow Lakes Storage Agreement (Contract No. 14-03-90179) between BPA and B. C. Hydro, Arrow Reservoir was surcharged by 132,100 sfd, from elevation 1444.0 feet to elevation 1446.0 feet, with water surplus to U.S. requirements.

The storage of this 132,100 sfd occurred from 16 to 22 June, after which Arrow discharged local inflow plus the Mica DOP target release. Arrow Reservoir was at elevation 1445.4 feet on 31 July.

C. DUNCAN RESERVOIR

Storage Evacuation Period. As shown on Chart 7, Duncan Reservoir filled to full pool elevation 1892.0 feet on 21 July 1979. Inflow was discharged from Duncan Reservoir to maintain full pool until 21 August when the outflow was increased to 7,000 cfs to supply water for use at downstream projects. By 31 August, the reservoir was drawn down approximately 2.5 feet from full pool. From 2 September through 13 October and except for the last week in September, the reservoir was drafted heavily to help fill Kootenay Lake to elevation 1745.3 feet. Discharge was increased to 10,000 cfs during this period drafting Duncan Reservoir to elevation 1861.5 feet by 13 October. Between 16 October and 3 December, Duncan outflow was reduced to minimum project release of 100 cfs to reduce spilling at Brilliant due to high outflows from the Libby project. This caused Duncan Reservoir to fill approximately 4 feet to elevation 1864.9 feet by 3 December. Duncan increased its outflow to 4,000 cfs on 4 December 1979 and maintained that outflow through to 11 March 1980 except for a period of about 7 days during the Christmas holidays in which Duncan discharged

10,000 cfs to meet B. C. Hydro system load requirements. The reservoir was at elevation 1820.5 feet, slightly above its Variable Refill Curve, on 1 March 1980. Project outflow was later reduced to 100 cfs and the reservoir filled slightly to elevation 1821.2 feet by 31 March.

Refill Period. Beginning 11 April and continuing for about one week, Duncan held its discharge at 4,000 cfs before it was reduced to capture the spring freshet. Streamflows were well above normal during May which caused the reservoir to fill by approximately 40 feet, to 1867.5 feet, by 31 May. The peak inflow into the Duncan Reservoir was 17,500 cfs which occurred on 21 May. The reservoir continued to fill through June and was full on 28 June. After 28 June it discharged inflow to hold full pool through July.

D. LIBBY RESERVOIR

Storage Evacuation Period. On 1 August 1979, Lake Koocanusa was at elevation 2450.7 feet as shown on Chart 8. Water supply was not sufficient to fill the lake in 1979 and the lake remained near elevation 2451.0 feet, 8 feet below full pool, most of August. The highest level reached was elevation 2451.4 feet on 19 August 1979.

Higher reservoir releases resulted in a draft of Lake Koocanusa in September and October to meet U.S. power requirements. Draft accelerated in November and December as releases were at full powerhouse capacity, about 20,000 cfs, much of the time. The lake had drafted to elevation 2385.1 feet by 1 January, about 25 feet below the 1 January flood control requirement and 15 feet above the 31 January Variable Refill Curve.

Libby continued to draft for power in January and February and the lake level was at elevation 2355.9 on 29 February, about one foot above its Variable Refill Curve.

The outflow in early March was reduced to 3,000 cfs when the 1 March water supply forecast revealed a less than 95% confidence of refill. The lake continued to draft slowly because of low inflows and reached its lowest elevation of the year, 2353.2 feet, on 9 April. At that time the lake was about 12 feet below the 30 April Variable Refill Curve.

Refill Period. Inflows to Libby began increasing in mid-April. The seasonal peak was reached on 7 May with a daily average inflow of 50,700 cfs. Inflows fluctuated generally between 25,000 and 40,000 cfs until late June before a definite recession was observed.

Libby outflow was at 3,000 cfs from mid-March through 1 June by which time the lake had filled to near elevation 2438. Releases were gradually increased to full powerhouse discharge during the first half of June to slow the rate of fill. From 18 through 24 June Libby spilled up to 10,000 cfs through the sluices in addition to the powerhouse flows of about 19,000 cfs as the lake was above its flood control rule curve. There was also concern about water quality and fishery should the lake fill and have to spill in early July. This was the first use of the sluices for controlling inflows since August 1976. The inflows decreased and the project outflow was reduced to 4,000 cfs from 29 June through 6 July while the lake filled to elevation 2458.5, one half foot from full pool. The lake was held within 1 foot of full during the rest of July. Lake

Koocanusa reached its highest elevation of the year, 2458.9 feet, on 12 July and was at elevation 2458.2 feet on 31 July.

E. KOOTENAY LAKE

Storage Evacuation Period. As shown on Chart 9, Kootenay Lake was at elevation 1743.3 feet on 31 July 1979. It held this level through August to 4 September with the discharge averaging 16,000 cfs during this period. During September, and through to mid-October, Kootenay Lake was gradually filled to slightly below its IJC rule curve elevation of 1745.3 feet. Kootenay Lake continued to operate slightly below its IJC rule curve until 4 December when it was drafted to provide a greater margin to cover probable contingencies which might restrict its discharge during the start up of the Seven Mile project. The discharge during that period averaged 30,000 cfs, spilling approximately 12,000 cfs past Brilliant project. The lake was drafted to its lowest elevation of 1738.1 feet by 4 April.

Refill Period. Kootenay Lake was operated on free flow during April and the first part of May 1980. The lake filled rapidly during that period and the level peaked at 1748.3 feet on 9 May. Subsequently, Kootenay Lake was drawn down to 1744.6 feet before it again went up, to 1746.1 feet on 27 June, due to high outflows from Duncan and Libby projects. Kootenay Lake was finally brought under control in the first week of July and the lake level stabilized slightly below 1743.3 feet as measured at the Nelson gauge.

## 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 1979-80 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 1979-80 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 1979-80 Operating Year.

The generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement was 621 average megawatts at rates up to 1,331 megawatts from 1 August 1979 through 31 March 1980, and 583 average megawatts at rates up to 1,311 megawatts from 1 April 1980 through 31 July 1980. During the period April 1979 through 31 March 1980, the CSPE participants assigned 71 average megawatts at rates up to 150 megawatts to Pacific Southwest utilities. Beginning 1 April 1980, the assignment was 68 average megawatts at rates up to 150 megawatts. CSPE power not assigned to Pacific Southwest utilities was used to meet Pacific Northwest loads.

Review of 1979-80 Operations. The actual volume runoff of the Columbia River at The Dalles for the period 1 January through 31 July 1979, was

83.2 million acre-feet or 75.9 percent of the 15 year average runoff (1963-77). Coordinated System reservoirs were 4.4 billion kilowatthours below their normal full content on 31 July 1979, the date that reservoirs are programmed to be full. This deficiency was equal to 9.3 percent of the total Coordinated System's seasonal reservoir storage energy. Because the Coordinated System reservoirs failed to refill by 31 July Firm Load Carrying Capabilities developed for the second year of the Coordinated System's final regulation for 1978-79, were adopted for the 1979-80 Operating Year.

Natural streamflows of the Columbia River at The Dalles for the August-December period of 1979, were the lowest of the 55-year record even though parts of the basin received above average precipitation during August and October. BPA began making Advance Energy deliveries totaling 780,000 megawatthours to its industrial customers from provisional draft of Federal reservoirs on 16 October 1979. These deliveries continued into early December.

The Hanford plant did not return to service from its summertime maintenance until mid-August, two weeks later than planned. An unexpected outage for three weeks in November and an extended outage for refueling in December further diminished the anticipated yearly production at the plant. Unit No. 2 at Centralia was out of service 1 October through 23 November to replace turbine blades. The Trojan Nuclear Plant returned to service 4 July after ten weeks of annual maintenance but went out of service again for another ten weeks, 12 October through 31 December, to repair two steam generator leaks and to perform some work required within the containment vessels to strengthen some walls that support hangers and pipes.

As a result of low precipitation during the fall months and failure of thermal plants to operate as planned, Coordinated System resevoirs were 5.5 and 7.6 billion kilowatthours below normal operating levels on 31 October, and 30 November, respectively. Average precipitation in December reduced the Coordinated System reservoir draft and the storage energy deficiency remained at 7.5 billion kilowatthours on 31 December 1979.

The 1 January 1980, volume runoff forecast for the Columbia River at The Dalles was 88.9 million acre-feet, equal to 81 percent of the 15-year average runoff (1963-1977). Volume runoff forecasts to major cyclic reservoirs were sufficient, however, to lower the 31 January 95% confidence refill curves. As a result, reservoirs were only 1.0 billion kilowatthours below these curves on 31 January.

Warm weather during April resulted in rapidly rising streamflows throughout the Columbia Basin. BPA restored secondary energy deliveries to Pacific Northwest customers for the first time in ten months on 22 April 1980. On 24 April, the operation for the spring juvenile fish out-migration in the Columbia River began. Minimum "Fish Flow" requirements exceeded seasonal power flow requirements so BPA arranged to store some of the excess energy with B. C. Hydro. On 26 April, BPA also began selling surplus energy to Pacific Southwest utilities.

BPA continued to store excess generation with B. C. Hydro during May while loading the Pacific Northwest-Southwest intertie to near capacity. The month of May was the wettest month in relation to normal precipitation since December 1977. As a result of an early snowmelt runoff, streamflows reached peak levels in early May.

The "Fish Flow" operation was concluded on 15 June. The minimum recommended flows as requested by the fishery agencies were met or exceeded throughout the entire juvenile fish out-migration. The Federal System energy losses due to fish spill were 196,046 megawatthours. A total of 813,900 megawatthours was stored in B. C. Hydro's Williston reservoir during the fish-flow operation. BPA expects to take return of this energy before 30 November 1980. In addition, BPA stored an additional 259,850 megawatthours in Williston reservoir which BPA could not sell or store elsewhere. Under this arrangement, B. C. Hydro is permitted to purchase this energy at 5.5 mills per kilowatthour. BPA also stored energy equivalent to 112,894 sfd in Mica reservoir to assist that reservoir in refilling before the end of the normal refill season.

The sale of nonfirm energy to California exceeded 2,817,000 megawatthours in June. BPA sold nearly 2,117,000 megawatthours of surplus energy at an average rate of 5.5 mills per kilowatthour. Net "on-line" deliveries, total nonfirm sales, and total Federal nonfirm sales exceeded all previous records in the 12-year operation of the Pacific Northwest-Southwest Interties. BPA discontinued Southwest surplus energy sales on 9 July 1980, as streamflows continued to recede. Secondary energy deliveries to

Pacific Northwest investor-owned utilities were curtailed 21 July and deliveries to public agencies were curtailed 31 July. The BPA nonfirm industrial load was served during July with a mixture of direct service, Advance Energy and non-Federal energy purchases.

The actual January-July volume runoff was of the Columbia River at The Dalles totaled 95.8 million acre-feet, equal to 87.4 percent of the 15-year (1963-77) average runoff. Coordinated System reservoirs filled to 98 percent of their normal full contents by 24 July 1980.

## B. FLOOD CONTROL

Flood control during the spring runoff was provided by the normal refill operation of the Treaty projects and other storage reservoirs in the Columbia River Basin. The unregulated peak at The Dalles was 544,000 cfs on 31 May 1980, which is about 3 feet above bankfull capacity. The maximum observed daily discharge during the spring runoff was 338,100 cfs at The Dalles. Low spring flows were observed on upstream tributaries. The observed and unregulated hydrographs for 1 July 1979 through 31 July 1980 at The Dalles are shown on the summary hydrograph on Chart 12 for comparison with historical flows. On Chart 13, the effects of regulation at The Dalles by Mica, Arrow, Duncan and Libby are separated from the other major storage projects in the basin.

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. The apparent delayed filling of Arrow Reservoir depicted in Chart 14 is accounted for by the temporary retention of some Arrow Treaty storage at Mica as mentioned in Section III-B.

## V. OPERATING CRITERIA

### A. GENERAL

The Columbia River Treaty requires that the reservoirs constructed in Canada be operated pursuant to flood control and 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 for the Preparation and Use of Hydroelectric Operating Plans dated May 1979, together with the Columbia River Treaty Flood Control Operating Plan dated October 1972, establish the general criteria of operations.

The Assured Operating Plan dated September 1974 established Operating Rule Curves for Duncan, Arrow and Mica during the 1979-80 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 1979 established data and criteria for determining the Operating Rule Curves for use in actual operations. At the request of the U.S. Entity these criteria included the Critical Rule Curves for Duncan, Arrow, and Mica from the 1979-80 Pacific Northwest Coordination Agreement final regulation. The Variable Refill Curves and flood control requirements subsequent to 1 January 1980, were determined on the basis of seasonal volume runoff forecasts during actual operation.

## B. POWER OPERATION

Consistent with all Detailed Operating Plans prepared since the installation of generation at Mica, the 1979-80 Detailed Operating Plan 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.

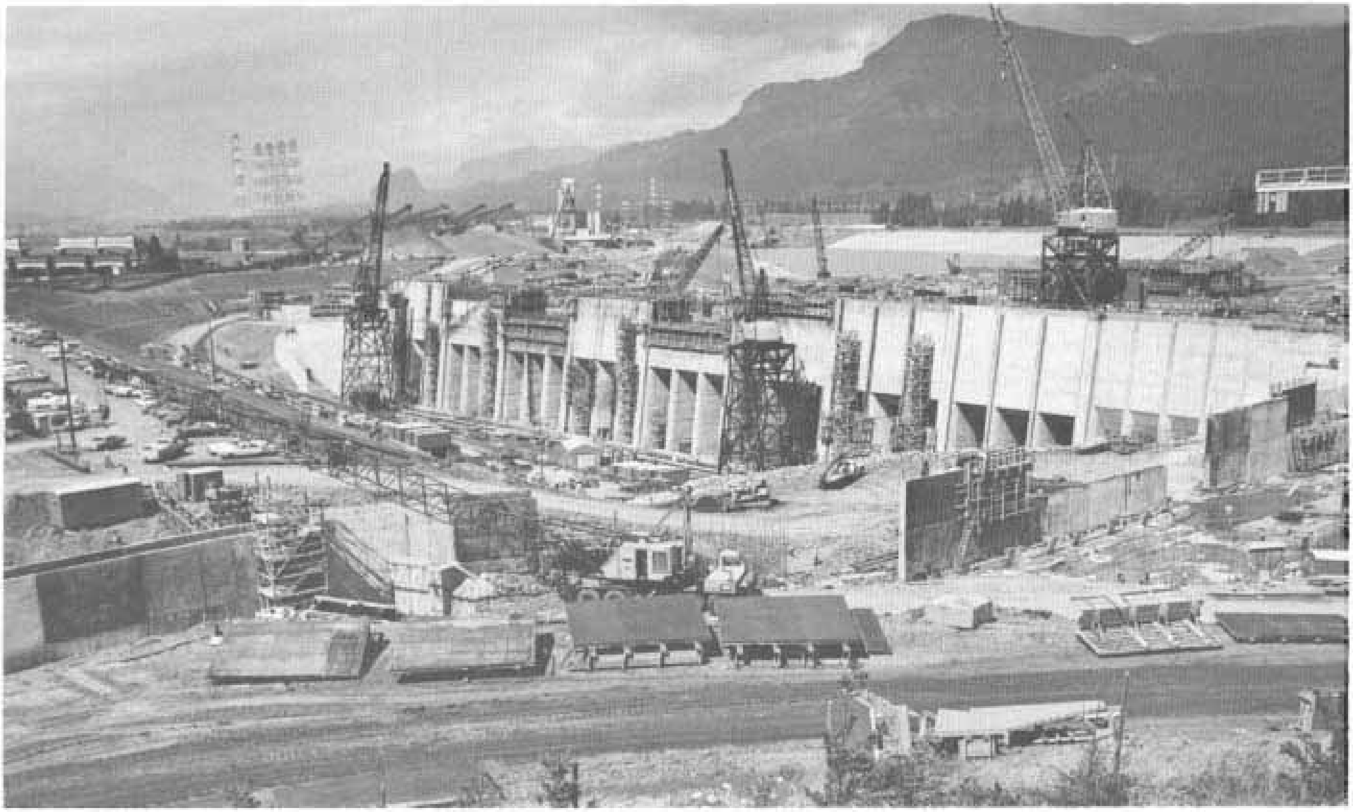
The power facilities in the United States which are downstream from the Treaty storage projects are all operated under the Pacific Northwest Coordination Agreement dated September 1964. Optimum generation in the United States was assured by the adoption, in the Assured and Detailed

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.

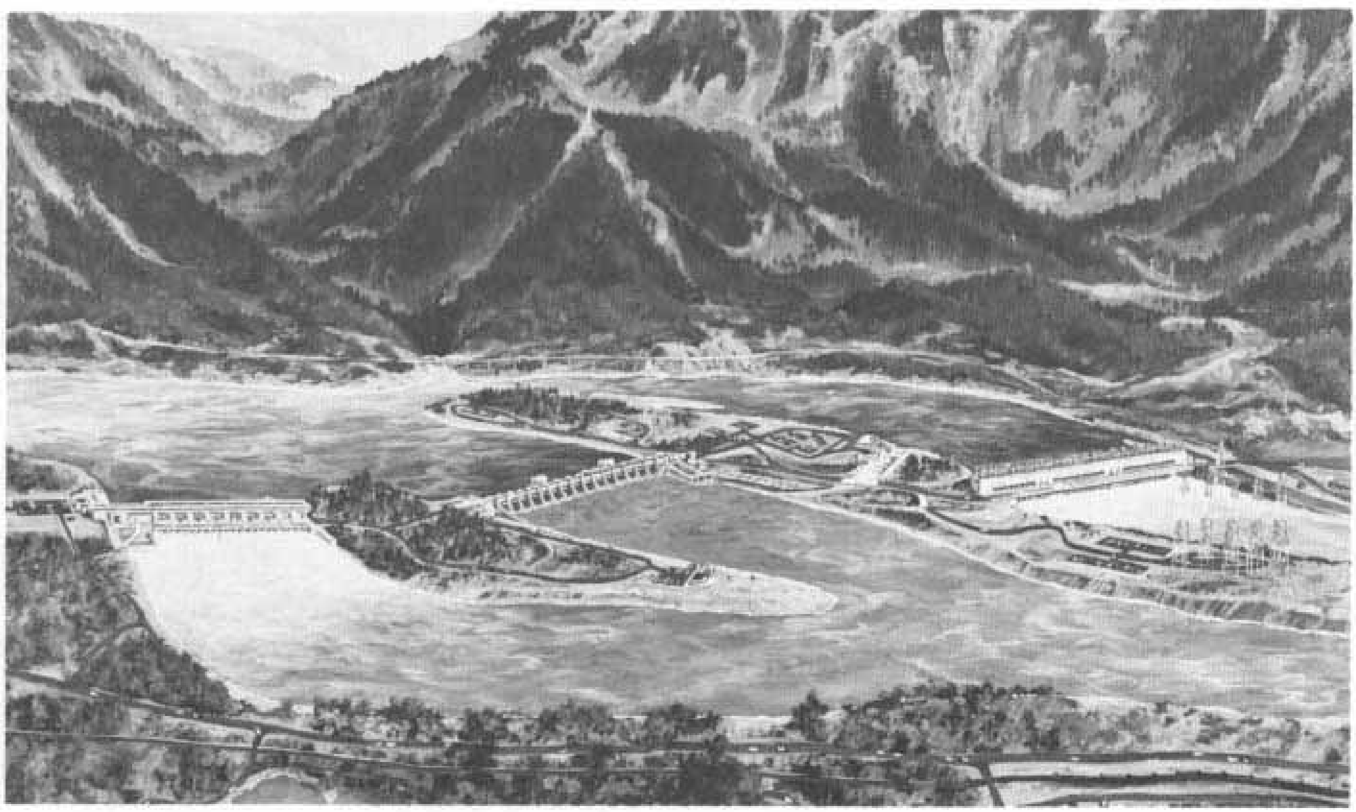
C. FLOOD CONTROL OPERATION

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.

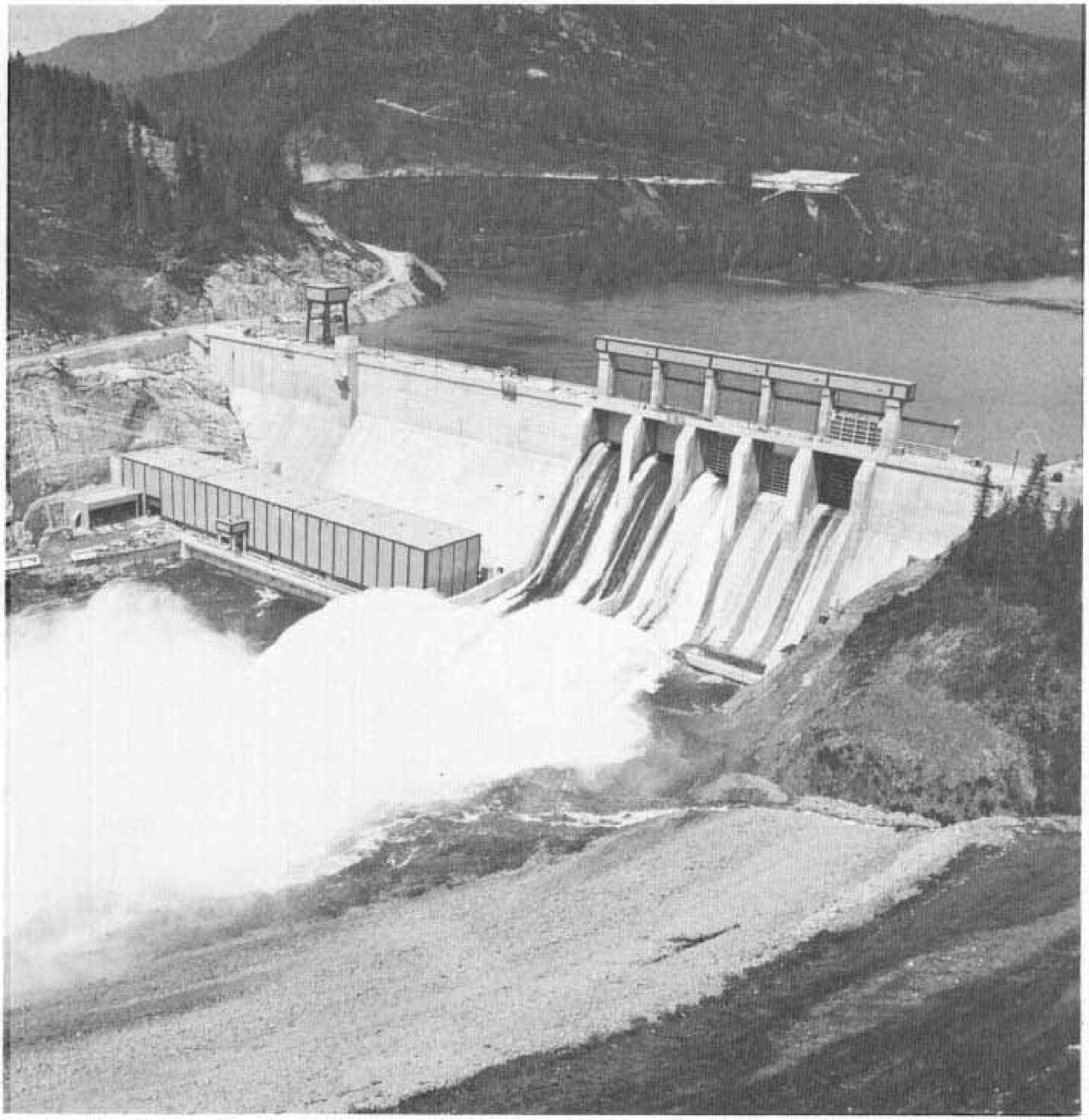
Flood control operation of the Columbia River Treaty projects during the refill period was controlled in part by the computed Initial Controlled Flow of the Columbia River at The Dalles. Other operating rules and local criteria were utilized to prepare day-to-day streamflow forecasts for key points in 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.



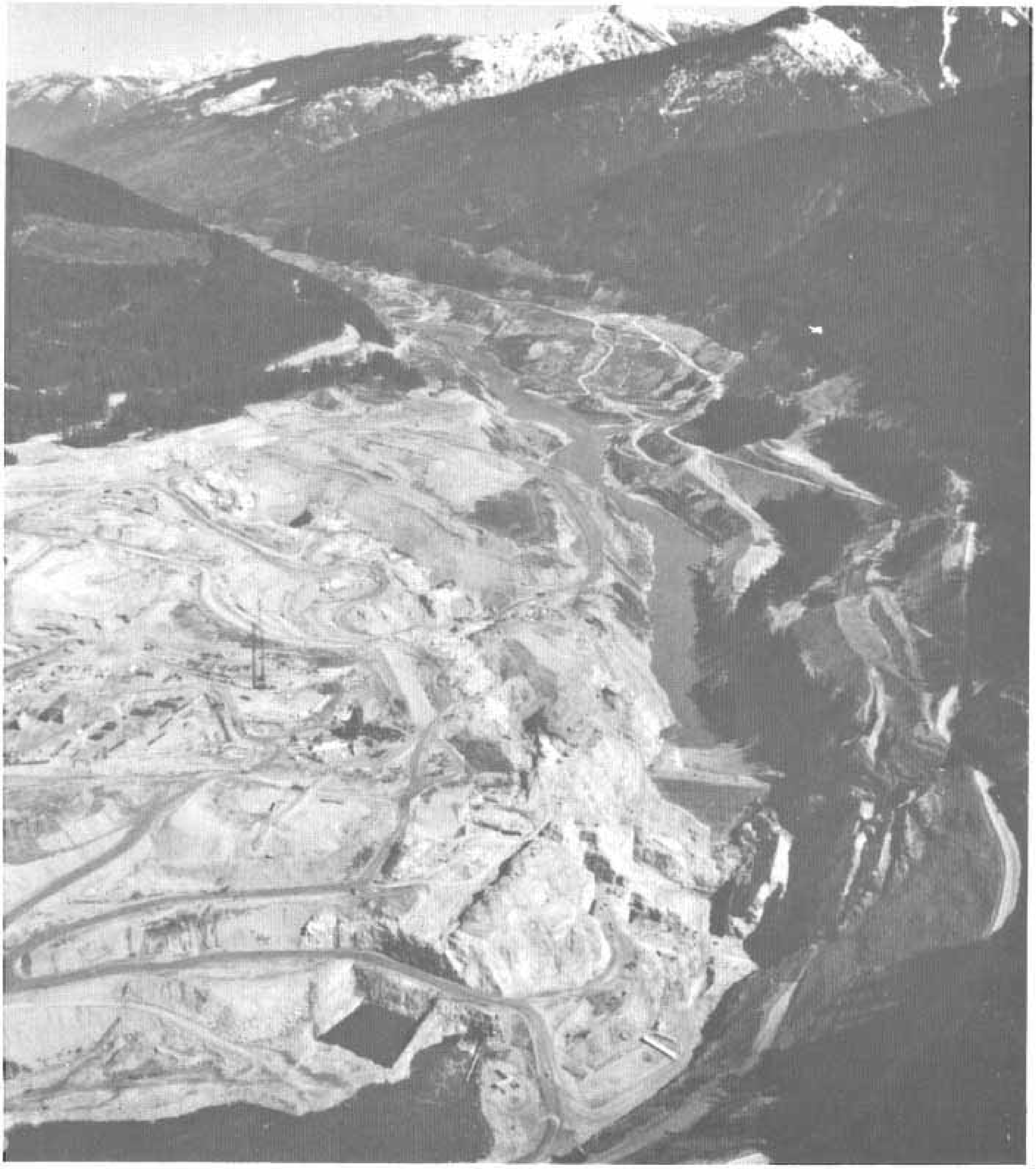
Looking downstream at Bonneville Dam second powerhouse construction on 16 July 1980 (above). Work was 87% complete on 31 July 1980. Power on line from the first of eight 66.5 MW units is expected in May 1981. Below is an artist's rendition of the completed project.



Mt. St. Helens Clean-up. The 18 May 1980 eruption of Mt. St. Helens sent massive amounts of mud and debris into the Toutle, Cowlitz, and Lower Columbia Rivers. Pictured are the Corps of Engineers hopper dredges BIDDLE, HARDING and PACIFIC with the Port of Portland pipeline dredge OREGON working to remove an estimated 14 million cubic yards of debris to restore the navigation channel depth to the Columbia River near Longview, Washington. Other dredges were working upstream on the Cowlitz River to restore its flow carrying capability. Mud and ash flows reduced the bankfull flow of the Cowlitz River at Castle Rock from 70,000 cfs to 7,000 cfs. The dredging efforts directed by the Corps of Engineers are expected to increase the bankfull capacity to 50,000 cfs.



B. C. Hydro's Seven Mile project entered commercial service in December 1979. By the end of July 1980, two 202.5 MW units were in-service with a third nearing completion. Ultimate capacity is 810 MW.



Construction work on the Revelstoke project is now well under way. The picture shows the construction area, the coffer dams and diversion tunnel (foreground) and the reservoir clearing (background).

## Table 1

## Unregulated Runoff Volume Forecasts
## Millions of Acre-Feet
## 1980

| Forecast Date - 1st of | DUNCAN Most Probable 1 Apr - 31 Aug | ARROW Most Probable 1 Apr - 31 Aug | MICA Most Probable 1 Apr - 31 Aug | LIBBY Most Probable 1 Apr - 31 Aug | UNREGULATED RUNOFF COLUMBIA RIVER AT THE DALLES, OREGON Most Probable 1 Jan - 31 Jul |
|---|---|---|---|---|---|
| January | 1.94 | 21.5 | 11.20 | 6.25 | 88.9 |
| February | 1.90 | 20.8 | 11.10 | 5.98 | 88.9 |
| March | 1.94 | 20.7 | 10.70 | 5.87 | 88.9 |
| April | 1.94 | 21.2 | 10.80 | 5.85 | 89.7 |
| May | 2.03 | 22.0 | 11.10 | 6.07 | 90.6 |
| June | 2.08 | 22.9 | 11.30 | 6.57 | 97.7 |
| July | 2.08 | 23.7 | 11.80 | 6.53 | 99.4 |
| Actual | 2.06 | 22.0 | 10.73 | 5.90 | 95.8 |

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

# Table 2
# Mica Reservoir Computation Form
# 1980

95 PERCENT CONFIDENCE FORECAST AND VARIABLE ENERGY CONTENT CURVE

| | | Initial 9/ | Jan 1 | Feb 1 | Mar 1 | Apr 1 | May 1 | Jun 1 |
|---|---|---|---|---|---|---|---|---|
| Probable Feb 1-Jul 31 Inflow, KSFD | 1/ | | 4614.0 | 4485.7 | 4449.1 | 4516.1 | 4664.9 | 4981.4 |
| 95$ Forecast Error, KSFD | | | 726.6 | 542.5 | 494.3 | 484.3 | 490.9 | 474.9 |
| 95$ Conf. Feb 1-Jul 31 Inflow, KSFD | 2/ | | 3887.4 | 3943.2 | 3954.8 | 4031.8 | 4170.0 | 4506.5 |
| Observed Feb 1-Date Inflow, KSFD | | | | | 109.0 | 222.4 | 610.2 | 2001.5 |
| 95$ Conf. Date-Jul 31 Inflow, KSFD | 3/ | | 3887.4 | 3943.2 | 3845.8 | 3809.4 | 3663.8 | 2505.0 |
| | | | | | | | | |
| Assumed Feb 1-Jul 31 Inflow, $ Volume | | | 100.0 | | | | | |
| Assumed Feb 1-Jul 31 Inflow, KSFD | 4/ | | 3887.4 | | | | | |
| Min Feb 1-Jul 31 Outflow, KSFD | | | 1820.0 | | | | | |
| Min Jan 31 Reservoir Content, KSFD | 5/ | 1439.0 | 1461.8 | | | | | |
| Min Jan 31 Reservoir Elevation, Feet | 6/ | 2427.3 | 2427.8 | | | | | |
| Jan 31 Variable Refill Curve, Feet | 7/ | | 2427.3 | | | | | |
| | | | | | | | | |
| Assumed Mar 1-Jul 31 Inflow, $ Volume | | | 97.8 | 97.8 | | | | |
| Assumed Mar 1-Jul 31 Inflow, KSFD | 4/ | | 3801.9 | 3856.5 | | | | |
| Min Mar 1-Jul 31 Outflow, KSFD | | | 1530.0 | 1530.0 | | | | |
| Min Feb 28 Reservoir Content, KSFD | 5/ | 1099.7 | 1257.3 | 1202.7 | | | | |
| Min Feb 28 Reservoir Elevation, Feet | 6/ | 2419.8 | 2423.3 | 2422.1 | | | | |
| Feb 28 Variable Refill Curve, Feet | 7/ | | 2419.8 | 2419.8 | | | | |
| | | | | | | | | |
| Assumed Apr 1-Jul 31 Inflow, $ Volume | | | 95.4 | 95.4 | 97.5 | | | |
| Assumed Apr 1-Jul 31 Inflow, KSFD | 4/ | | 3708.6 | 3761.8 | 3753.5 | | | |
| Min Apr 1-Jul 31 Outflow, KSFD | | | 1220.0 | 1220.0 | 1220.0 | | | |
| Min Mar 31 Reservoir Content, KSFD | 5/ | 698.2 | 1040.6 | 987.4 | 995.7 | | | |
| Min Mar 31 Reservoir Elevation, Feet | 6/ | 2410.6 | 2418.5 | 2417.3 | 2417.4 | | | |
| Mar 31 Variable Refill Curve, Feet | 7/ | | 2410.6 | 2410.6 | 2410.6 | | | |
| | | | | | | | | |
| Assumed May 1-Jul 31 Inflow, $ Volume | | | 91.0 | 91.0 | 93.1 | 95.4 | | |
| Assumed May 1-Jul 31 Inflow, KSFD | 4/ | | 3537.6 | 3588.3 | 3580.5 | 3634.2 | | |
| Min May 1-Jul 31 Outflow, KSFD | | | 920.0 | 920.0 | 920.0 | 920.0 | | |
| Min Apr 30 Reservoir Content, KSFD | 5/ | 416.6 | 911.6 | 860.9 | 868.7 | 815.0 | | |
| Min Apr 30 Reservoir Elevation, Feet | 6/ | 2404.0 | 2415.5 | 2414.4 | 2414.6 | 2413.3 | | |
| Apr 30 Variable Refill Curve, Feet | 7/ | | 2404.0 | 2404.0 | 2404.0 | 2404.0 | | |
| | | | | | | | | |
| Assumed Jun 1-Jul 31 Inflow, $ Volume | | | 74.1 | 74.1 | 75.8 | 77.7 | 81.5 | |
| Assumed Jun 1-Jul 31 Inflow, KSFD | 4/ | | 2880.6 | 2921.9 | 2915.2 | 2959.9 | 2904.5 | |
| Min Jun 1-Jul 31 Outflow, KSFD | | | 610.0 | 610.0 | 610.0 | 610.0 | 610.0 | |
| Min May 31 Reservoir Content, KSFD | 5/ | 935.6 | 1258.6 | 1217.3 | 1224.0 | 1179.3 | 1234.7 | |
| Min May 31 Reservoir Elevation, Feet | 6/ | 2416.1 | 2423.3 | 2422.4 | 2422.6 | 2421.6 | 2422.8 | |
| May 31 Variable Refill Curve, Feet | 7/ | | 2416.1 | 2416.1 | 2416.1 | 2416.1 | 2416.1 | |
| | | | | | | | | |
| Assumed Jul 1- Jul 31 Inflow, $ Volume | | | 36.9 | 36.9 | 37.8 | 38.7 | 40.6 | 49.8 |
| Assumed Jul 1- Jul 31 Inflow, KSFD | 4/ | | 1434.5 | 1455.1 | 1453.7 | 1474.2 | 1446.9 | 1247.5 |
| Min Jul 1-Jul 31 Outflow, KSFD | | | 310.0 | 310.0 | 310.0 | 310.0 | 310.0 | 310.0 |
| Min Jun 30 Reservoir Content, KSFD | 5/ | 2317.1 | 2404.7 | 2384.1 | 2385.5 | 2365.0 | 2392.3 | 2591.7 |
| Min Jun 30 Reservoir Elevation, Feet | 6/ | 2445.9 | 2447.7 | 2447.8 | 2447.3 | 2446.9 | 2447.4 | 2451.5 |
| Jun 30 Variable Refill Curve, Feet | 7/ | | 2445.9 | 2445.9 | 2445.9 | 2445.9 | 2445.9 | 2445.9 |
| | | | | | | | | |
| Jul 31 Variable Refill Curve, Feet | | 2469.8 | 2469.8 | 2469.8 | 2469.8 | 2469.8 | 2469.8 | 2469.8 |
| | | | | | | | | |
| Mica Accumulated Dead Storage | | | 6313.0 | 6313.0 | 6313.0 | 6313.0 | 6313.0 | 6313.0 |

1/ Developed by Canadian Entity.
2/ Line 1-Line 2
3/ Line 3-Line 4
4/ Preceding Line X Line 5
5/ Full Content (3529.2 KSFD) Plus Preceding Line Less Line Preceding That (Usable Storage). Footnote does not apply to "Initial" column.
6/ From Reservoir Elevation-Storage Content Table Dated Mar 25, 1974 (Footnote 5 Plus the Accumulated Dead Storage)
7/ Lower of Elevation on Preceding Line or Elevation Determined by Adding Dead Storage to Initial Contents
8/ Limited to Lower Limit for Variable Refill Curve.
9/ Base Energy Content Curve.

# Table 3
# Arrow Lakes Reservoir Computation Form
# 1980

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

| | | Initial 10/ | Jan 1 ARROW LOCAL | Feb 1 ARROW LOCAL | Mar 1 ARROW LOCAL | Apr 1 ARROW LOCAL | May 1 ARROW LOCAL | Jun 1 ARROW LOCAL |
|---|---|---|---|---|---|---|---|---|
| Probable Feb 1-Jul 31 Inflow, KSFD | 1/ | | 4994.8 | 4430.8 | 4502.1 | 4718.0 | 5596.5 | 5742.3 |
| 95$ Forecast Error, KSFD | | | 994.0 | 772.0 | 732.5 | 584.8 | 534.2 | 504.0 |
| 95$ Conf. Feb 1-Jul 31 Inflow, KSFD | 2/ | | 4000.8 | 3658.8 | 3769.6 | 4133.2 | 5062.3 | 5238.3 |
| Observed Feb 1 - Date Inflow, KSFD | | | | | 166.3 | 354.2 | 1114.6 | 2810.6 |
| 95$ Conf. Date-Jul 31 Inflow, KSFD | 3/ | | 4000.8 | 3658.8 | 3603.3 | 3779.0 | 3947.7 | 2427.7 |
| Assumed Feb 1-Jul 31 Inflow, $ Volume | | | 100.0 | | | | | |
| Assumed Feb 1-Jul 31 Inflow, KSFD | 4/ | | 4000.8 | | | | | |
| Min. Feb 1-Jul 31 Outflow, KSFD | | | 2393.3 | | | | | |
| Mica Refill Requirements, KSFD | 8/ | | 1820.0 | | | | | |
| Min Jan 31 Reservoir Content, KSFD | 5/ | 2343.5 | 683.6 | | | | | |
| Min Jan 31 Reservoir Elevation, Feet | 6/ | 1424.2 | 1393.3 9/ | | | | | |
| Jan 31 Variable Refill Curve, Feet | 7/ | | 1393.3 9/ | | | | | |
| Assumed Mar 1-Jul 31 Inflow, $ Volume | | | 97.3 | 97.3 | | | | |
| Assumed Mar 1-Jul 31 Inflow, KSFD | 4/ | | 3892.8 | 3560.0 | | | | |
| Min Mar 1-Jul 31 Outflow, KSFD | | | 2248.3 | 1528.1 | | | | |
| Mica Refill Requirements, KSFD | 8/ | | 1530.0 | 1530.0 | | | | |
| Min Feb 28 Reservoir Content, KSFD | 5/ | 1315.8 | 405.1 | 353.1 | | | | |
| Min Feb 28 Reservoir Elevation Feet | 6/ | 1405.8 | 1387.4 | 1386.3 9/ | | | | |
| Feb 28 Variable Refill Curve, Feet | 7/ | | 1387.4 | 1386.3 9/ | | | | |
| Assumed Apr 1-Jul 31 Inflow, $ Volume | | | 94.1 | 94.1 | 97.1 | | | |
| Assumed Apr 1-Jul 31 Inflow, KSFD | 4/ | | 3764.8 | 3442.9 | 3498.8 | | | |
| Min Apr 1-Jul 31 Outflow, KSFD | | | 2093.3 | 1373.1 | 1528.1 | | | |
| Mica Refill Requirements, KSFD | 8/ | | 1220.0 | 1220.0 | 1220.0 | | | |
| Min Mar 31 Reservoir Content, KSFD | 5/ | 1206.5 | 688.1 | 289.8 | 388.9 | | | |
| Min Mar 31 Reservoir Elevation, Feet | 6/ | 1403.8 | 1393.4 | 1384.8 | 1387.1 | | | |
| Mar 31 Variable Refill Curve, Feet | 7/ | | 1393.4 | 1384.8 | 1387.1 | | | |
| Assumed May 1-Jul 31 Inflow, $ Volume | | | 87.2 | 87.2 | 91.2 | 92.7 | | |
| Assumed May 1-Jul 31 Inflow, KSFD | 4/ | | 3488.7 | 3190.4 | 3286.2 | 3503.1 | | |
| Min May 1-Jul 31 Outflow, KSFD | | | 1719.9 | 1078.0 | 1235.6 | 1078.0 | | |
| Mica Refill Requirements, KSFD | 8/ | | 920.0 | 920.0 | 920.0 | 920.0 | | |
| Min Apr 30 Reservoir Content, KSFD | 5/ | 1425.1 | 890.8 | 547.1 | 609.0 | 234.5 | | |
| Min Apr 30 Reservoir Elevation, Feet | 6/ | 1407.9 | 1397.6 | 1390.5 | 1391.8 | 1383.5 | | |
| Apr 30 Variable Refill Curve, Feet | 7/ | | 1397.6 | 1390.5 | 1391.8 | 1383.5 | | |
| Assumed Jun 1-Jul 31 Inflow, $ Volume | | | 63.9 | 63.9 | 70.4 | 67.9 | 73.3 | |
| Assumed Jun 1-Jul 31 Inflow, KSFD | 4/ | | 2556.5 | 2338.0 | 2536.7 | 2565.9 | 2893.7 | |
| Min Jun 1-Jul 31 Outflow, KSFD | | | 1233.7 | 764.6 | 879.8 | 764.6 | 672.0 | |
| Mica Refill Requirements, KSFD | 8/ | | 610.0 | 610.0 | 610.0 | 610.0 | 610.0 | |
| Min May 31 Reservoir Content, KSFD | 5/ | 2180.8 | 1646.8 | 1396.2 | 1312.7 | 1168.3 | 747.9 | |
| Min May 31 Reservoir Elevation, Feet | 6/ | 1421.9 | 1412.0 | 1407.4 | 1405.8 | 1403.0 | 1394.6 | |
| May 31 Variable Refill Curve, Feet | 7/ | | 1412.0 | 1407.4 | 1405.8 | 1403.0 | 1394.6 | |
| Assumed Jul 1-Jul 31 Inflow, $ Volume | | | 27.5 | 27.5 | 32.7 | 29.2 | 31.5 | 43.0 |
| Assumed Jul 1-Jul 31 Inflow, KSFD | 4/ | | 1100.2 | 1006.2 | 1178.3 | 1103.5 | 1243.5 | 1043.9 |
| Min Jul 1-Jul 31 Outflow, KSFD | | | 763.2 | 461.4 | 535.5 | 461.4 | 400.5 | 155.0 |
| Mica Refill Requirements, KSFD | 8/ | | 310.0 | 310.0 | 310.0 | 310.0 | 310.0 | 310.0 |
| Min Jun 30 Reservoir Content, KSFD | 5/ | 3415.3 | 2932.6 | 2724.8 | 2626.8 | 2627.5 | 2426.6 | 2380.7 |
| Min Jun 30 Reservoir Elevation, Feet | 6/ | 1441.5 | 1433.9 | 1430.5 | 1428.9 | 1428.9 | 1425.6 | 1424.8 |
| Jun 30 Variable Refill Curve, Feet | 7/ | | 1433.9 | 1430.5 | 1428.9 | 1428.9 | 1425.6 | 1424.8 |
| Jul 31 Variable Refill Curve, Feet | | 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/ Full Content (3579.6 KSFD) Less Line Preceding Plus Line Preceding That Less Line Preceding that for Arrow Local. For Arrow Total, Full Content (3579.6 KSFD) Plus Two Preceding Liness Less Line Preceding That. Footnote does not apply to "initial" column.
6/ From Reservoir Elevation-Storage Content Table Dated Feb. 28, 1974
7/ Lower of the Elevation on Preceding Line or Elevation Determined Prior to Year (Initial)
8/ Mica Minimum Power Discharges for Arrow Local. For Arrow Total, Mica Full Content Less Variable Refill Curve From Mica Computation Form.
9/ Limited to Lower Limit for Variable Refill Curve.
10/ Base energy content curve.

# Table 4
# Duncan Reservoir Computation Form 1980

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

| | | Initial[9] | Jan 1 | Feb 1 | Mar 1 | Apr 1 | May 1 | Jun 1 |
|---|---|---|---|---|---|---|---|---|
| Probable Feb 1-Jul 31 Inflow, KSFD | 1/ | | 852.4 | 819.3 | 834.0 | 831.7 | 879.0 | 943.1 |
| 95$ Forecast Error, KSFD | | | 155.3 | 119.3 | 14.7 | 107.9 | 99.7 | 93.6 |
| 95$ Conf. Feb 1-Jul 31 Inflow, KSFD | 2/ | | 697.1 | 700.0 | 719.2 | 723.8 | 779.3 | 849.5 |
| Observed Feb 1-Date Inflow, KSFD | | | | | 15.0 | 32.5 | 127.9 | 435.3 |
| 95$ Conf. Date-Jul 31 Inflow, KSFD | 3/ | | 679.1[8] | 700.0 | 704.2 | 691.3 | 651.4 | 414.2 |
| | | | | | | | | |
| Assumed Feb 1-Jul 31 Inflow, $ Volume | | | 100.0 | | | | | |
| Assumed Feb 1-Jul 31 Inflow, KSFD | 4/ | | 697.1 | | | | | |
| Min Feb 1-Jul 31 Outflow, KSFD | | | 150.9 | | | | | |
| Min Jan 31 Reservoir Content, KSFD | 5/ | 234.8 | 159.6 | | | | | |
| Min Jan 31 Reservoir Elevation, Feet | 6/ | 1834.0 | 1823.1 | | | | | |
| Jan 31 Variable Refill Curve, Feet | 7/ | | 1823.1 | | | | | |
| | | | | | | | | |
| Assumed Mar 1-Jul 31 Inflow, $ Volume | | | 97.8 | 97.8 | | | | |
| Assumed Mar 1-Jul 31 Inflow, KSFD | 4/ | | 681.8 | 684.6 | | | | |
| Min Mar 1-Jul 31 Outflow, KSFD | | | 148.0 | 115.8 | | | | |
| Min Feb 28 Reservoir Content, KSFD | 5/ | 244.0 | 172.0 | 137.0 | | | | |
| Min Feb 28 Reservoir Elevation, Feet | 6/ | 1835.3 | 1824.9 | 1819.6 | | | | |
| Feb 28 Variable Refill Curve, Feet | 7/ | | 1824.9 | 1819.6 | | | | |
| | | | | | | | | |
| Assumed Apr 1-Jul 31 Inflow, $ Volume | | | 95.4 | 95.4 | 97.5 | | | |
| Assumed Apr 1-Jul 31 Inflow, KSFD | 4/ | | 665.1 | 667.8 | 686.6 | | | |
| Min Apr 1-Jul 31 Outflow, KSFD | | | 144.9 | 112.7 | 120.8 | | | |
| Min Mar 31 Reservoir Content, KSFD | 5/ | 258.1 | 185.6 | 150.7 | 140.0 | | | |
| Min Mar 31 Reservoir Elevation, Feet | 6/ | 1837.2 | 1826.9 | 1821.7 | 1820.1 | | | |
| Mar 31 Variable Refill Curve, Feet | 7/ | | 1826.9 | 1821.7 | 1820.1 | | | |
| | | | | | | | | |
| Assumed May 1-Jul 31 Inflow, $ Volume | | | 90.3 | 90.3 | 92.2 | 94.6 | | |
| Assumed May 1-Jul 31 Inflow, KSFD | 4/ | | 629.5 | 632.1 | 649.3 | 654.0 | | |
| Min May 1-Jul 31 Outflow, KSFD | | | 109.3 | 85.0 | 91.1 | 85.0 | | |
| Min Apr 30 Reservoir Content, KSFD | 5/ | 236.5 | 185.6 | 158.7 | 147.6 | 136.8 | | |
| Min Apr 30 Reservoir Elevation, Feet | 6/ | 1834.2 | 1826.9 | 1822.9 | 1821.2 | 1819.6 | | |
| Apr 30 Variable Refill Curve, Feet | 7/ | | 1826.9 | 1822.9 | 1821.2 | 1819.6 | | |
| | | | | | | | | |
| Assumed Jun 1-Jul 31 Inflow, $ Volume | | | 70.5 | 70.5 | 72.0 | 73.9 | 78.1 | |
| Assumed Jun 1-Jul 31 Inflow, KSFD | 4/ | | 491.5 | 493.5 | 507.1 | 510.9 | 508.7 | |
| Min Jun 1-Jul 31 Outflow, KSFD | | | 72.5 | 56.4 | 60.4 | 56.4 | 49.0 | |
| Min May 31 Reservoir Content, KSFD | 5/ | 343.8 | 286.6 | 268.7 | 259.1 | 251.3 | 246.1 | |
| Min May 31 Reservoir Elevation, Feet | 6/ | 1848.6 | 1841.1 | 1838.7 | 1837.3 | 1836.3 | 1835.5 | |
| May 31 Variable Refill Curve, Feet | 7/ | | 1841.1 | 1838.7 | 1837.3 | 1836.3 | 1835.5 | |
| | | | | | | | | |
| Assumed Jul 1- Jul 31 Inflow, $ Volume | | | 33.3 | 33.3 | 34.0 | 34.9 | 36.9 | 47.2 |
| Assumed Jul 1- Jul 31 Inflow, KSFD | 4/ | | 232.1 | 233.1 | 239.4 | 241.3 | 240.4 | 195.5 |
| Min Jul 1-Jul 31 Outflow, KSFD | | | 36.8 | 28.6 | 30.7 | 28.6 | 24.9 | 3.1 |
| Min Jun 30 Reservoir Content, KSFD | 5/ | 532.8 | 510.5 | 501.3 | 497.1 | 493.1 | 490.3 | 513.4 |
| Min Jun 30 Reservoir Elevation, Feet | 6/ | 1872.0 | 1869.4 | 1868.3 | 1867.8 | 1867.3 | 1867.0 | 1869.7 |
| Jun 30 Variable Refill Curve, Feet | 7/ | | 1869.4 | 1868.3 | 1867.8 | 1867.3 | 1867.0 | 1869.7 |
| | | | | | | | | |
| Jul 31 Variable Refill Curve, Feet | | 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. Footnote does not apply to "Initial" column.
6/ From Reservoir Elevation-Storage Content Table Dated Feb 21, 1973
7/ Lower of Elevation on Preceding Line or Elevation Determined Prior to the Year (Initial)
8/ Limited to Lower Limit for Variable Refill Curve.
9/ Base Energy Content Curve.

## Table 5

# Libby Reservoir Computation Form 1980

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

| | | Jan 1 | Feb 1 | Mar 1 | Apr 1 | May 1 | Jun 1 |
|---|---|---|---|---|---|---|---|
| Probable Jan 1-Jul 31 Inflow, KAF | | 6309.0 | 5975.9 | 5795.0 | 5749.7 | 5923.7 | 6377.2 |
| & KSFD | | 3180.8 | 3012.8 | 2921.6 | 2898.8 | 2986.5 | 3215.2 |
| 95% Forecast Error, KSFD | | 877.2 | 598.8 | 546.6 | 495.1 | 414.7 | 348.4 |
| Observed Jan 1-Date Inflow, KSFD | | 0.0 | 52.0 | 118.0 | 200.3 | 547.9 | 1728.4 |
| 95% Conf. Date-Jul 31 Inflow, KSFD | 1/ | 2303.5 | 2362.1 | 2257.1 | 2203.4 | 2023.9 | 1138.4 |
| | | | | | | | |
| Assumed Feb 1-Jul 31 Inflow, % Volume | | 96.94 | | | | | |
| Assumed Feb 1-Jul 31 Inflow, KSFD | 2/ | 2233.0 | | | | | |
| Feb Minimum Flow Requirement, CFS | 3/ | 3000.0 | | | | | |
| Min Feb 1-Jul 31 Outflow, KSFD | 4/ | 598.7 | | | | | |
| Min Jan 31 Reservoir Content, KSFD | 5/ | 853.0 | | | | | |
| Min Jan 31 Reservoir Content, Feet | 6/ | 2370.1 | | | | | |
| Jan 31 Energy Content Curve, Feet | 7/ | 2370.1 | | | | | |
| Base Energy Content Curve, Feet | 2403.1 | | | | | | |
| Lower Limit for VECC, Feet | 2345.3 | | | | | | |
| | | | | | | | |
| Assumed Mar 1-Jul 31 Inflow, % Volume | | 94.17 | 97.14 | | | | |
| Assumed Mar 1-Jul 31 Inflow, KSFD | 2/ | 2169.2 | 2294.5 | | | | |
| Mar Minimum Flow Requirement, CFS | 3/ | 3000.0 | 3000.0 | | | | |
| Min Mar 1-Jul31 Outflow, KSFD | 4/ | 511.7 | 463.4 | | | | |
| Min Feb 28 Reservoir Content, KSFD | 5/ | 829.8 | 656.2 | | | | |
| Min Feb 28 Reservoir Content, Feet | 6/ | 2368.4 | 2354.9 | | | | |
| Feb 28 Energy Content Curve, Feet | 7/ | 2368.4 | 2354.9 | | | | |
| Base Energy Content Curve, Feet | 2401.7 | | | | | | |
| Lower Limit for VECC, Feet | 2326.1 | | | | | | |
| | | | | | | | |
| Assumed Apr 1-Jul 31 Inflow, % Volume | | 90.79 | 93.66 | 96.42 | | | |
| Assumed Apr 1-Jul 31 Inflow, KSFD | 2/ | 2091.4 | 2212.3 | 2176.3 | | | |
| Apr Minimum Flow Requirement, CFS | 3/ | 3432.0 | 3036.0 | 3132.0 | | | |
| Min Apr 1-Jul 31 Outflow, KSFD | 4/ | 418.7 | 370.4 | 382.1 | | | |
| Min Mar 31 Reservoir Content, KSFD | 5/ | 814.6 | 645.4 | 693.2 | | | |
| Min Mar 31 Reservoir Content, Feet | 6/ | 2367.2 | 2354.0 | 2357.9 | | | |
| Mar 31 Energy Content Curve, Feet | 7/ | 2367.2 | 2354.0 | 2357.9 | | | |
| Base Energy Content Curve, Feet | 2400.4 | | | | | | |
| Lower Limit for VECC, Feet | 2294.3 | | | | | | |
| | | | | | | | |
| Assumed May 1-Jul 31 Inflow, % Volume | | 81.71 | 84.29 | 86.77 | 90.00 | | |
| Assumed May 1-Jul 31 Inflow, KSFD | 2/ | 1882.2 | 1991.0 | 1958.4 | 1983.0 | | |
| May Minimum Flow Requirement, CFS | 3/ | 3432.0 | 3036.0 | 3132.0 | 3036.0 | | |
| Min May 1-Jul 31 Outflow, KSFD | 4/ | 315.7 | 279.3 | 288.1 | 279.3 | | |
| Min Apr 30 Reservoir Content, KSFD | 5/ | 920.8 | 775.6 | 817.0 | 783.6 | | |
| Min Apr 30 Reservoir Content, Feet | 6/ | 2374.7 | 2364.3 | 2367.4 | 2364.9 | | |
| Apr 30 Energy Content Curve, Feet | 7/ | 2374.7 | 2364.3 | 2367.4 | 2364.9 | | |
| Base Energy Content Curve, Feet | 2399.0 | | | | | | |
| Lower Limit for VECC, Feet | 2287.0 | | | | | | |
| | | | | | | | |
| Assumed Jun 1-Jul 31 Inflow, % Volume | | 52.75 | 54.42 | 56.02 | 58.10 | 64.56 | |
| Assumed Jun 1-Jul 31 Inflow, KSFD | 2/ | 1215.1 | 1285.4 | 1264.4 | 1280.2 | 1306.6 | |
| Jun Minimum Flow Requirement, CFS | 3/ | 3432.0 | 3036.0 | 3132.0 | 3036.0 | 3000.0 | |
| Min Jun 1-Jul 31 Outflow, KSFD | 4/ | 209.4 | 185.2 | 191.1 | 185.2 | 183.0 | |
| Min May 31 Reservoir Content, KSFD | 5/ | 1481.5 | 1387.1 | 1414.0 | 1392.4 | 1363.7 | |
| Min May 31 Reservoir Content, Feet | 6/ | 2410.1 | 2404.4 | 2406.0 | 2404.7 | 2403.0 | |
| May 31 Energy Content Curve, Feet | 7/ | 2410.1 | 2404.4 | 2406.0 | 2404.7 | 2403.0 | |
| Base Energy Content Curve, Feet | 2423.9 | | | | | | |
| Lower Limit for VECC, Feet | 2287.0 | | | | | | |
| | | | | | | | |
| 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 | 2/ | 437.0 | 462.3 | 454.8 | 460.5 | 470.0 | 409.5 |
| Jul Minimum Flow Requirement, CFS | 3/ | 3432.0 | 3036.0 | 3132.0 | 3036.0 | 3000.0 | 3000.0 |
| Min Jul 1-Jul 31 Outflow, KSFD | 4/ | 106.4 | 94.1 | 97.1 | 94.1 | 93.0 | 93.0 |
| Min Jun 30 Reservoir Content, KSFD | 5/ | 2156.7 | 2119.2 | 2129.6 | 2120.9 | 2110.3 | 2170.8 |
| Min Jun 30 Reservoir Content, Feet | 6/ | 2443.9 | 2442.1 | 2442.6 | 2442.2 | 2441.7 | 2444.6 |
| Jun 30 Energy Content Curve, Feet | 7/ | 2443.9 | 2442.1 | 2442.6 | 2442.2 | 2441.7 | 2444.6 |
| Base Energy Content Curve, Feet | 2450.1 | | | | | | |
| Lower Limit for VECC, Feet | 2287.0 | | | | | | |
| Jul 31 Energy Content Curve, Feet | | 2459.0 | 2459.0 | 2459.0 | 2459.0 | 2459.0 | 2459.0 |
| | | | | | | | |
| Jan 1-Jul 31 Forecast, -Earlybird, MAF | 8/ | 86.4 | 89.7 | 88.9 | 89.7 | 90.6 | 97.7 |
| At The Dalles -Official, MAF | | 88.9 | 88.9 | 89.7 | 89.7 | 90.6 | 97.7 |

1/ Expected Inflow Minus (95% Error & Jan 1-Date Inflow)
2/ Preceeding Line Times Line 1/
3/ Based on Power Discharge Requirements determined by 8/
4/ Cumulative Minimum Outflow (Date to July) from 3/
5/ Full Content (2487.3 KSFD) Plus Outflow Minus Inflow, (2487.3 + 4/ - 2/)
6/ Elev. from 5/ Interpolated from NWPP Storage Elev. Table
7/ Elev. From 6/, But < Base ECC, and > ECC Lower Limit
8/ Used to Calculate the power discharge requirement for 3/

Table by Hydro

Table 6

## Computation of Initial Controlled Flow
## Columbia River at The Dalles
## 1 May 1980

| | | |
|---|---|---|
| 1 May Forecast of May - August Unregulated Runoff Volume, MAF | | 67.6 |
| Less Estimated Depletions, MAF | | 1.5 |
| Less Upstream Storage Corrections, MAF | | |
| Mica | 6.1 | |
| Arrow | 5.0 | |
| Libby | 3.2 | |
| Duncan | 1.0 | |
| Hungry Horse | 0.9 | |
| Flathead Lake | 0.5 | |
| Noxon | 0.1 | |
| Pend Oreille Lake | 0.5 | |
| Grand Coulee | 2.7 | |
| Brownlee | 0.2 | |
| Dworshak | 0.6 | |
| John Day | 0.2 | |
| TOTAL | 22.5 | 22.5 |
| Forecast of Adjusted Residual Runoff Volume, MAF | | 45.1 |
| Computed Initial Controlled Flow From Chart 1 of Flood Control Operating Plan, KCFS | | 275.0 |

**Chart 1**

## Seasonal Precipitation
## Columbia River Basin
## October 79 - April 80
## Percent of 1963-77 Average

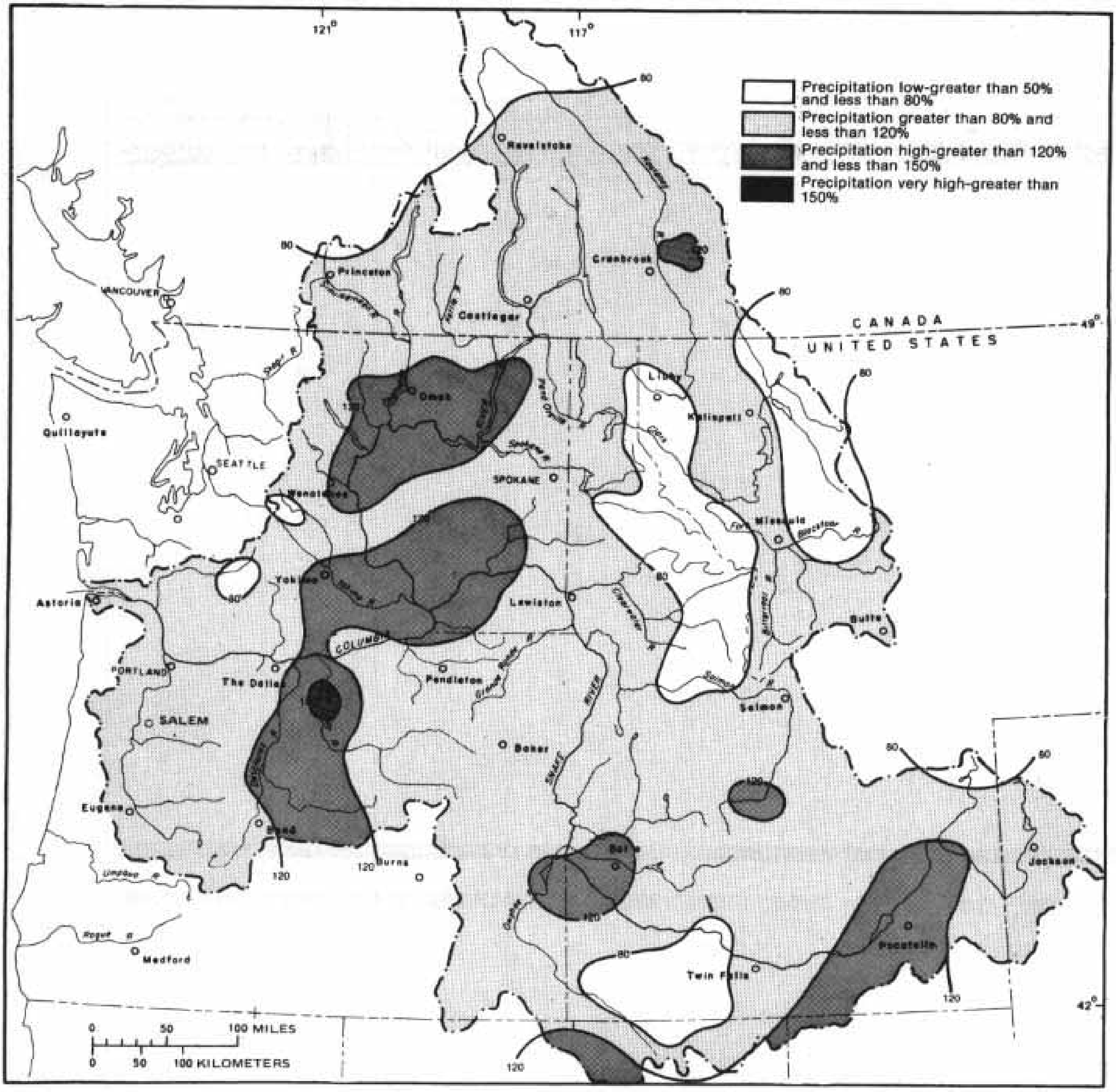


Chart 2
**Winter Season**
**Temperature and Precipitation Indexes 1979-80**
**Columbia River Basin above The Dalles**

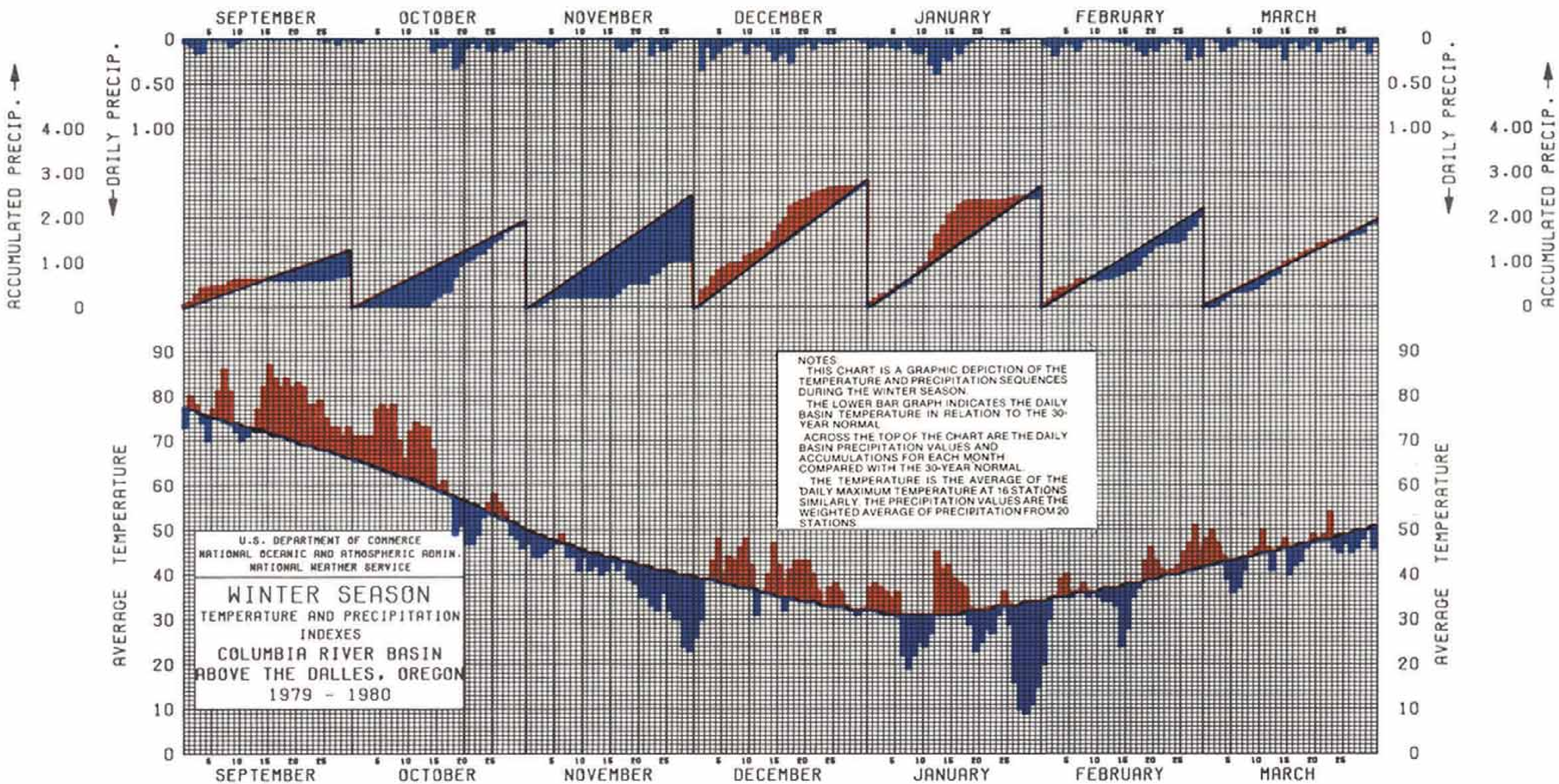
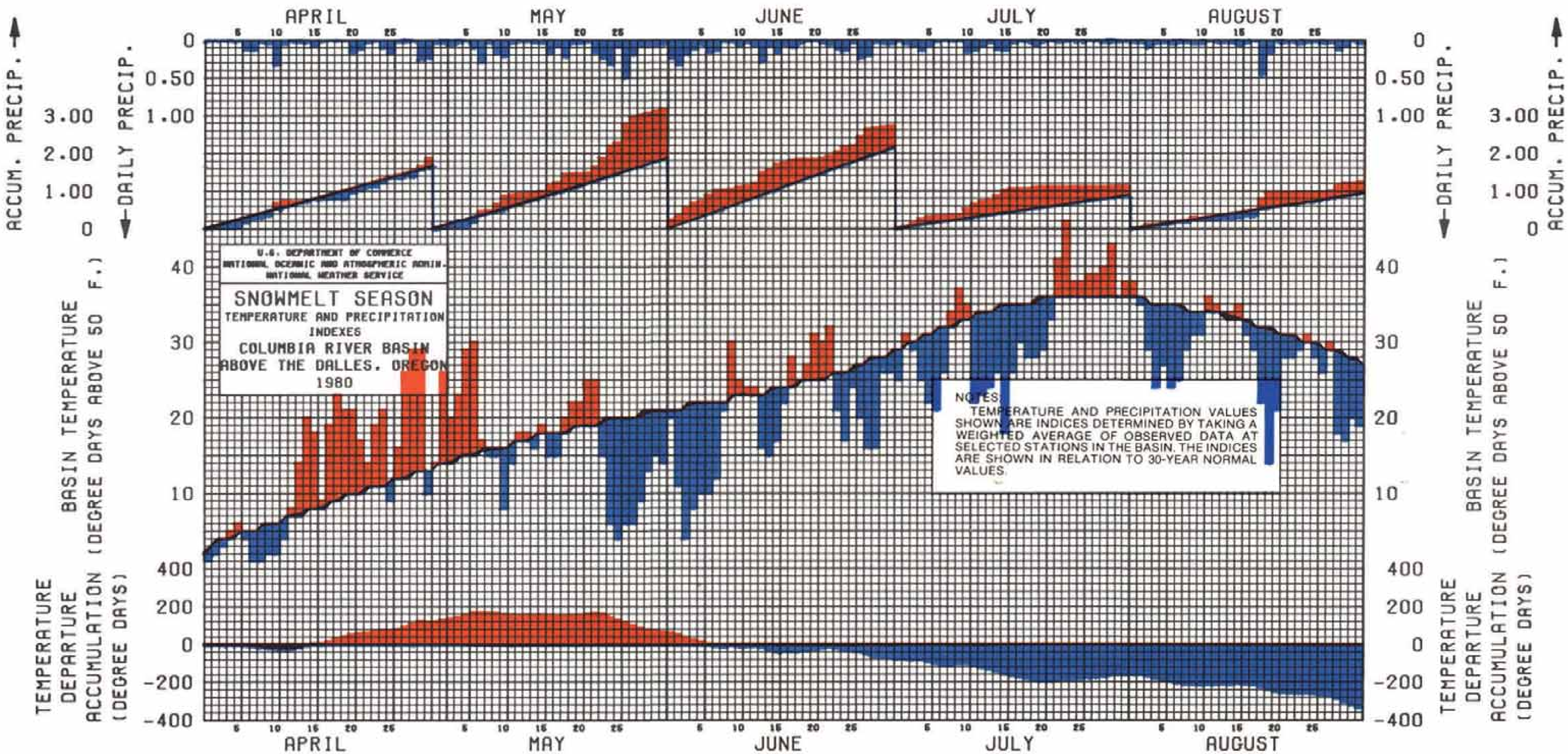
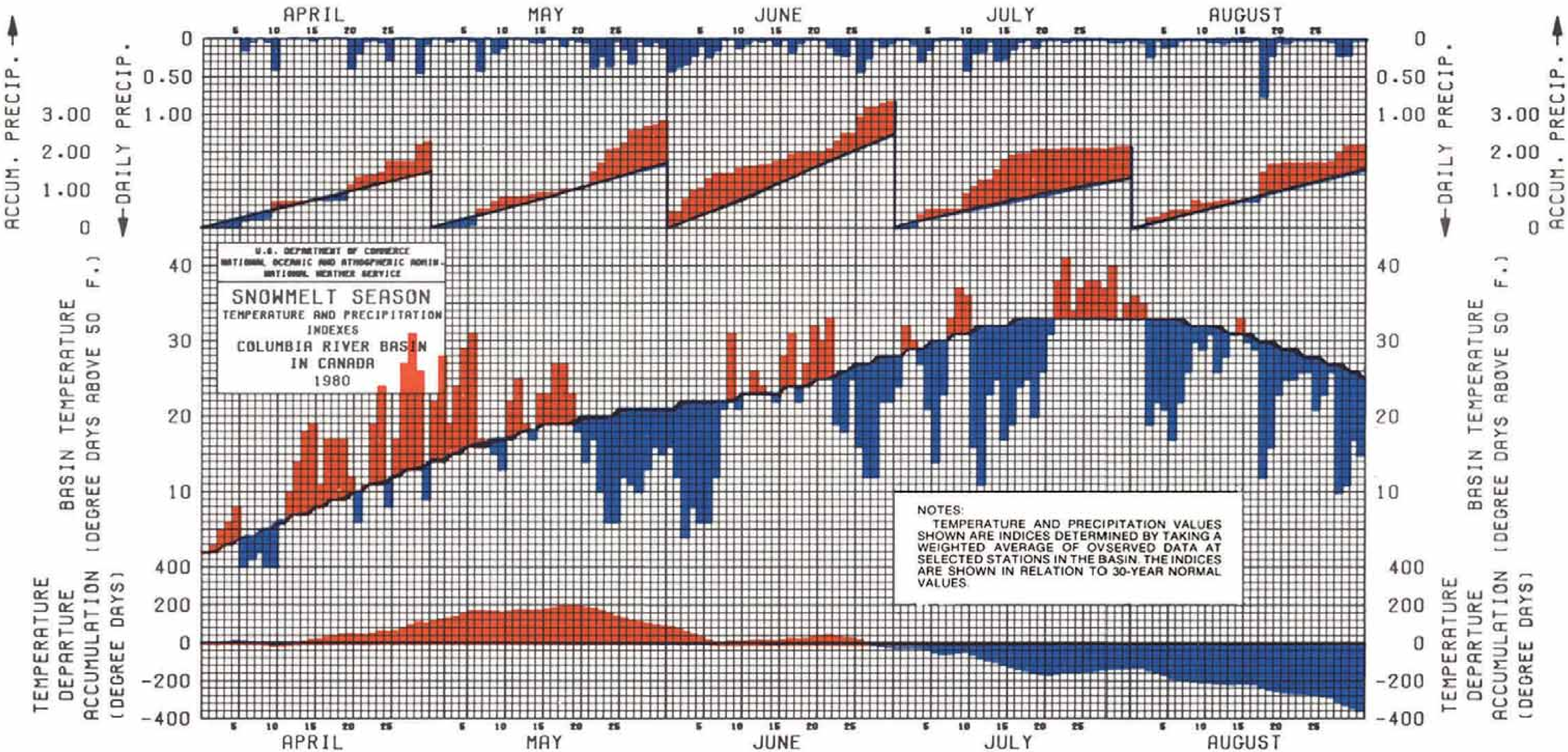


Chart 3

**Snowmelt Season**
**Temperature and Precipitation Indexes 1980**
**Columbia River Basin above The Dalles**

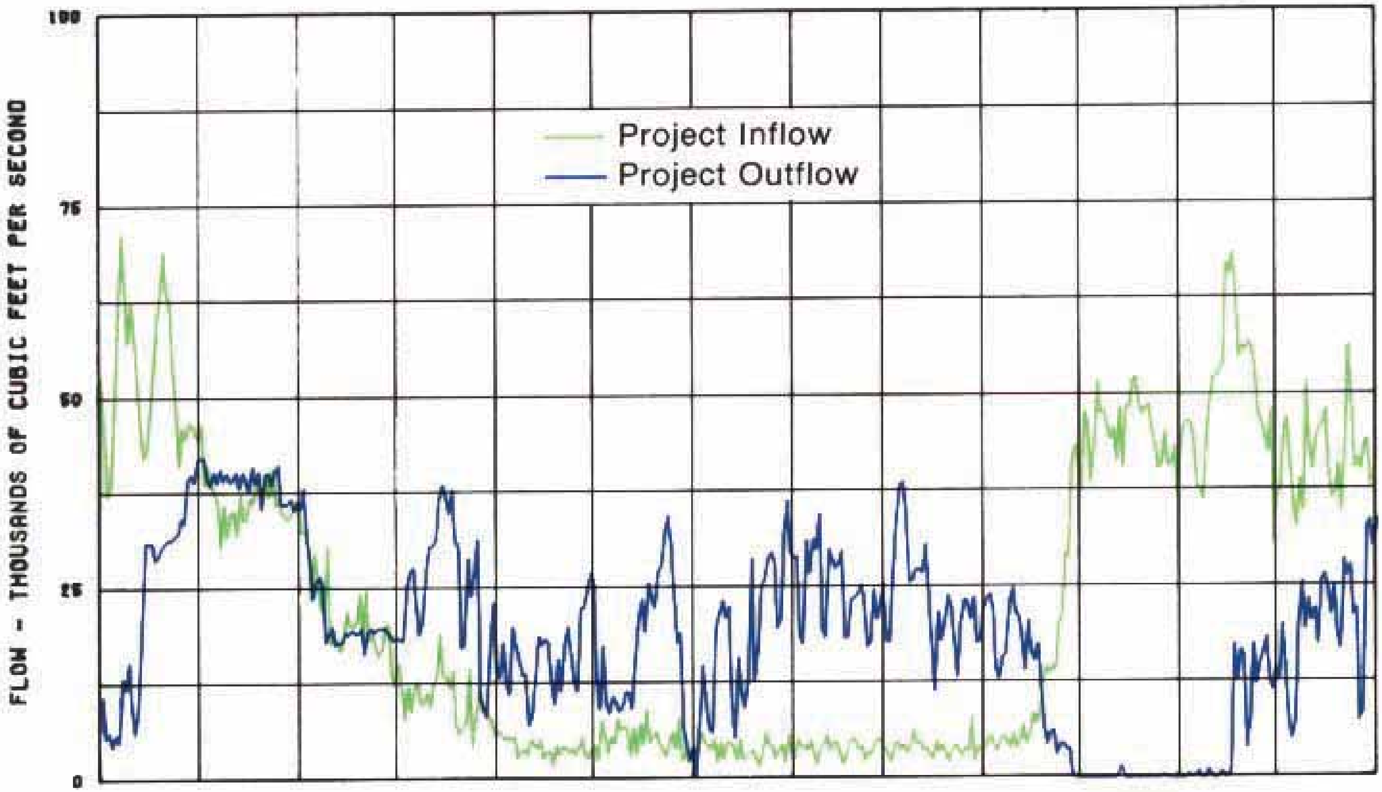


**Snowmelt Season**
**Temperature and Precipitation Indexes 1980**
**Columbia River Basin at Canada**



## Chart 5

# Regulation of Mica
# 1 July 1979 - 31 July 1980



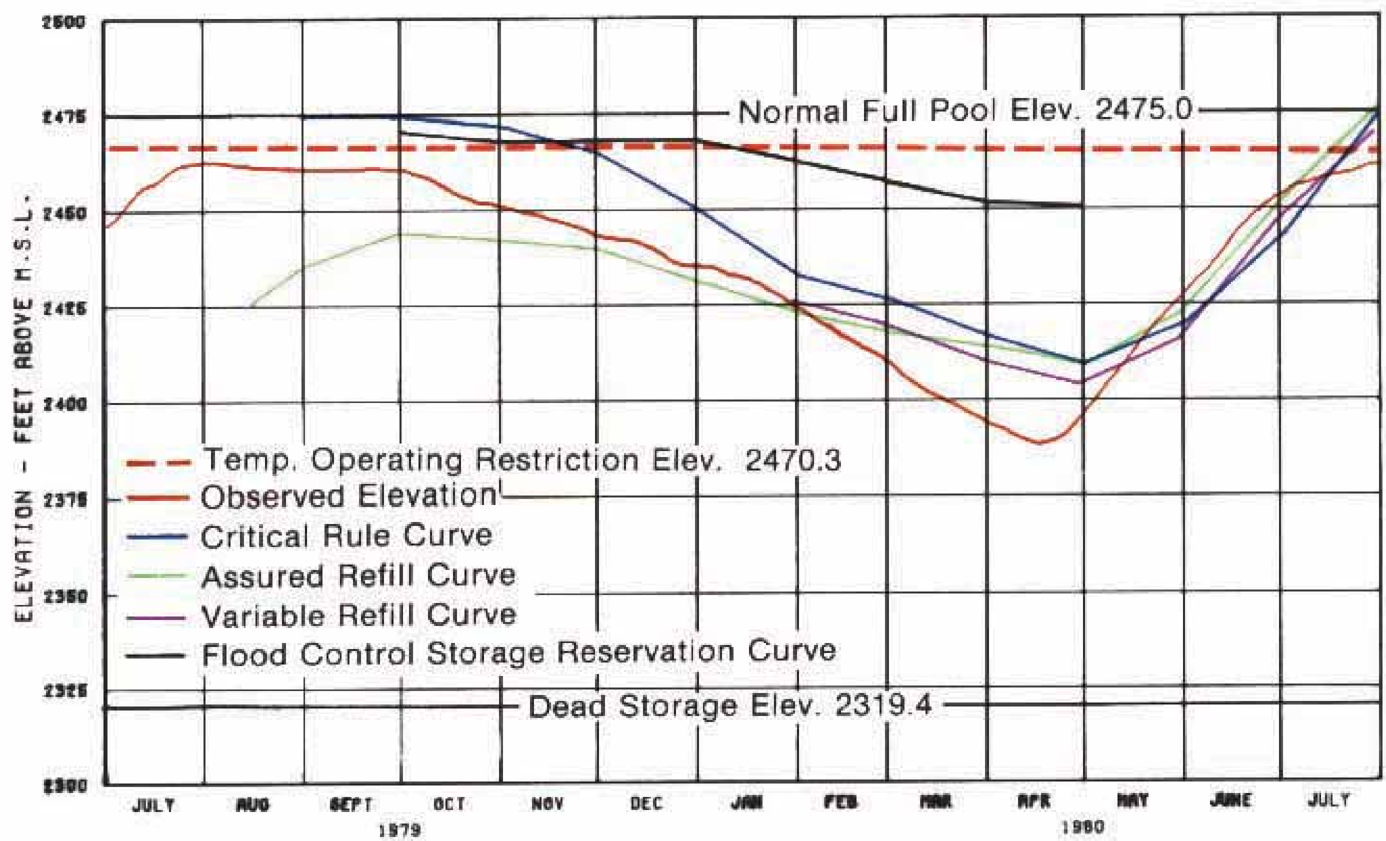
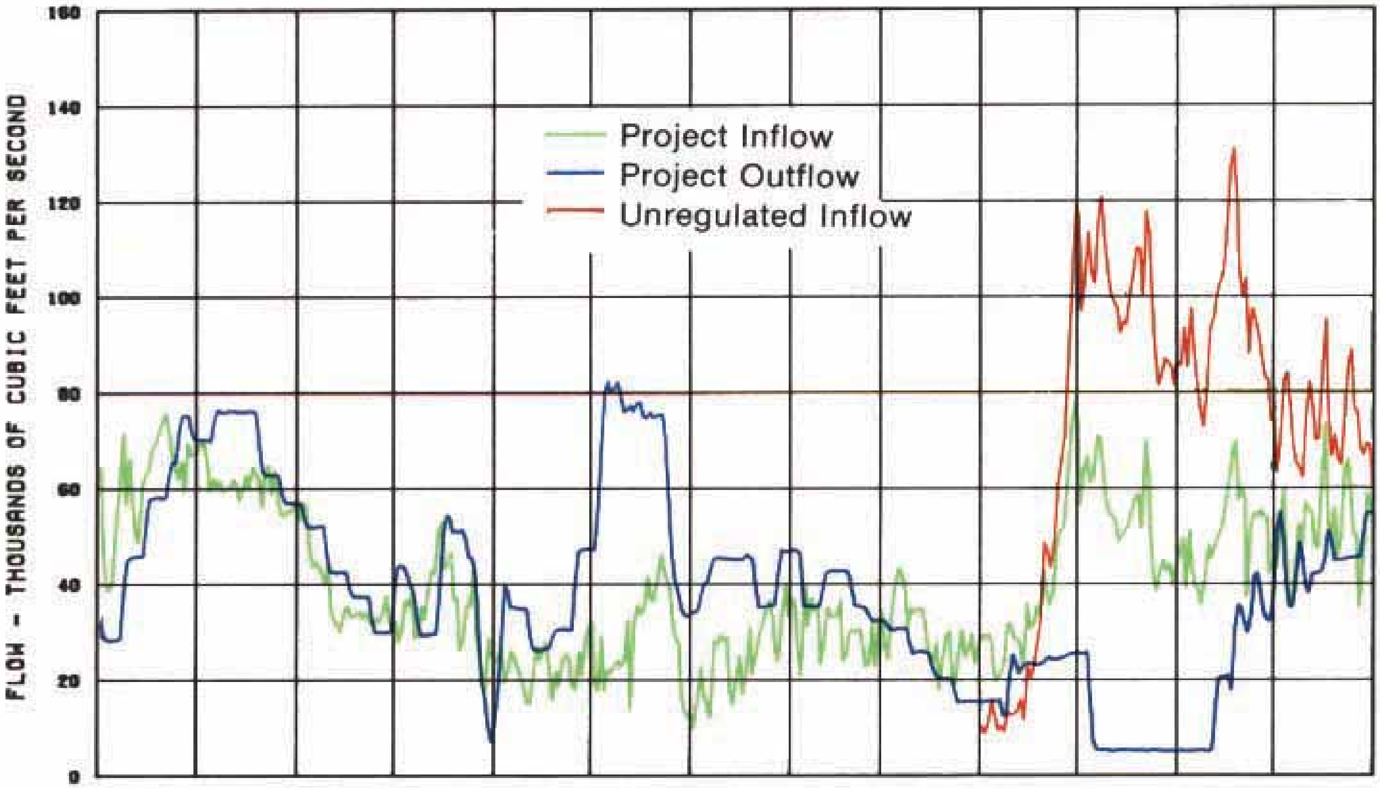
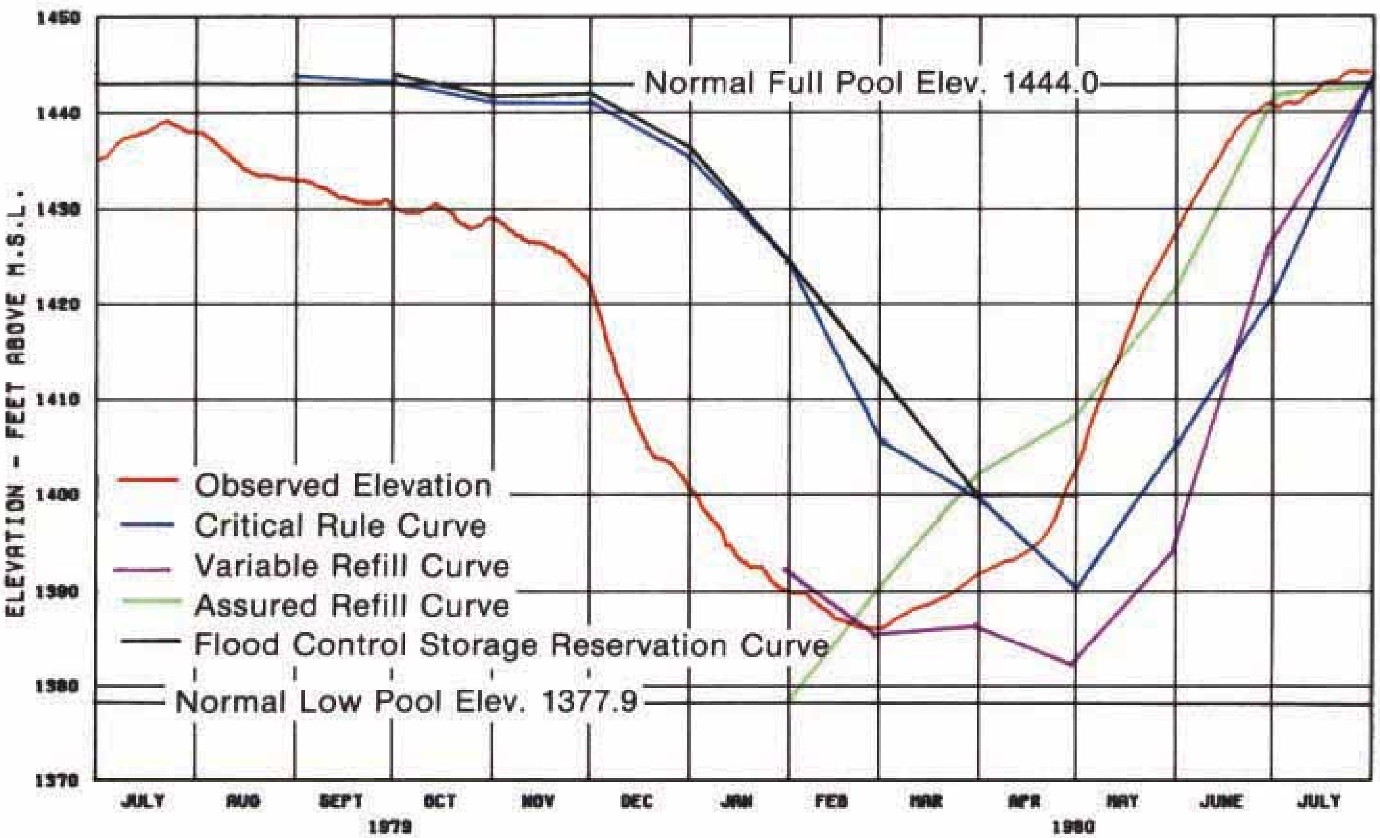



Chart 6

## Regulation of Arrow
## 1 July 1979 - 31 July 1980

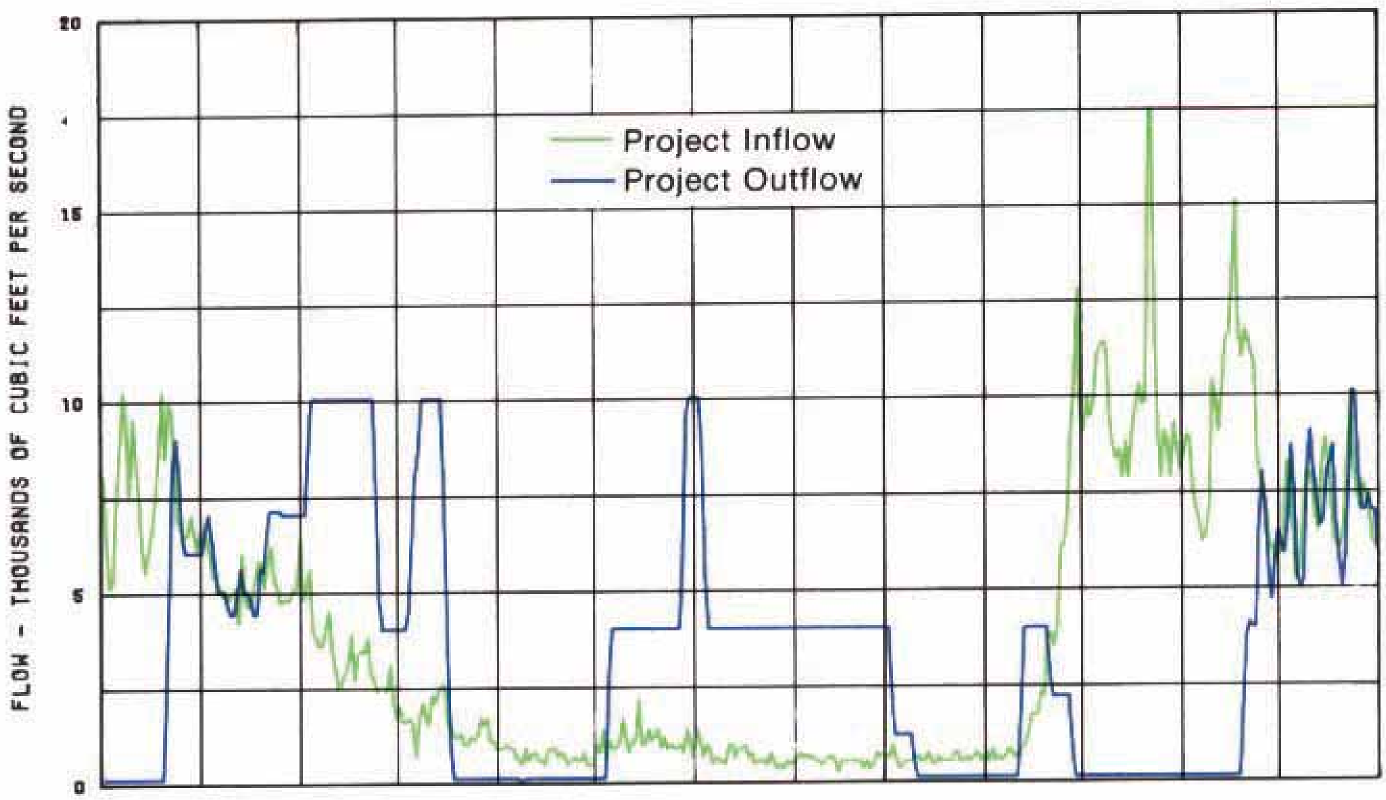



ARDB

**Chart 7**

## Regulation of Duncan
## 1 July 1979 - 31 July 1980



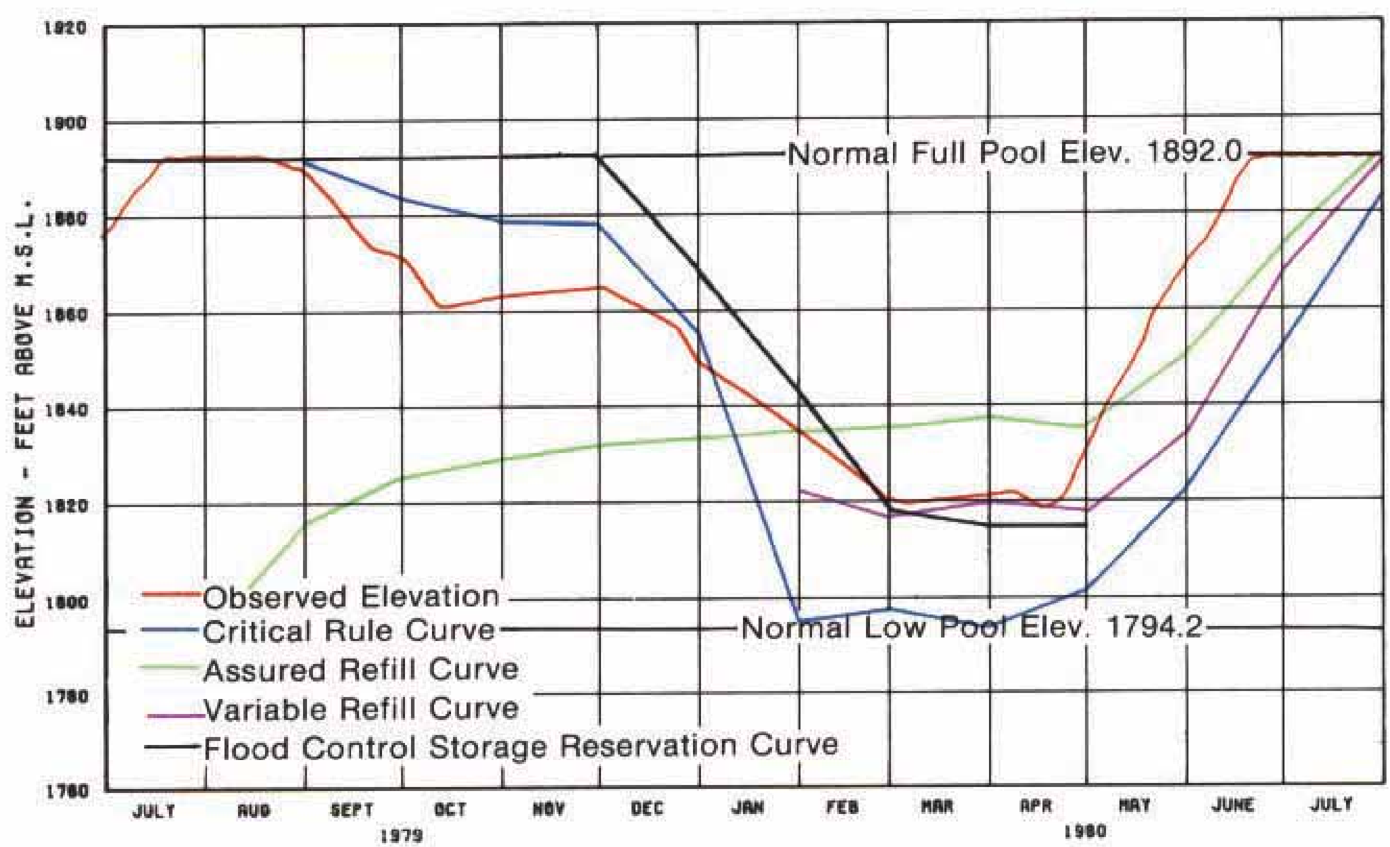



Chart 8

## Regulation of Libby
## 1 July 1979 - 31 July 1980

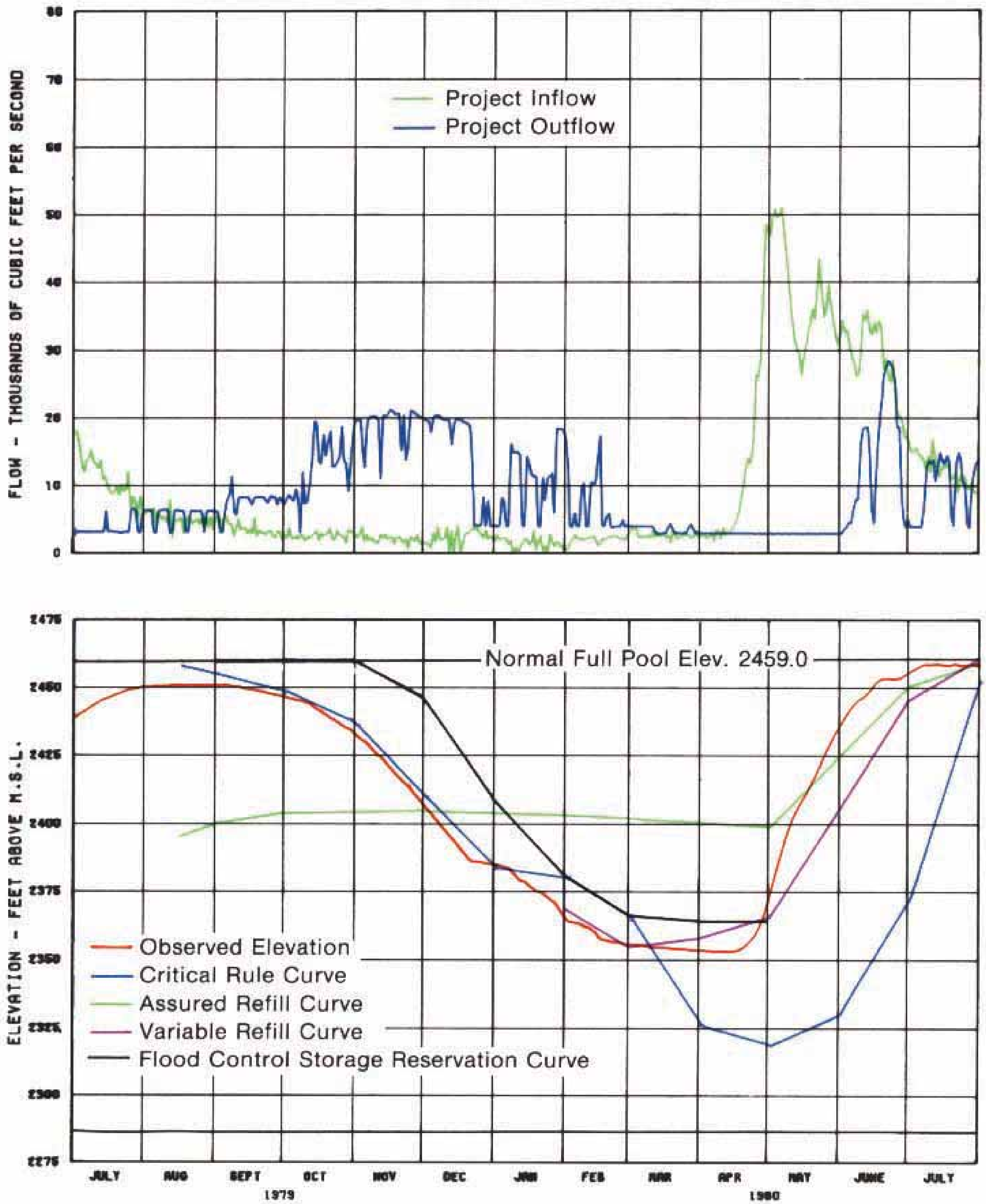
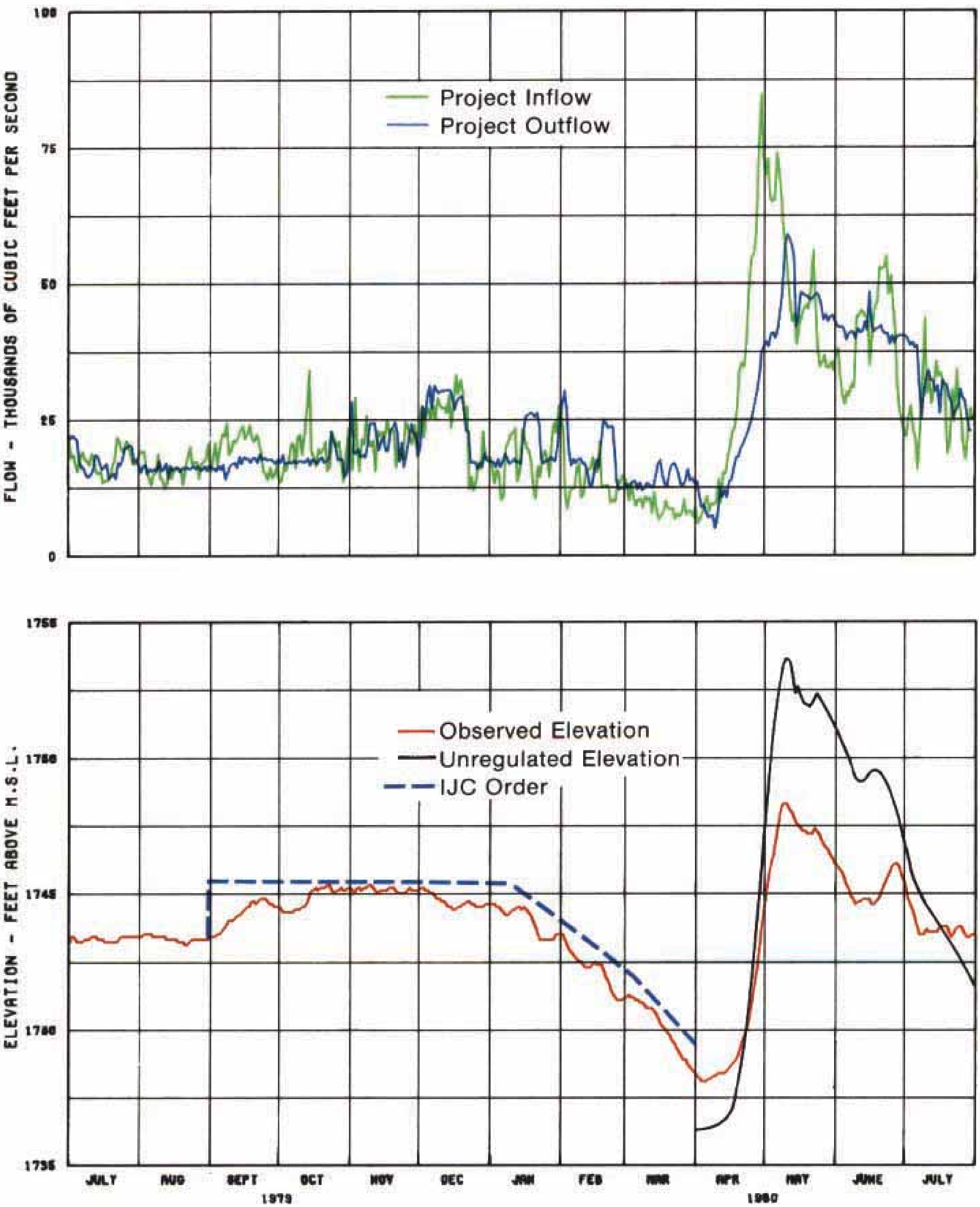


Chart 9

## Regulation of Kootenay Lake
## 1 July 1979 - 31 July 1980



## Chart 10

# Columbia River at Birchbank
# 1 July 1979 - 31 July 1980

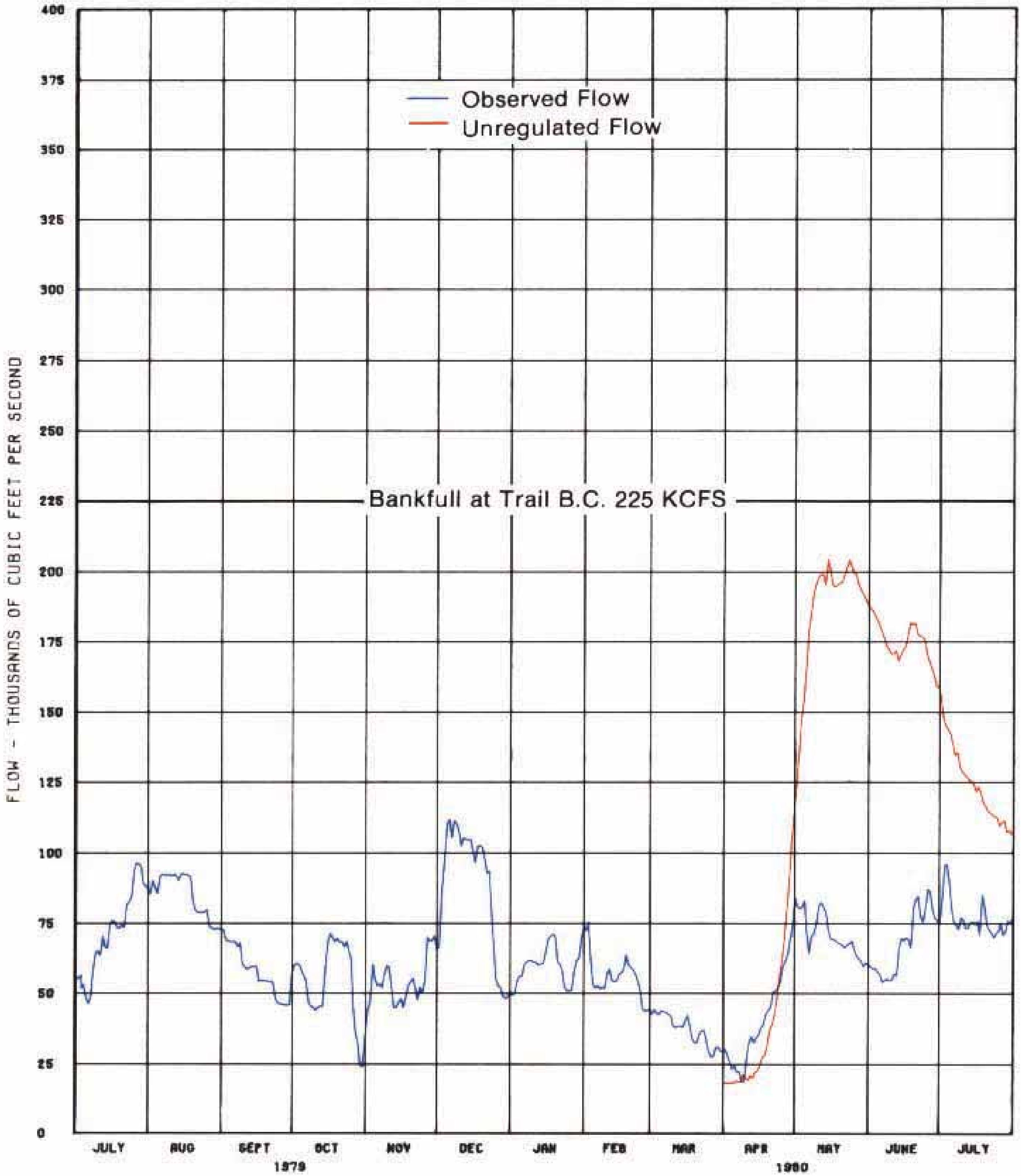
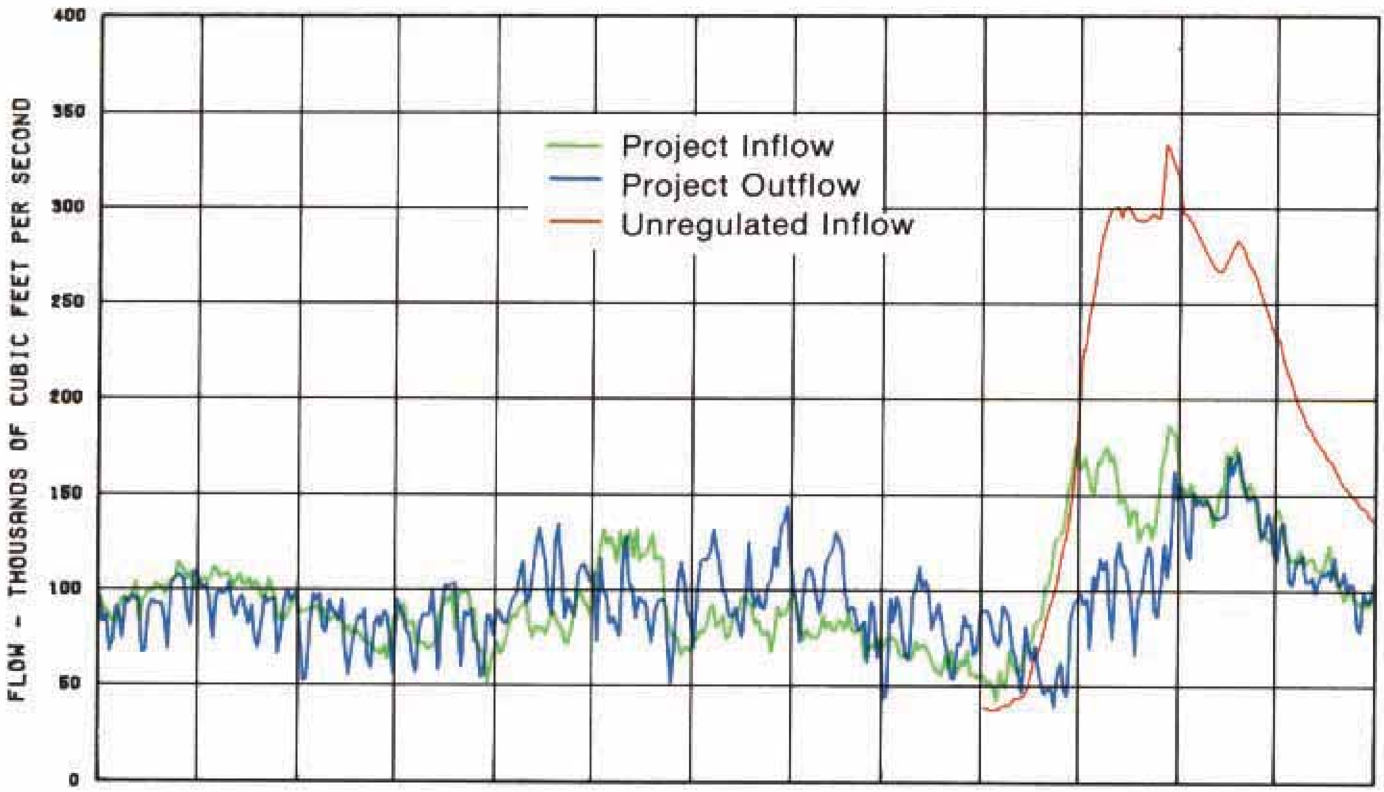


**Chart 11**

## Regulation of Grand Coulee
## 1 July 1979 - 31 July 1980



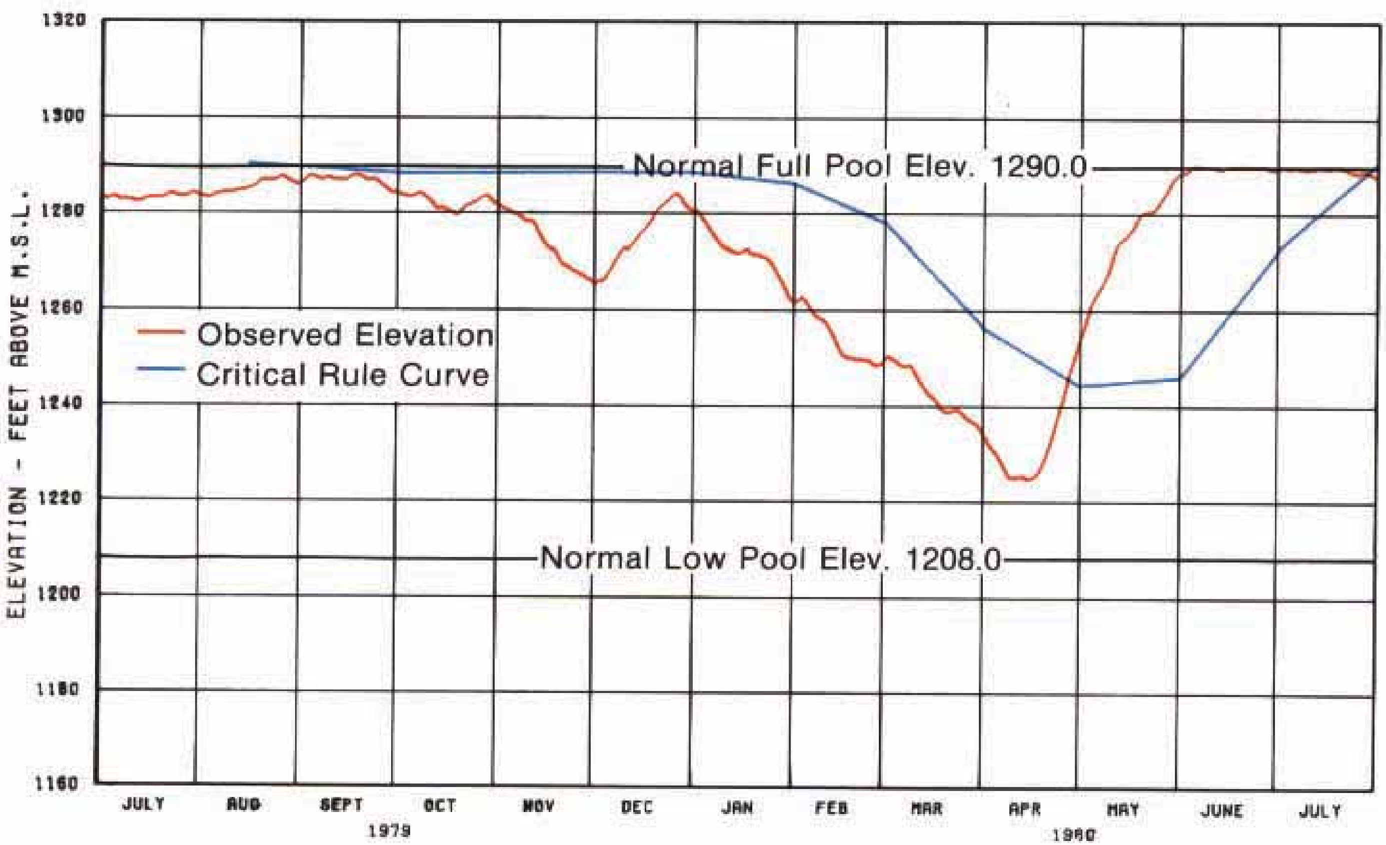



Chart 12

**Summary Hydrographs**
**Columbia River at The Dalles**
**1 July 1979 - 31 July 1980**

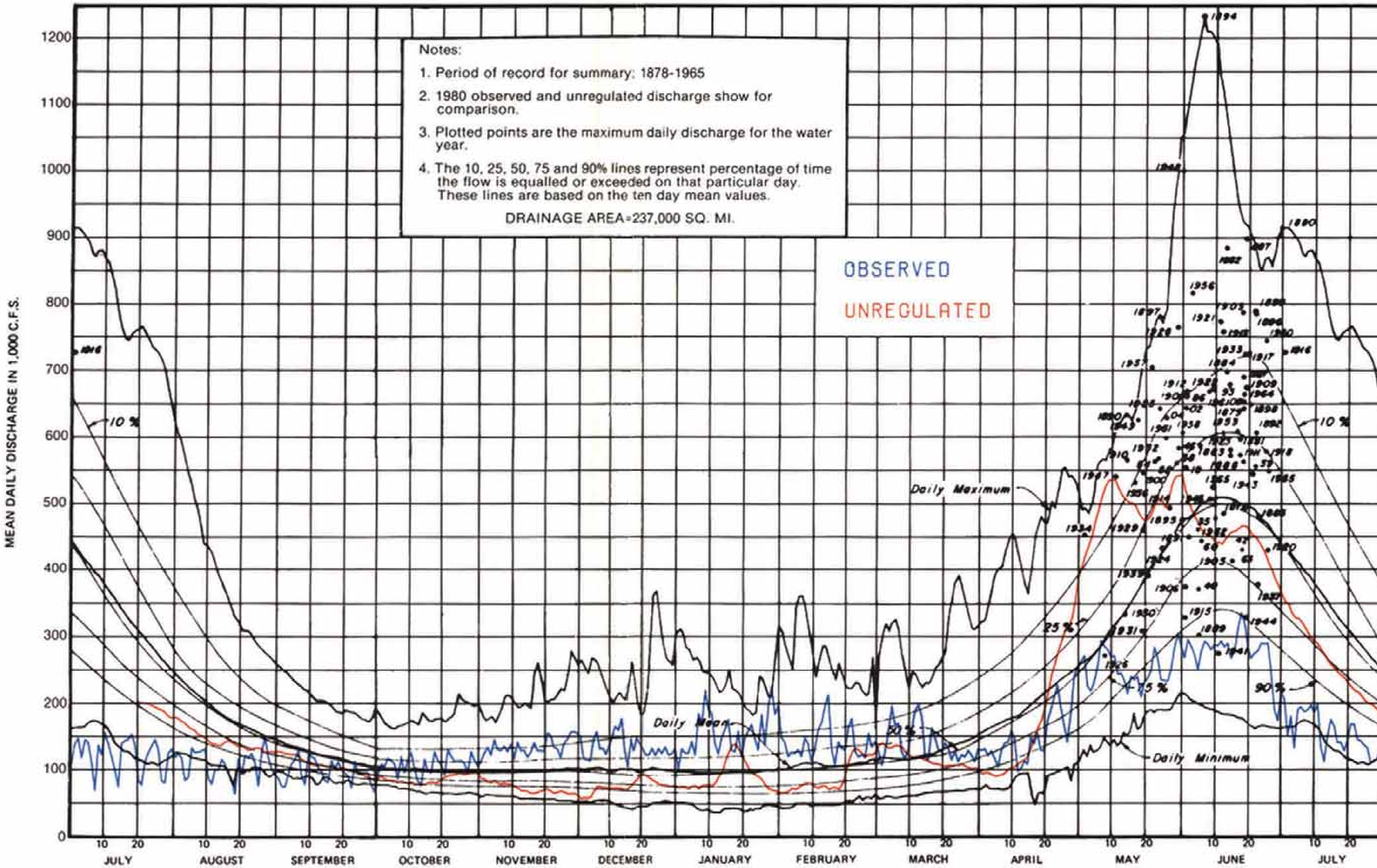


**Chart 13**

## Columbia River at The Dalles
## 1 April 80 - 31 July 1980

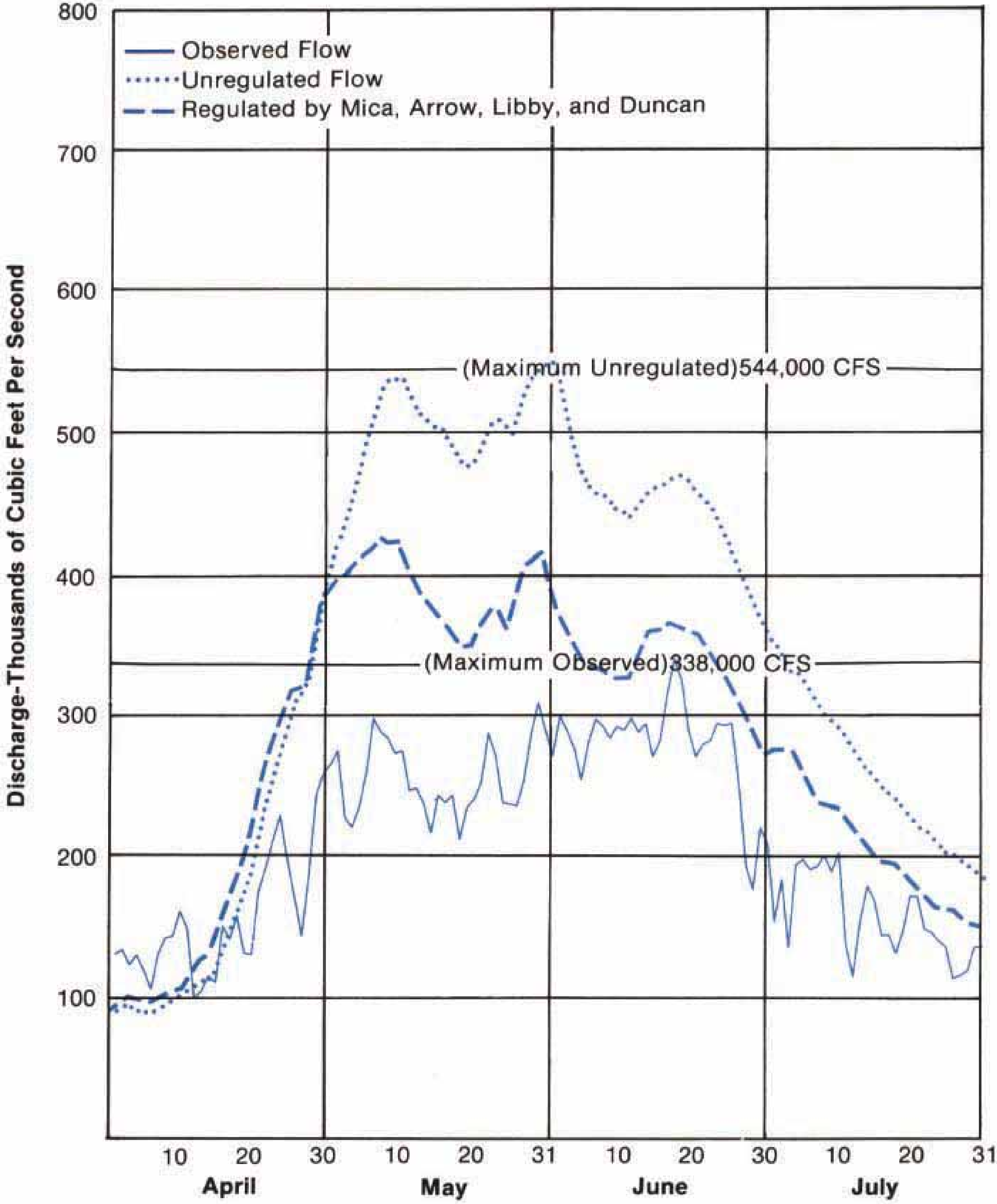
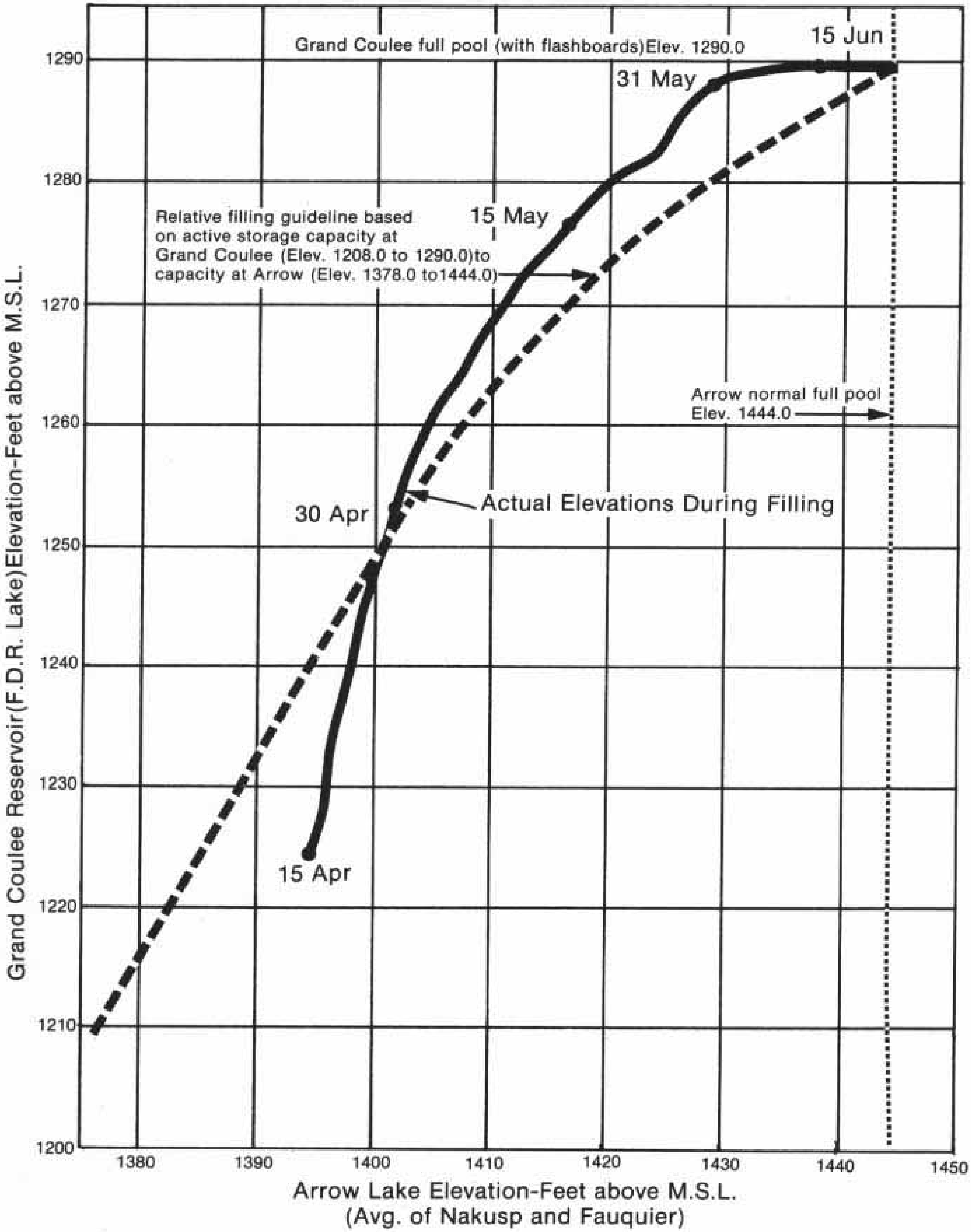


Chart 14

## 1980 Relative Filling Arrow and Grand Coulee



## REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period 1 August 1979 through 31 July 1980:


1. "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans dated 1 May 1979.

2. "Columbia River Treaty Hydroelectric Operating Plan - Assured Operating Plan for Operating Year 1979-80", dated September 1974.

3. "Detailed Operating Plan for Columbia River Treaty Storage - 1 August 1979 through 31 July 1980", dated September 1979.

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