REPORT

OF

COLUMBIA RIVER TREATY

CANADIAN AND UNITED STATES ENTITIES

for the period

1 October 1971

to

30 September 1972

October 1972

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## INTRODUCTION

This report describes the joint actions of the Canadian and United States Entities during the period 1 October 1971 to 30 September 1972, in discharging their responsibility for formulating, and carrying out, operating arrangements necessary to implement the Columbia River Treaty.

Previous reports on this subject are:-

| Period Covered | Date of Report |
|---|---|
| 16 September 1964 to 30 September 1967 | 22 April 1968 |
| 1 October 1967 to 30 September 1968 | January 1969 |
| 1 October 1968 to 30 September 1969 | April 1970 |
| 1 October 1969 to 30 September 1970 | December 1970 |
| 1 October 1970 to 30 September 1971 | October 1971 |

## ORGANIZATION AND MEETINGS

The names of the members of the two Entities and their representatives are shown in Appendix A.

During the period 1 October 1971 to 30 September 1972, the

Canadian and United States Entities held two regular meetings and Canadian Entity representatives and the United States Co-ordinators met on six occasions.

The two international committees, listed in Appendix B, which were established effective 19 September 1968, continued their work. These two committees directed and coordinated studies with the support of the staffs of B.C. Hydro and Power Authority, Bonneville Power Administration and the U.S. Corps of Engineers, North Pacific Division.

The Entities received reports and recommendations on operating procedures, facilities and other matters essential to Columbia River Treaty implementation from the international committees. Where necessary, formal agreement on various items was reached by the Entities and Appendix C lists these official agreements reached and recorded during the period of this report.

## CONSTRUCTION OF THE TREATY STORAGE PROJECTS

Construction work on Mica and Libby proceeded on schedule during the year. Two Columbia Construction Progress reports, Nos. 23 and 24, were issued by B.C. Hydro and Power Authority on the construction of Mica and the Division Engineer, North Pacific Division, Corps of Engineers, U.S. Army, issued reports Nos. 8 and 9 on the progress of construction of the Libby dam project.

Because these reports give a detailed description of the construction achieved on the projects during this period, it is not considered necessary to repeat the information in this report.

The procurement and preparation of the land required for that portion of the Libby reservoir in Canada is a responsibility of the Government of the Province of British Columbia.

All the necessary clearing, acquisition and relocation of roads and highways are proceeding according to schedule and no difficulties are envisaged in completing this work before the Libby reservoir reaches the normal full pool elevation of 2459 feet.

## COLUMBIA STORAGE OPERATION - OPERATING ARRANGEMENTS

During the period covered by this report, Duncan, Arrow and Libby reservoirs were operated for power and flood control.

During this reporting year the Canadian entitlement to downstream power benefits from Duncan and Arrow had been purchased by the Columbia Storage Power Exchange and transferred and assigned to the Bonneville Power Administration. The United States Entity delivered capacity and energy to the C.S.P.E. participants in accordance with the Canadian Entitlement Exchange Agreement dated 13 August 1964.

The operation of the storages was generally in accordance with:

(a) "Hydroelectric Operating Plans for Canadian Storage during the Operating Years 1969-70 through 1974-75", dated 15 February 1969, and the amendment thereto dated September 1969.

(b) "Columbia River Treaty Detailed Operating Plan for Canadian Storage - 1 July 1971 through 31 July 1972", dated 19 August 1971.

(c) "Detailed Operating Plan for Columbia River Treaty Storage - 1 July 1972 through 31 July 1973", dated 19 September 1972.

(d) "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", dated November 12, 1968.

Attached to this report as Appendix D is "Report on Operation of Columbia River Treaty Projects - 1 August 1971 through 31 July 1972", dated October 1972, which gives a detailed description of the operation of the Treaty storages for the first ten months of the 12-month period of this report. This report also describes in detail the run-off conditions prevailing and the reservoir regulation during the year.

The run-off conditions were somewhat abnormal and affected the way in which the Treaty projects were operated. The streamflows during the period 1 October 1971 to 31 December 1971 were about median but increased during the period January to August 1972 to well above median flows. In general the snow accumulation proved to be one of the largest of record and the largest in this century. The large snowpack coupled with the fairly rapid melt resulted in the second largest unregulated run-off in the period of record. However, the reservoir regulation reduced the flows measured at The Dalles, Oregon, to 618,000 cfs.

A brief description follows of the operation of the Duncan, Arrow and Libby reservoirs during the period 1 October 1971 to

30 September 1972.

Duncan

On 1 October 1971, the Duncan reservoir was at the full pool elevation of 1892 feet and continued at this elevation until the first week in November when the drafting of the reservoir commenced. The Duncan reservoir was drafted to its minimum flood control elevation at the end of February. The filling of the reservoir commenced on 5 May 1972 and the normal full pool elevation of 1892 feet was reached by 27 July 1972 and was maintained at this elevation through the end of September.

Arrow

On 1 October 1971, the Arrow reservoir was at approximately elevation 1444 feet and was drawndown to approximately elevation 1440 feet by the end of October. Drafting of Arrow Lakes to near its minimum elevation was completed in early February.

The filling of the reservoir was commenced on 4 May 1972 and reached elevation 1444 feet on 19 July 1972. Thereafter, filling continued to reach elevation 1446 feet on 23 July 1972. This additional 2 feet of storage was made in accordance with the agreement dated May 9, 1972 between B.C. Hydro and Power Authority and the Bonneville Power Administration, for the purpose of assisting in the future filling of Mica reservoir.

This additional storage was released starting in mid-September and elevation 1444 feet was reached at the end of the month. The releases of this extra storage did not conflict with the requirements of the Detailed Operating Plan.

Libby

The Libby project closure was made on 21 March 1972. This was in advance of the scheduled 1st April date of closure because of exceptionally high inflows. Outflow from the project was maintained at 2,000 cfs through the temporary sluice until 31 March 1972. On this date the final temporary sluice was closed and the project began passing free flow through the three permanent sluices.

Libby reservoir storage was filled to the spillway crest elevation of 2405 feet by 1 August 1972 and drafting of the reservoir began in early September. It is planned to draft Libby reservoir to elevation 2230 feet as rapidly as possible consistent with certain limiting drawdown rates and consistent with the requirements of the I.J.C. Order for Kootenay Lake.

A Board of Consultants for the Corps of Engineers made an inspection of a potential slide area in the reservoir and as a result recommended its drawdown to permit placement of a rock buttress on the left abutment.

## OPERATING COMMITTEE ACTIVITIES

The work carried out in the year 1971/71 on the Assured Operating for the year 1976/77 was finalized in March 1972 by the

Entities signing an agreement in March 1972 on the Plan and corresponding Downstream Power Benefits.* The main reason for the delay was the complexity of the studies to determine optimum generation in Canada and optimum generation in the United States. Because of the difficulties of interpretation of Annex A, paragraph 7 of the Treaty, the Entities agreed on procedures set out in the document "Operating Plans with Mica Generation", dated 15 November 1971. This requires at least eight studies to be made which is very time consuming. The procedure will be incorporated in the "Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans" when it is next revised.

In accordance with its terms of reference the Operating Committee was responsible throughout the year for implementing the current hydroelectric and flood control operating plans for the storage provided in Canada under the Columbia River Treaty. This aspect of the Committee's work is described in Appendix D, "Report on Operation of Columbia River Treaty Projects", dated October 1972.

During the year the Operating Committee carried out work on the Assured Operating Plan for the year 1977/78. The work required for this Operating Plan took an unusually long period of time to complete because of the complexities concerned with operating four units of the Mica generating plant for the first time and the requirement of producing optimum power generation in both Canada and downstream in the

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* See Appendix C, Items 1 and 2

United States. Seven different regulation studies were required and in some instances three or four variations were needed to determine an optimum generation. Although most of the work has been completed it will probably not be until November 1972 before an agreement is signed on this subject between the Entities.

During this period of reporting the work on the Detailed Operating Plan for the 1972-73 operating year was completed but the Entities have yet to sign an agreement on this. There was a delay in preparing the Plan because of a change in the construction schedule for the third powerhouse at Grand Coulee which resulted in the deep storage draft being delayed for one year. The Detailed Operating Plan had, therefore, to be modified to incorporate adjustments of the Grand Coulee and Arrow storage regulations.

Up to the present the Flood Control Operating Plan which has been in operation has been the "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", dated November 12, 1968. During the year the Corps of Engineers prepared a draft of the "Columbia River Treaty Flood Control Operating Plan" dated September 1972, on which discussions were held with the United States and Canadian Entities. The final version of this document is expected to be ready in October when it will be considered by the Entities.

The Committee continued with the studies of the filling of Mica reservoir. The last report on this subject was an addendum, dated 8 September 1971, to the original report "The Initial Filling of Mica Reservoir", dated September 1970. These studies are being up-dated each year to take account of the changing conditions with respect to loads and resources and a new report on this subject is expected to be available later in 1972.

The Operating Committee was also engaged in the preparation of "Report on Operation of Columbia River Treaty Projects", dated October 1972, which is Appendix D to this report.

An International Task Force has been appointed by the Entities to study the possibility of the gains which might be made through the electrical coordination of the interconnected systems in the Pacific Northwest in the United States and the interconnected systems in British Columbia. The first objectives of the Task Force will be to establish the principles for the coordination and to develop the scope of the studies.

## HYDROMETEOROLOGICAL COMMITTEE ACTIVITIES

Some of the work undertaken by the Hydrometeorological Committee in the year ended 30 September 1971 was finalized during the year 1971-72 as follows:

(a) "Plan for Exchange of Operational Hydrometeorological Data", dated 9 November 1971, which superseded an earlier Plan dated 28 May 1969. The Permanent Engineering Board concurred with the Plan on 22 February 1972 and an agreement was signed by the Entities on 28 March and 10 April 1972*.

(b) "Columbia River Treaty Hydrometeorological System - Treaty Facilities", dated November 1971, which superseded the earlier Recommendation dated October 1970. The Permanent Engineering Board concurred with the Recommendation on 22 February 1972 and an agreement was signed by the Entities on 28 March and 10 April 1972*.

(c) "Columbia River Treaty Hydrometeorological Supporting Facilities", dated November 1971, was sent for information to the Permanent Engineering Board on 15 December 1971.

The Corps of Engineers completed arrangements with the Water Resources Service, Government of British Columbia, for the snow pillow installation at Moyie Mountain in Canada. This station is operating satisfactorily.

The gauge at Fort Steele was completely destroyed during June of this year. Water Survey of Canada plans to replace the gauge as soon as possible. However, some right-of-way difficulties are being encountered. In the interim a manual gauge is being operated.

The Corps of Engineers made three snow flights from each of their District offices in Seattle and Walla Walla. The Seattle District, 4 - 5 May flight showed snow covered areas ranging from 46 to 86 percent.

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* See Appendix C, Items 3 & 4.

The 24 - 26 May flight showed from 22 to 76 percent snow cover. The flight on 8 - 9 June showed 10 to 56 percent cover. Because of adverse weather, the Walla Walla District snow flight of 31 March covered only the Lower Snake River reach and showed snow cover ranging from 15 to 80 percent. Adverse weather delayed the next Walla Walla District flight to 3 - 4 May, showing snow cover from 20 to 70 percent. The last Walla Walla flight was on 26 - 27 May and showed snow coverage from 20 to 45 percent.

One aerial snowline survey was conducted over the Canadian portion of the Columbia Basin on June 8 and 9, 1972. Snowline elevations ranged from about 4,000 feet in the northern valleys to a maximum of 6,600 near Kimberley in the Kootenay Valley. In general snowline elevations for this date were close to 1,000 feet lower than the average of the last three years. Further evidence for the very high snow accumulation this year were numerous new snow slides and mud slides. Many areas showed flooding as this survey coincided closely to the time of maximum runoff.

## COOPERATION WITH PERMANENT ENGINEERING BOARD

The Entities continued cooperating with the Permanent Engineering Board in the discharge of its functions and a joint meeting of the Permanent Engineering Board and the Entities was held on 17 November 1971 in Portland.

Semi-annual reports were forwarded by the Entities to the Board covering the period 1 October 1971 to 31 March 1972 and 1 April 1972 to 30 September 1972.

In addition, the construction progress reports - B.C. Hydro's Reports Nos. 23 and 24 on Mica, and the Corps of Engineers' Reports Nos. 8 and 9 on Libby, were supplied to the Permanent Engineering Board.

Copies of the "Runoff Volume Forecast Program for Treaty Reservoirs" were sent to the United States Section of the Permanent Engineering Board.

Copies of the agreements shown in Appendix C were sent to the Board.

## COLUMBIA RIVER TREATY ENTITIES

### CANADA

THE HON. R.G. WILLISTON
CHAIRMAN

Director
British Columbia Hydro and
Power Authority
Vancouver, B.C.

### UNITED STATES OF AMERICA

MR. HENRY R. RICHMOND
CHAIRMAN

Administrator
Bonneville Power Administration
Department of the Interior
Portland, Oregon.

MAJOR-GENERAL K.T. SAWYER
Division Engineer
North Pacific Division
Corps of Engineers, U.S. Army
Portland, Oregon.

### Canadian Entity Representatives

MR. W.D. KENNEDY

Manager
Canadian Entity Services
British Columbia Hydro and
Power Authority
Vancouver, B.C.

### United States Entity Coordinators

MR. BERNARD GOLDHAMMER
COORDINATOR

Asst. Administrator for Power
Management
Bonneville Power Administration
Portland, Oregon.

MR. GORDON FERNALD, Jr.
COORDINATOR

Chief, Engineering Division
North Pacific Division
Corps of Engineers, U.S. Army
Portland, Oregon.

MR.H. KROPITZER
SECRETARY

Executive Assistant to the Administrator
Bonneville Power Administration
Portland, Oregon.

APPENDIX B

## COLUMBIA RIVER TREATY

## INTERNATIONAL COMMITTEES

The official membership of the two International Committees for the year 1 October 1971 to 30 September 1972, was as follows:

| | Canadian Section | United States Section |
|---|---|---|
| COLUMBIA RIVER TREATY OPERATING COMMITTEE | P.R. Purcell (Chairman) | C.E. Hildebrand (Co-Chairman)(1) |
| | D.R. Forrest | D.M. Rockwood(1) |
| | W.E. Kenny | H.M. McIntyre (Co-Chairman)(2) |
| | | C.W. Blake(2) |
| COLUMBIA RIVER TREATY HYDROMETEOROLOGICAL COMMITTEE | P.R. Purcell (Chairman) | F.A. Limpert (Chairman)(2) |
| | U. Sporns | D.M. Rockwood(1) |

All Canadian Committee members represent B.C. Hydro and Power Authority. United States Committee members represent (1) United States Corps of Engineers, or (2) Bonneville Power Administration.

APPENDIX C

# COLUMBIA RIVER TREATY

## OFFICIAL AGREEMENTS OF THE ENTITIES

## 1 OCTOBER 1971 - 30 SEPTEMBER 1972

| Item No. | Date Agreement Signed by Entities | Description |
|---|---|---|
| 1. | 16 & 21 March 1972 | Columbia River Treaty Hydroelectric Operating Plan - Assured Operating Plan for Operating Year 1976-77, dated January 1972. |
| 2. | 16 & 21 March 1972 | Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1976-77, dated January 31, 1972. |
| 3. | 28 March & 10 April 1972 | Plan for Exchange of Operational Hydromet. Data, dated November 9, 1971 |
| 4. | 28 March & 10 April 1972 | Columbia River Treaty Hydrometeorological System Treaty Facilities, dated November 1971. |

APPENDIX D

"Report on Operation of Columbia River Treaty Projects
1 August 1971 through 31 July 1972"

dated October 1972

ATTACHED

# REPORT ON OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1971 THROUGH 31 JULY 1972


COLUMBIA RIVER TREATY OPERATING COMMITTEE

OCTOBER 1972

REPORT ON

OPERATION OF COLUMBIA TREATY PROJECTS

1 AUGUST 1971 THROUGH 31 JULY 1972

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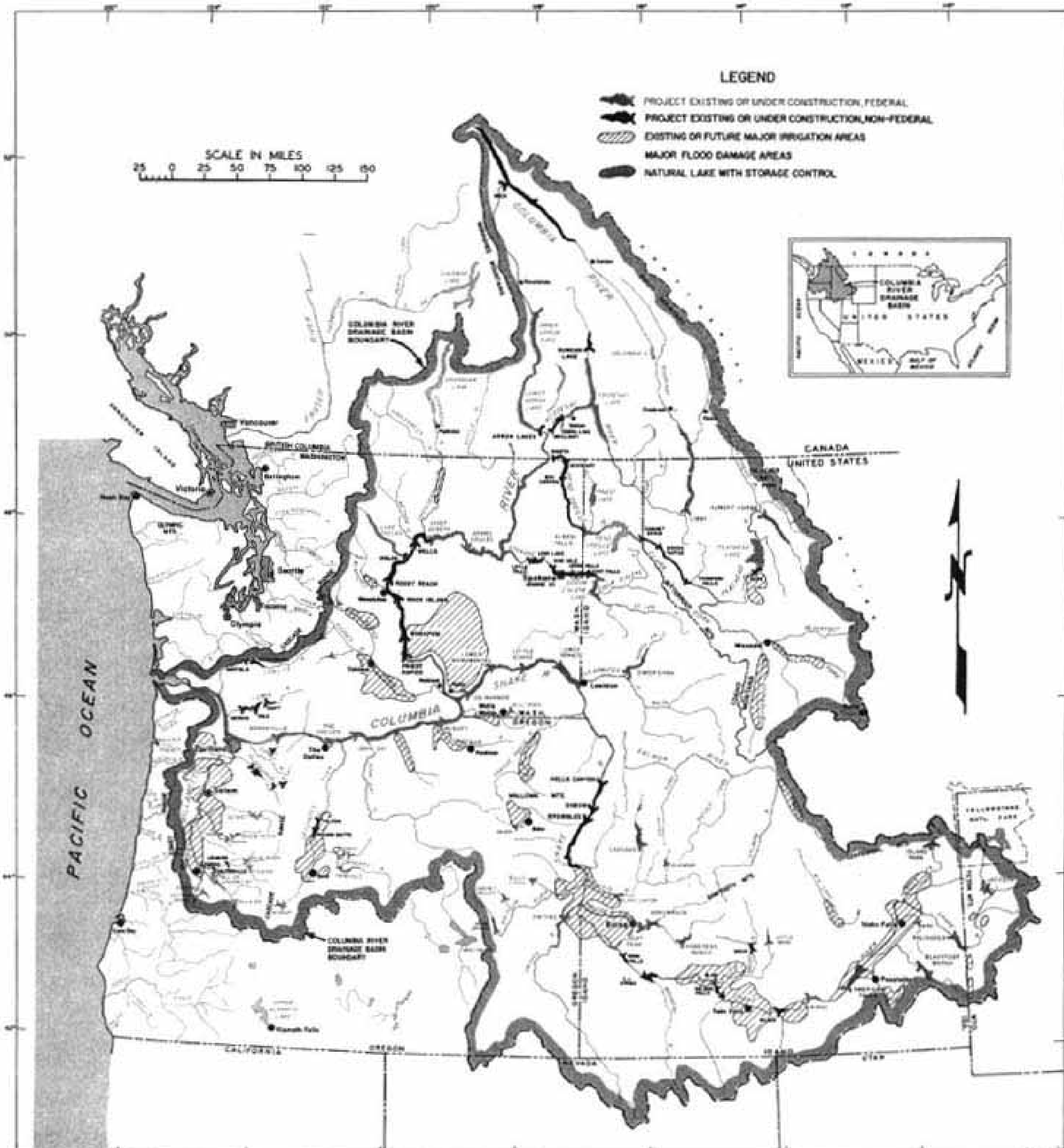
# COLUMBIA RIVER BASIN



# REPORT ON
# OPERATION OF COLUMBIA RIVER TREATY PROJECTS
# 1 AUGUST 1971 THROUGH 31 JULY 1972

## I INTRODUCTION

### A. AUTHORITY

Duncan and Arrow 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. The Treaty requires that the reservoirs be operated for 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 Duncan, Arrow and Libby reservoir for power and flood control during the period 1 August 1971 through 31 July 1972, 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 19 August 1971. During the drawdown season from mid-August 1971 to mid-April 1972, the regulation of the Canadian storage content was normally determined by the Operating Committee on a weekly basis. From 22 May through 21 July, during the 1972 flood control refill period, project outflows were determined on a daily basis.

## II WEATHER AND STREAMFLOW

A. WEATHER

Late summer and early fall weather was typified by hot spells interspersed by occasional rainy periods so that overall precipitation and temperatures were near average for this season. In the Canadian portion of the Basin, heavy fall precipitation increased soil moisture prior to the snow accumulation season. Precipitation amounts increased and snow began to accumulate at higher elevations as the season advanced but the total was slightly below average for the months of October and November 1971 for most portions of the Basin.

Precipitation for the Basin in general was above normal or well above normal each month from December 1971 through April 1972. As a result for the Columbia River Basin as a whole the precipitation over the snow accumulation season was markedly above normal. Chart 1 shows the geographical distribution of the accumulated 7-month (October 1971 - April 1972) precipitation over the entire Columbia River Basin, expressed as percentage of the 1953-67 average. As shown, roughly half of the Basin had more than 120 percent of average precipitation and areas in Canada and in the Snake River Basin had more than 150 percent of average.

Chart 2 depicts the sequence of precipitation and average daily temperatures during the five-month period October 1971 through February 1972 for the Columbia Basin as a whole. Charts 3 and 4 present the precipitation and temperature indexes for the March through July 1972 season, which includes the primary snowmelt period. The snowmelt temperature index is based on maximum daily rather than average daily temperatures. Chart 3 applies to the entire Columbia River Basin above The Dalles and Chart 4 applies to the upper Columbia and Kootenay River Basins in Canada. In the derivation of the basin-average indexes, the wet areas which produce the most runoff are more heavily weighted than the dry areas which usually produce less runoff. Since the major portion of the runoff which occurs during this season is produced by snowmelt, the temperature sequences shown on Charts 3 and 4 are of special significance to system reservoir regulation in that they largely control the production of streamflow.

Temperatures were much colder than normal in April and therefore the snowpack continued to accumulate later than usual. By the first of May many snow courses in the Basin had record or near-record snowpacks for that date. Most snow courses in the Columbia Basin reported accumulations over 140 percent of average for the 1953-1967 base period. Several courses had snowpacks over 200 percent of average. The stage was dramatically set for potentially record high flows in many areas.

B. STREAMFLOW

River flows were above normal during August and September 1971 due in part to the late snowmelt of the previous year's heavy snowpack and also some rainy periods in both months. By October and November the flows were near normal at most locations in the Basin. During the period from December 1971 through February 1972 streamflow was above normal at some stations and below normal at other stations in the Basin. Heavy rainstorms in the western and southern areas caused high flows in those areas while cold temperatures in other areas resulted in icing conditions and low flows in the northern portions of the area. A record minimum daily flow for February of 3090 cubic feet per second (cfs) occurred at Columbia River near Revelstoke on 2 February. During March flows in that portion of the Basin below the international boundary were generally well above normal due to above average precipitation, some warming at lower elevations and reservoir evacuation.

Below normal temperatures delayed the first pronounced snow-melt rise of the season until the middle of May. The prolonged above average warm spell in late May and early June as shown on Charts 3 and 4 resulted in the peak inflows of the season at the Treaty projects and most other projects in the Basin. The wet but cool weather which prevailed throughout the rest of June and most of July resulted in decreasing inflows without any further significant rises in inflows. Maximum mean daily inflows of the season were 88,600 cfs on 3 June for Libby, 25,000 cfs on 11 June for Duncan and 259,000 cfs on 11 June for Arrow. Inflow hydrographs for these reservoirs are shown on Charts 5, 6 and 8 respectively. Regulated and unregulated flows at three downstream points, Columbia River at Birchbank, Grand Coulee Dam and The Dalles are shown for the main snowmelt period by the hydrographs on Charts 9, 10 and 12 respectively.

## C. SEASONAL RUNOFF VOLUMES

Volume of runoff during the snowmelt season, as well as the variation with time, is 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 Duncan and Arrow projects and the unregulated runoff of Columbia River at The Dalles. The forecasts for Duncan and Arrow inflow were prepared by B.C. Hydro and Power Authority and those for the lower Columbia River and Libby inflow were prepared by the Columbia River Forecasting Service. Also shown on Table 1 are the actual volumes for these four locations for the April - August 1972 season.

Preliminary April-August runoff volumes, adjusted for upstream reservoir storage effects, are listed for eight locations in the following tabulation:

| STREAM AND LOCATION | THOUSANDS OF ACRE-FEET | PERCENT OF 1953-67 AVERAGE |
|---|---|---|
| Libby Reservoir Inflow | 8,940 | 125 |
| Duncan Reservoir Inflow | 2,520 | 114 |
| Columbia River at Mica Dam | 14,900 | 123 |
| Arrow Reservoir Inflow | 30,100 | 128 |
| Columbia River at Birchbank | 53,200 | 123 |
| Grand Coulee (FDR) Reservoir Inflow | 80,200 | 122 |
| Snake River near Clarkston | 31,300 | 133 |
| Columbia River at The Dalles | 128,700 | 130 |

Comparison of the above tabulation with the seasonal precipitation map on Chart 1 reveals the general relationship between snow-accumulation season precipitation and snowmelt season runoff when expressed in percent of average.

## III RESERVOIR OPERATION

### A. ARROW RESERVOIR

Reservoir Evacuation Period. As indicated on Chart 8, Arrow Reservoir was at elevation 1446.0 ft. on 1 August 1971, with water stored between elevations 1446 ft. and 1444 ft. by agreement between B.C. Hydro and B.P.A. Seasonal drawdown began on 21 September and Normal Full Pool of 1444.0 ft. was reached on 30 September. Drafting continued during October and November. During December and the first three weeks of January 1972, Arrow Reservoir was drafted close to rule curve in order to maintain head at Grand Coulee Dam for power generation. During this period, Grand Coulee was required to spill a considerable volume of water, in addition to generating at full capacity, to provide water for needed generation at downstream projects. On 23 January, when Arrow reservoir was at elevation 1387.5 ft., outflow was reduced because of high flows in the Lower Columbia due to mid-January storms. The reservoir reached 1380.5 ft. on 10 February and was held at about this elevation until 13 April before further drafting to Normal Low Pool, elevation 1377.7 ft. by 17 April to provide flood control space for the approaching flood season.

Flood Control Refill Period. Arrow Reservoir was maintained near Normal Low Pool, elevation 1377.7 ft. until about 10 May when involuntary storing began because of rising inflows. The reservoir was on "free flow" until 23 May when flood control storing began. To provide flood control in Canada, outflow was again reduced on 30 May and regulated to control the flow of the Columbia River at Birchbank so as to prevent excessively high river stages at Trail, B.C. The inflow to Arrow Reservoir "peaked" twice: 2 June (234,000 cfs) and 11 June (259,100 cfs). Outflows were greater than 150,000 cfs from 20 June through 30 June, with the mean daily peak of 158,000 cfs on 26 June. Birchbank flows exceeded 250,000 cfs from 2 June through 5 July, with a mean daily peak of 253,000 cfs on 20 June. As shown on Chart 8, Arrow Reservoir level was gradually raised to elevation 1434 ft., 10 feet below Normal Full Pool, by 18 June and held near that level for the next two weeks. Normal Full Pool, elevation 1444.0 ft. was reached on 19 July and a further surcharge from 1444.0 ft. to 1446.0 ft. was filled by 23 July by agreement between B.C. Hydro and B.P.A. Reservoir level was maintained at elevation 1446.0 ft. until 31 July 1972.

## B. DUNCAN RESERVOIR

Reservoir Evacuation Period. As indicated on Chart 6, Duncan Reservoir was at Normal Full Pool, elevation 1892.0 ft. on 1 August 1971 and was maintained at that elevation until 6 November when the seasonal drawdown began. Duncan was drafted nearly 28 feet in January 1972 and by the end of February had reached the minimum flood control pool, elevation 1807.5 ft. Further drafting to elevation 1805.0 ft. was effected by 13 March to permit shoreline clearing but high inflows to Kootenay Lake prevented further evacuation. Duncan Reservoir was held near minimum pool for the first few days of May, with inflow and outflow near 2,000 cfs.

Flood Control Refill Period. On 5 May, Duncan outflow was reduced to the flood control minimum of 100 cfs, which was maintained through May and the first half of June. Peak inflows were experienced on 1 June (23,070 cfs) and 11 June (24,760 cfs). By June 15, the reservoir had reached elevation 1870 ft. and outflows were then increased to about 6,000 cfs. Normal Full Pool elevation 1892 ft. was reached on 27 July and maintained until 31 July 1972.

C. LIBBY RESERVOIR

Libby dam was closed and initial filling of Lake Koocanusa began on 21 March 1972. There had been minor involuntary storage before that date. Filling continued until the reservoir reached elevation 2404 ft. on 19 July. Absence of spillway gates limited the maximum forebay to spillway crest elevation 2405 ft. Several short-term special regulations were conducted requiring varying forebay elevation and project ouflow to accommodate construction needs and fish population studies. The reservoir was at elevation 2404.5 ft. in late August 1972.

## 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 1971-72 Detailed Operating Plan designed to achieve optimum power generation downstream in the United States of America. The Canadian Entitlement to downstream power benefits for the 1971-72 operating year having been sold in 1964 to Columbia Storage Power Exchange, deliveries of power and energy specified under the Canadian Entitlement Exchange Agreements and attributable to Arrow and Duncan under the provisions of these agreements continued through the 1971-72 Operating Year. Generation at the projects in the United States for this purpose during the period 1 April 1971 through 31 March 1972 was 572 average megawatts at rates up to 987 megawatts. Subsequent to 31 March 1972, the energy amount remained at 572 average megawatts, but the maximum rate of generation increased to 995 megawatts.

The estimated firm load-resource balance for the United States Pacific Northwest Coordinated System showed about 230 average megawatts firm energy in excess of firm loads during the storage draft period 1 August 1971 through 15 April 1972. The estimated potential secondary energy requirements of the Coordinated System for interruptible industrial loads and replacement of thermal and other higher cost generation varied by months from 900 to 2100 average megawatts. On 1 October 1971, this estimate was reduced 500 average megawatts to reflect continued cutback in production by industries as new potlines failed to start-up production. Interruptible load estimates were higher than the previous year due to a shift from firm power to interruptible provided for under some contracts with industries.

Chronology. Streamflows receded rapidly in August 1971 from the high levels experienced during the summer. Federal plants ceased spilling shortly after mid-August. Deliveries of surplus power to the Pacific Southwest and service to all Pacific Northwest secondary energy loads and interruptible industrial loads were discontinued midnight, August 23. Direct service to area secondary loads was curtailed to conserve energy as a protection against possible cold weather and loss of generating capability. During the periods of curtailment, B.P.A.

interruptible industrial loads were served from non-Federal hydro surplus and provisional energy from the Federal system. Streamflow levels of the Federal Columbia River Power System averaged above median-month levels during August and the first half of September.

On 15 September 1971 the energy in storage in Federal System reservoirs reached 1610 megawatt-months above Critical Rule Curve levels, providing sufficient resource capability to meet the 1 billion kilowatt-hours of Hanford energy sold to the industries and the 175,200 megawatt-hours of energy purchased by the industries under the Arrow Lakes and Whatshan storage agreements. At this time, secondary energy deliveries to Pacific Northwest utilities and B.P.A. interruptible industrial load was resumed.

Direct service to all interruptible industrial customers and secondary energy sales to private and public agencies was again curtailed on October 18. This action became necessary due to projected resource availability being insufficient, primarily from the new Centralia steam plant, to meet firm load requirements should streamflows recede to critical. Interruptible loads continued to be served from provisional storage releases.

Secondary energy was made available to public agencies beginning November 1. Direct service to interruptible industrial loads and private utility secondary energy was resumed November 24. Another curtailment of secondary service to interruptible industrial loads and private utility secondary loads was required December 28, 1971, through January 11, 1972 because of reduced availability of generation from Hanford and Centralia steamplants.

Streamflows of the Columbia River rose substantially during mid-January as a result of a warm Pacific storm throughout the basin.

Some streams west of the Cascades experienced record-breaking floods. The warm spell was followed by an extended cold snap throughout the area, causing flows to recede sharply again. No difficulties were encountered in serving total power loads for the balance of the year. The Federal System declared surplus energy available for export beginning February 17, 1972.

The Hanford steamplant was shut down March 4, and the Centralia steamplant was shut down March 23 due to high hydro capability on the Coordinated System. Generation to replace these plants was picked up on the lower Columbia River plants which effectively reduced spill at McNary, John Day and The Dalles.

Because of rising streamflows on the Kootenai River in Montana, the Libby project was closed ahead of schedule on March 21.

Volume inflow forecasts into Duncan Reservoir were sufficient to lower the Variable Refill Curve to its bottom elevation of 1792.4 ft. from January 31 through May 31, 1972, as indicated in Table 3.

## B. FLOOD CONTROL

Main Stem Regulation. Without regulation of upstream reservoirs, the 1972 high water season would have produced both the highest peak flow and the largest April through August runoff volume of the century, measured at The Dalles, Oregon. The computed unregulated peak discharge at The Dalles was 1,050,000 cfs on 12 June; the actual observed peak discharge was 618,000 cfs on 20 June. By comparison, the 1948 observed peak discharge was 1,010,000 cfs. In terms of seasonal runoff, the April through August volume in 1972 was equivalent to the April through September volume in 1948, about 129 maf. At Vancouver, Washington, a key gauging station for evaluating flooding on the Lower Columbia River, the 1972 maximum stage was 21.5 feet instead of a computed unregulated stage of 31.5 feet. At Vancouver, bankfull stage is 16 feet and major flood stage is 26 feet on the gauge.

In Canada, the 1972 unregulated peak discharge of the Columbia River at Birchbank, B.C. would have reached about 372,000 cfs, exceeding the estimated 1948 peak and almost equalling the 1961 record of 375,000 cfs.

Local Regulation. Local flood control by individual reservoirs was significant in 1972. Unregulated discharges at Bonners Ferry, Idaho would have caused stages near 38 feet, a major flood; the operation of Libby Reservoir held the observed maximum to 24 feet. Kootenai Flats area also received major flood control benefits from Libby operation.

Mean daily inflow to Duncan Reservoir exceeded 10,000 cfs from 25 May through 10 August, with peak inflows exceeding 22,000 cfs on two occasions in June while Duncan outflow was restricted to 100 cfs. Flood damage on Duncan River downstream from the Lardeau River occurred on 1 June as a result of a sharp flood peak on the Lardeau River caused by snowmelt runoff and heavy rain. During this time, Duncan outflow was maintained at the 100 cfs minimum and remained at this rate until 15 June. Outflows were held below 8,000 cfs until 28 July when they were gradually increased. During July and August, the outflow did not exceed 12,000 cfs.

The operation of Libby Reservoir on the Kootenai River combined with the operation of Duncan Reservoir on the Duncan River reduced the peak stage of Kootenay Lake by about 7½ feet, as indicated on Chart 7.

During June and July, outflows from Arrow Reservoir were regulated not only for the control of the Lower Columbia River, but also to control the flow of the Columbia River at Birchbank, British Columbia, 17 miles upstream from the International Boundary and 7 miles upstream from Trail, B.C., a critical area for flood control in Canada. Because of the large inflow volume forecast for Arrow Reservoir, flows at Birchbank were allowed to exceed 250,000 cfs from 2 June through 5 July with a peak of 253,000 on 20 June.

Minor flooding did occur at Castlegar and Trail because of the high flows but the flood stage at Trail corresponding to the computed unregulated peak flow of 372,000 cfs would have been about 10 feet higher. The actual peak flow was 253,000 cfs.

Chart 9 shows the observed discharge at Birchbank for the period 1 July 1971 through 31 July 1972 as well as the unregulated discharge for May-July 1972. Chart 9 also shows the adjusted 15-year average discharge at Birchbank to provide a basis of comparison. Chart 10 shows the regulation by Grand Coulee reservoir during the period July 1971-July 1972. The actual peak inflow to Roosevelt Lake at Grand Coulee Dam was 405,000 cfs on 17 June 1972 when the outflow was 351,000 cfs. The computed unregulated peak inflow was 559,000 cfs on 13 June, at which time the actual outflow was 318,000 cfs. Chart 11 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 Interim Flood Control Operating Plan. The guideline shown on Chart 11 is based on relative space available on 31 May. Prior to that date both projects were virtually on freeflow and storage was involuntary. The basis for the computation of initial controlled flow of 580,000 cfs for the Columbia River at The Dalles, Oregon, is shown on Table 2.

A comparison of the 1971-72 observed discharge and the adjusted average discharge for the period 1953-67 for Columbia River at The Dalles is shown on Chart 12. Chart 13 separated the effects of

Libby, Duncan and Arrow projects from those of all other major storage projects on the flow of Columbia River at The Dalles during the period April through July 1972. These three projects contributed about 31 percent of the total effective storage for flood control regulation for the lower Columbia River during the peak runoff month of June.

## 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 derogate from 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 Interim Flood Control Operating Plan of 12 November 1968, both developed by special task forces, establish the general criteria of operations.

The Assured Operating Plan dated 15 February 1969 established Operating Rule Curves for Duncan and Arrow during the 1971-72 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 Interim Flood Control Operating Plan.

The Detailed Operating Plan established Operating Rule Curves based on power loads and resource data available just prior to the operating year for use in actual operations. The Variable Refill Curves and flood control requirements subsequent to 1 January 1972 were determined on the basis of seasonal volume runoff forecasts during actual operation.

B. POWER OPERATION

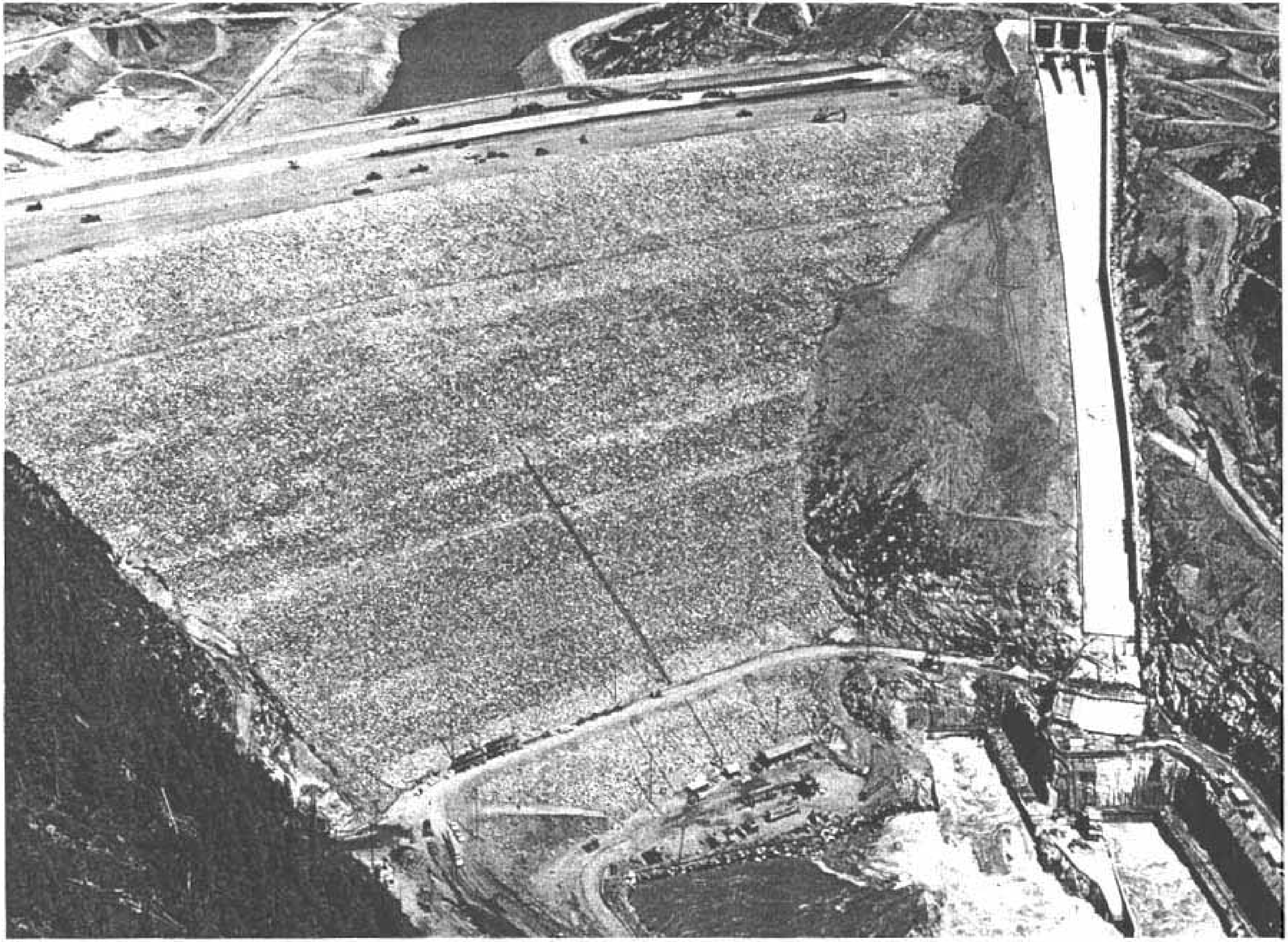
The Detailed Operating Plan dated 19 August 1971 was designed to achieve optimum power generation downstream in the United States, consistent with project operating limits and flood control requirements.

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 within the limits of 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

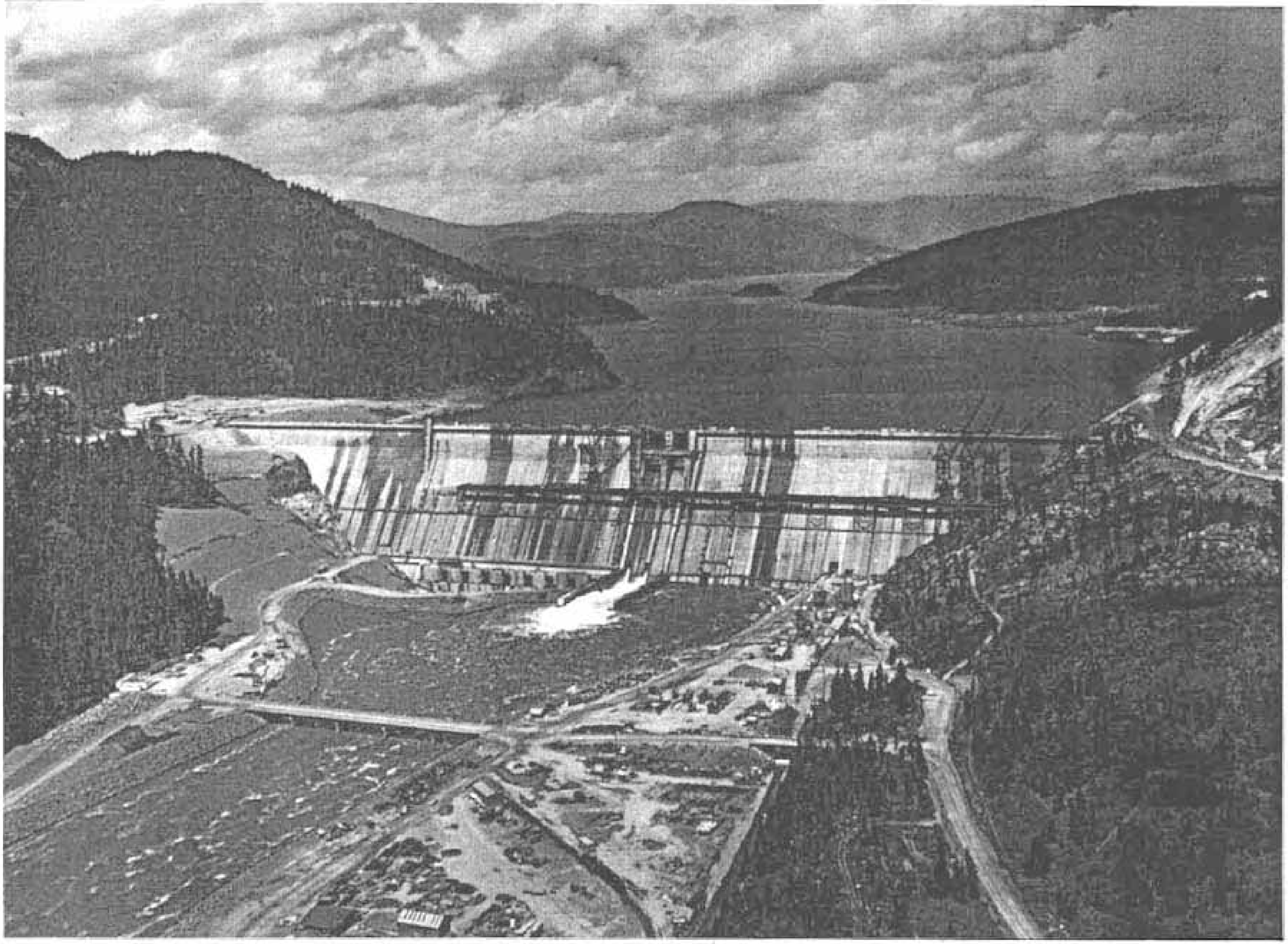
The Interim Flood Control Operating Plan was designed to minimize flood damage both in Canada and in the United States. The flood control operation during the drawdown period consisted of evacuating and holding available, consistent with refill criteria, storage space sufficient to control the maximum flood that may 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 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.



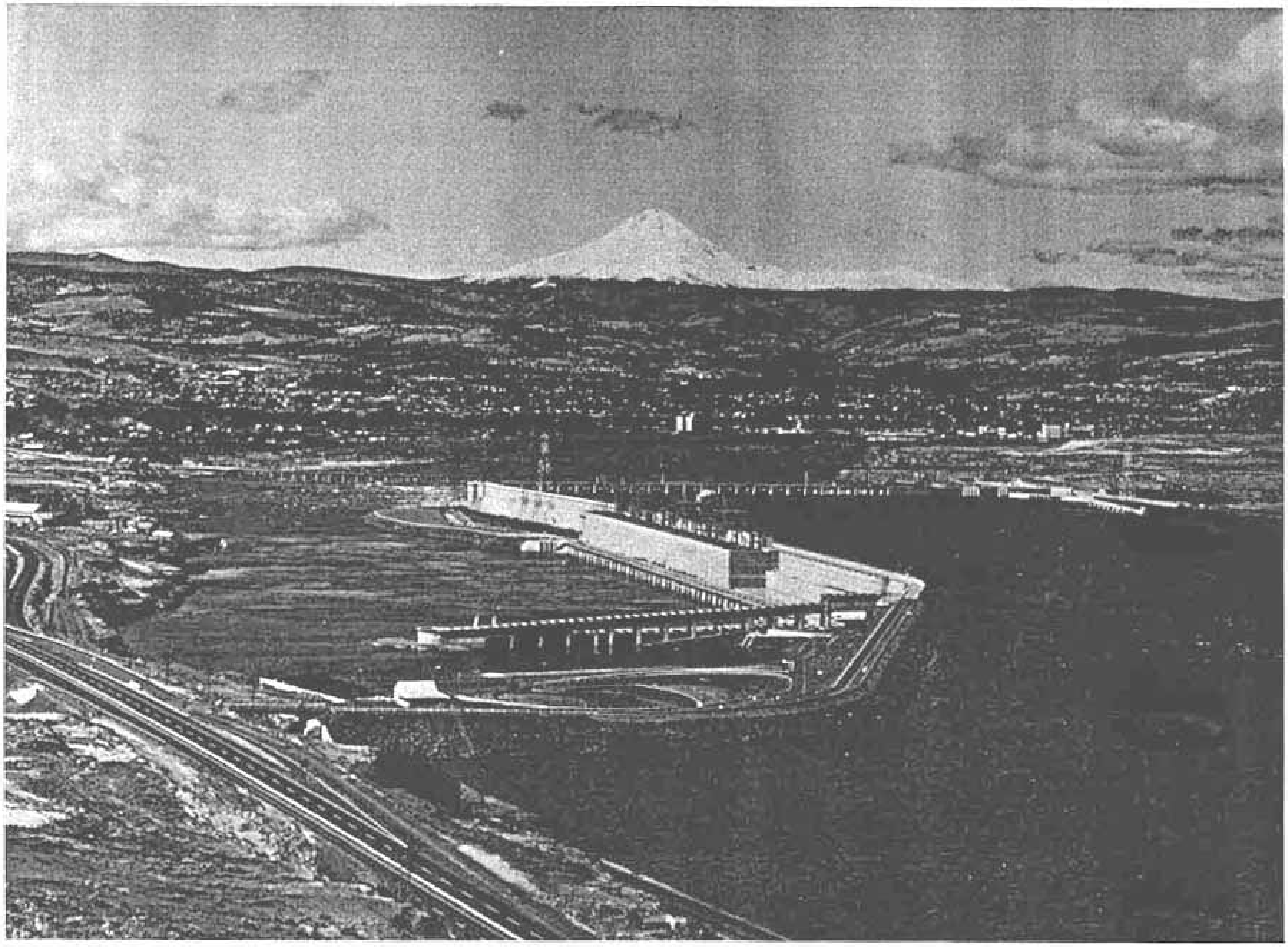
View from downstream of Mica Dam, showing construction progress as of 6 June 1972. Columbia River discharge through tunnels was 87,500 c.f.s. A record peak flow of over 129,000 c.f.s. was passed on 12 June 1972.

*B.C. Hydro Photograph*



View from downstream of Libby Dam, showing construction progress as of 22 July 1972 with Lake Koocanusa behind the project at elevation 2404 feet. Initial filling of the lake began with closure of the dam on 31 March 1972.

*U.S. Corps of Engineers Photograph*



View of The Dalles Dam looking downstream with the City of The Dalles, Oregon and Mount Hood in the background. Generating units numbers 15 through 22 are being added in the skeleton bays at the upstream end of the powerhouse shown in the center of the picture. The east fishway is shown in front of the powerhouse and the 23-gate spillway is shown behind the powerhouse.

*U.S. Corps of Engineers Photograph*

SEASONAL VOLUME RUNOFF FORECASTS
MILLIONS OF ACRE-FEET
1972

| | Duncan Lake Inflow | | Arrow Lake Inflow | | Libby | Unregulated Runoff Columbia River at The Dalles, Oregon |
|---|---|---|---|---|---|---|
| Forecast Date - 1st of: | Most Probable 1 Apr. - 31 Aug. | 95% Probable Date - 31 July | Most Probable 1 Apr. - 31 Aug. | 95% Probable Date - 31 July | Most Probable 1 Apr. - 31 Aug. | Most Probable 1 Apr. - 31 Aug. |
| January | 2.16 | 1.50 | 22.7 | 16.8 | 6.87 | 105 |
| February | 2.34 | 1.68 | 24.5 | 18.6 | 7.88 | 116 |
| March | 2.44 | 1.77 | 25.6 | 19.3 | 8.57 | 129 |
| April | 2.64 | 1.92 | 26.7 | 19.8 | 7.89 | 125 |
| May | 2.67 | 1.88 | 26.4 | 18.5 | 7.82 | 125 |
| June | 2.62 | 1.43 | 26.7 | 13.5 | 7.65 | 124 |
| Actual | 2.52 | | 30.1 | | 8.94 | 129 |



TABLE 1

TABLE 2

COMPUTATION OF INITIAL CONTROLLED FLOW
COLUMBIA RIVER AT THE DALLES, OREGON
1 MAY 1972

| | | |
|---|---|---|
| Forecast of May - August Unregulated Runoff Volume, MAF | | 111.0 |
| Less Estimated Depletions, MAF | | 0.7 |
| Less Upstream Storage Corrections, MAF | | |
| Arrow | 5.0 | |
| Duncan | 1.3 | |
| Libby | 3.4 | |
| Hungry Horse | 2.2 | |
| Flathead Lake | 0.5 | |
| Noxon | 0.1 | |
| Dworshak | 1.4 | |
| Pend Oreille Lake | 0.5 | |
| Grand Coulee | 5.2 | |
| Brownlee | 1.0 | |
| John Day | 0.5 | |
| TOTAL | 21.1 | 21.1 |
| Forecast of Adjusted Residual Runoff Volume, MAF | | 89.2 |
| Computed Initial Controlled Flow (From Chart 1, of Interim Flood Control Plan), KCFS | | 580 |

TABLE 3

DUNCAN RESERVOIR COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

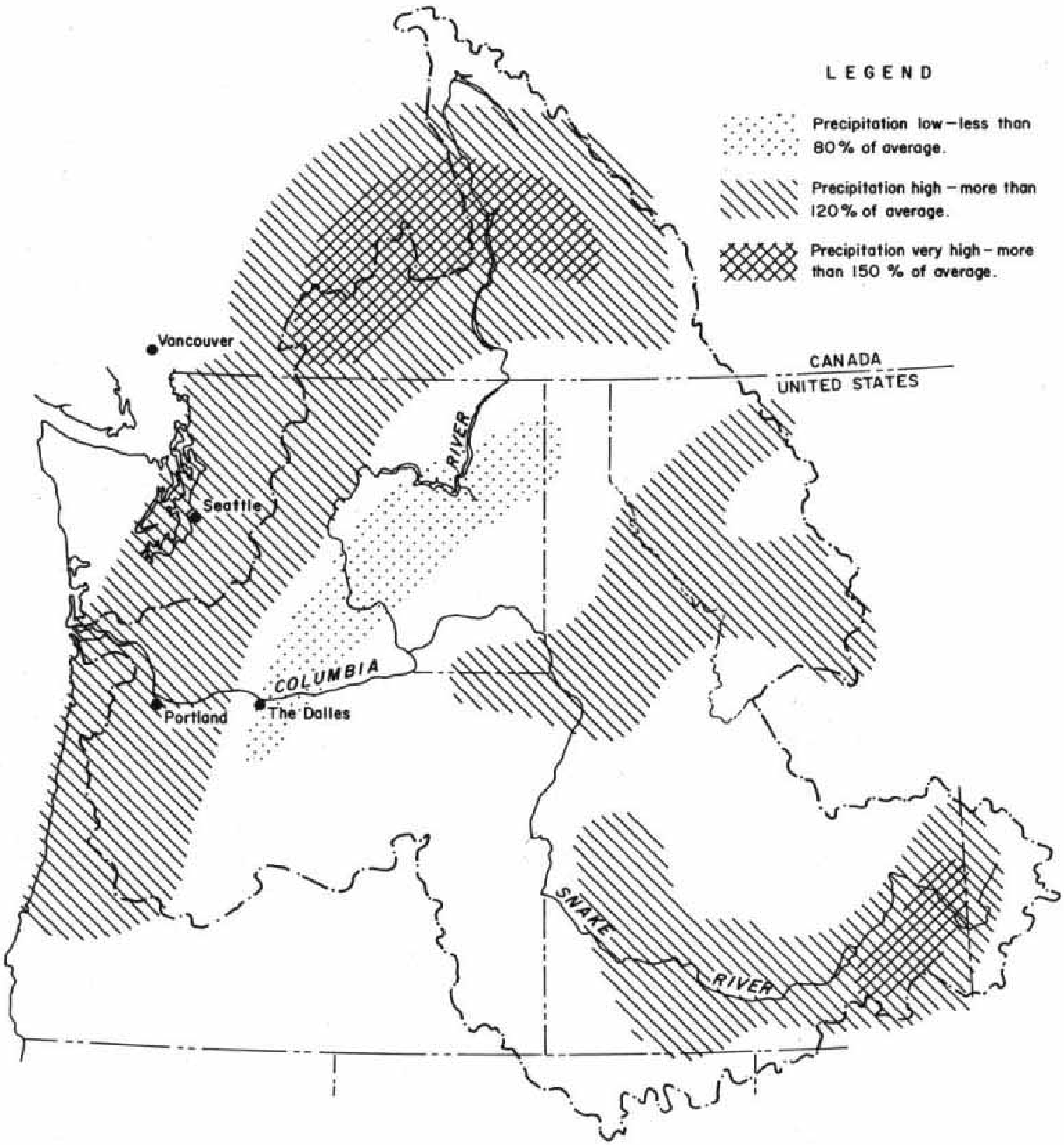
1972

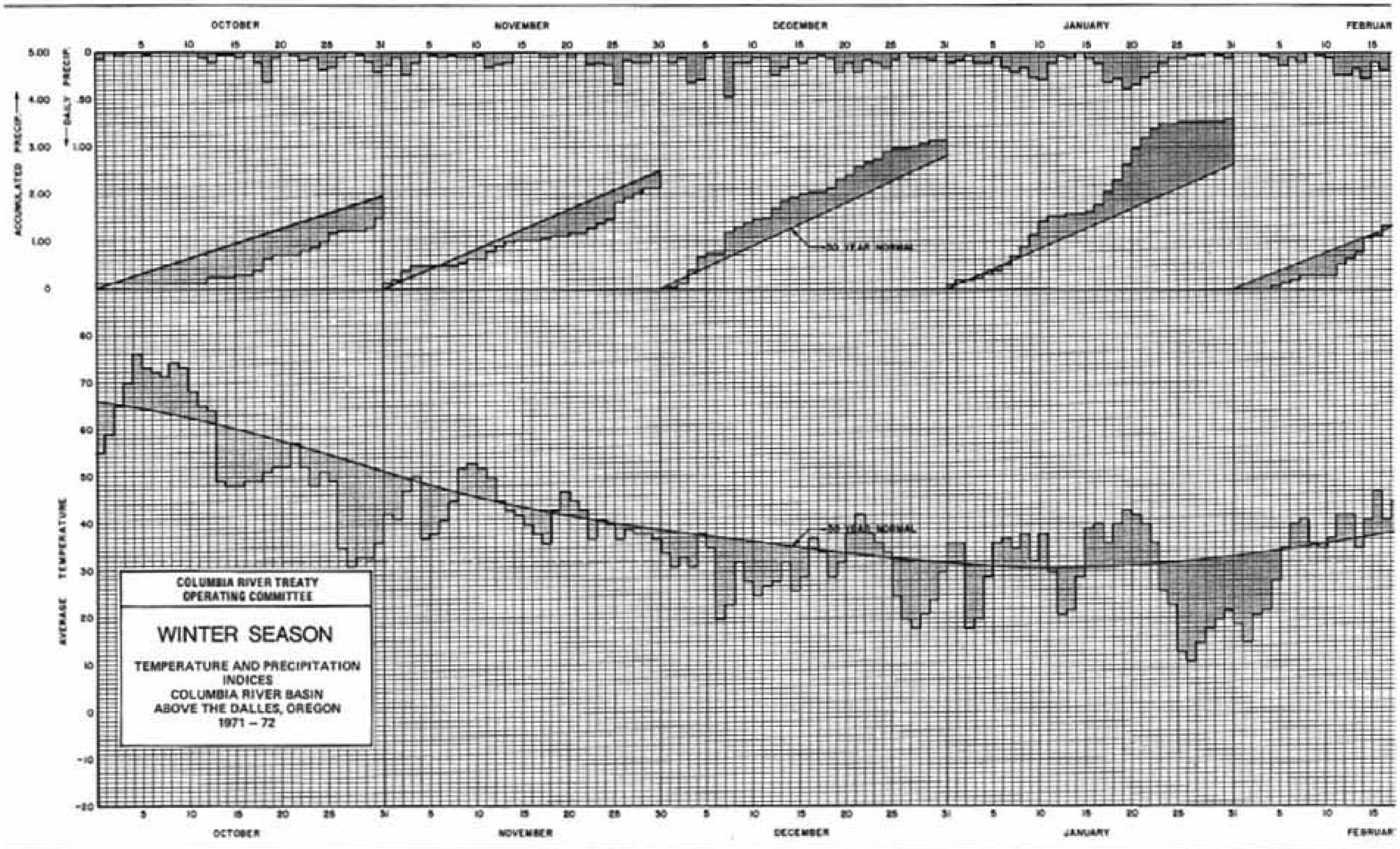
| Forecast Date | Initial | Jan. 1 | Feb. 1 | Mar. 1 | Apr. 1 | May 1 | June 1 |
|---|---|---|---|---|---|---|---|
| 1. Probable Feb. 1 - July 31 inflow, KSFD 1/ | | 923.8 | 1000.2 | 1046.2 | 1144.0 | 1153.5 | 1134.8 |
| 2. 95% forecast error, KSFD | | 191.5 | 150.7 | 129.8 | 116.8 | 106.9 | 95.5 |
| 3. 95% confidence Feb. 1 - July 31 inflow, KSFD 2/ | | 732.3 | 849.5 | 916.4 | 1027.2 | 1046.6 | 1039.3 |
| 4. Observed Feb. 1 - date inflow, KSFD | | 0.0 | 0.0 | 22.6 | 58.1 | 100.1 | 320.3 |
| 5. 95% confidence date - July 31 inflow, KSFD 3/ | | 732.3 | 849.5 | 893.8 | 969.1 | 946.5 | 719.0 |
| Assumed Feb. 1 - July 31 inflow, % volume | | 100.0 | | | | | |
| Assumed Feb. 1 - July 31 inflow, KSFD 4/ | | 732.3 | | | | | |
| Min. Feb. 1 - July 31 outflow, KSFD | | 18.1 | | | | | |
| Min. Jan. 31 reservoir content, KSFD 5/ | | 2.0 | | | | | |
| Min. Jan. 31 reservoir elev., ft. 6/ | | 1792.4 | | | | | |
| Jan. 31 Variable Refill Curve, ft. 7/ | 1812.9 | 1792.4 | | | | | |
| Assumed Mar. 1 - July 31 inflow, % volume | | 98.1 | 98.1 | | | | |
| Assumed Mar. 1 - July 31 inflow, KSFD 4/ | | 718.4 | 833.4 | | | | |
| Min. Mar. 1 - July 31 outflow, KSFD | | 15.3 | 15.3 | | | | |
| Min. Feb. 28 reservoir content, KSFD 5/ | | 12.8 | 4.8 | | | | |
| Min. Feb. 28 reservoir elev., ft. 6/ | | 1794.5 | 1792.4 | | | | |
| Feb. 28 Variable Refill Curve, ft. 7/ | 1813.9 | 1794.5 | 1792.4 | | | | |
| Assumed Apr. 1 - July 31 inflow, % volume | | 96.1 | 96.1 | 98.0 | | | |
| Assumed Apr. 1 - July 31 inflow, KSFD 4/ | | 703.7 | 816.4 | 875.9 | | | |
| Min. Apr. 1 - July 31 outflow, KSFD | | 12.2 | 12.2 | 12.2 | | | |
| Min. Mar. 31 reservoir content, KSFD 5/ | | 24.2 | 4.8 | 4.8 | | | |
| Min. Mar. 31 reservoir elev., ft. 6/ | | 1797.2 | 1792.4 | 1792.4 | | | |
| Mar. 31 Variable Refill Curve, ft. 7/ | 1815.4 | 1797.2 | 1792.4 | 1792.4 | | | |
| Assumed Apr. 16 - July 31 inflow, % volume | | 94.6 | 94.6 | 96.5 | 98.5 | | |
| Assumed Apr. 16 - July 31 inflow, KSFD 4/ | | 692.8 | 803.6 | 862.5 | 954.6 | | |
| Min. Apr. 16 - July 31 outflow, KSFD | | 10.7 | 10.7 | 10.7 | 10.7 | | |
| Min. Apr. 15 reservoir content, KSFD 5/ | | 34.1 | 4.8 | 4.8 | 4.8 | | |
| Min. Apr. 15 reservoir elev., ft. 6/ | | 1799.4 | 1792.4 | 1792.4 | 1792.4 | | |
| Apr. 15 Variable Refill Curve, ft. 7/ | 1816.1 | 1799.4 | 1792.4 | 1792.4 | 1792.4 | | |
| Assumed May 1 - July 31 inflow, % volume | | 91.1 | 91.1 | 92.9 | 94.8 | | |
| Assumed May 1 - July 31 inflow, KSFD 4/ | | 667.1 | 773.9 | 830.3 | 918.7 | | |
| Min. May 1 - July 31 outflow, KSFD | | 9.2 | 9.2 | 9.2 | 9.2 | | |
| Min. Apr. 30 reservoir content, KSFD 5/ | | 58.1 | 4.8 | 4.8 | 4.8 | | |
| Min. Apr. 30 reservoir elev., ft. 6/ | | 1804.2 | 1792.4 | 1792.4 | 1792.4 | | |
| Apr. 30 Variable Refill Curve, ft. 7/ | 1818.1 | 1804.2 | 1792.4 | 1792.4 | 1792.4 | | |
| Assumed June 1 - July 31 inflow, % volume | | 71.7 | 71.7 | 73.1 | 74.6 | 78.7 | |
| Assumed June 1 - July 31 inflow, KSFD 4/ | | 525.1 | 609.1 | 653.4 | 722.9 | 744.9 | |
| Min. June 1 - July 31 outflow, KSFD | | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | |
| Min. May 31 reservoir content, KSFD 5/ | | 196.8 | 113.2 | 68.9 | 4.8 | 4.8 | |
| Min. May 31 reservoir elev., ft. 6/ | | 1826.7 | 1813.8 | 1806.2 | 1792.4 | 1792.4 | |
| May 31 Variable Refill Curve, ft. 7/ | 1835.2 | 1826.7 | 1813.8 | 1806.2 | 1792.4 | 1792.4 | |
| Assumed July 1 - July 31 inflow, % volume | | 33.9 | 33.9 | 34.6 | 35.3 | 37.2 | 47.3 |
| Assumed July 1 - July 31 inflow, KSFD 4/ | | 248.2 | 288.0 | 309.2 | 342.1 | 352.1 | 340.1 |
| 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/ | | 470.6 | 431.3 | 410.1 | 377.2 | 367.2 | 379.2 |
| Min. June 30 reservoir, elev., ft. 6/ | | 1863.0 | 1858.1 | 1855.4 | 1851.2 | 1849.9 | 1851.5 |
| June 30 Variable Refill Curve, ft. 7/ | 1870.3 | 1863.0 | 1858.1 | 1855.4 | 1851.2 | 1849.9 | 1851.5 |
| July 31 Variable Refill Curve, ft. | 1892.0 | 1892.0 | 1892.0 | 1892.0 | 1892.0 | 1892.0 | 1892.0 |

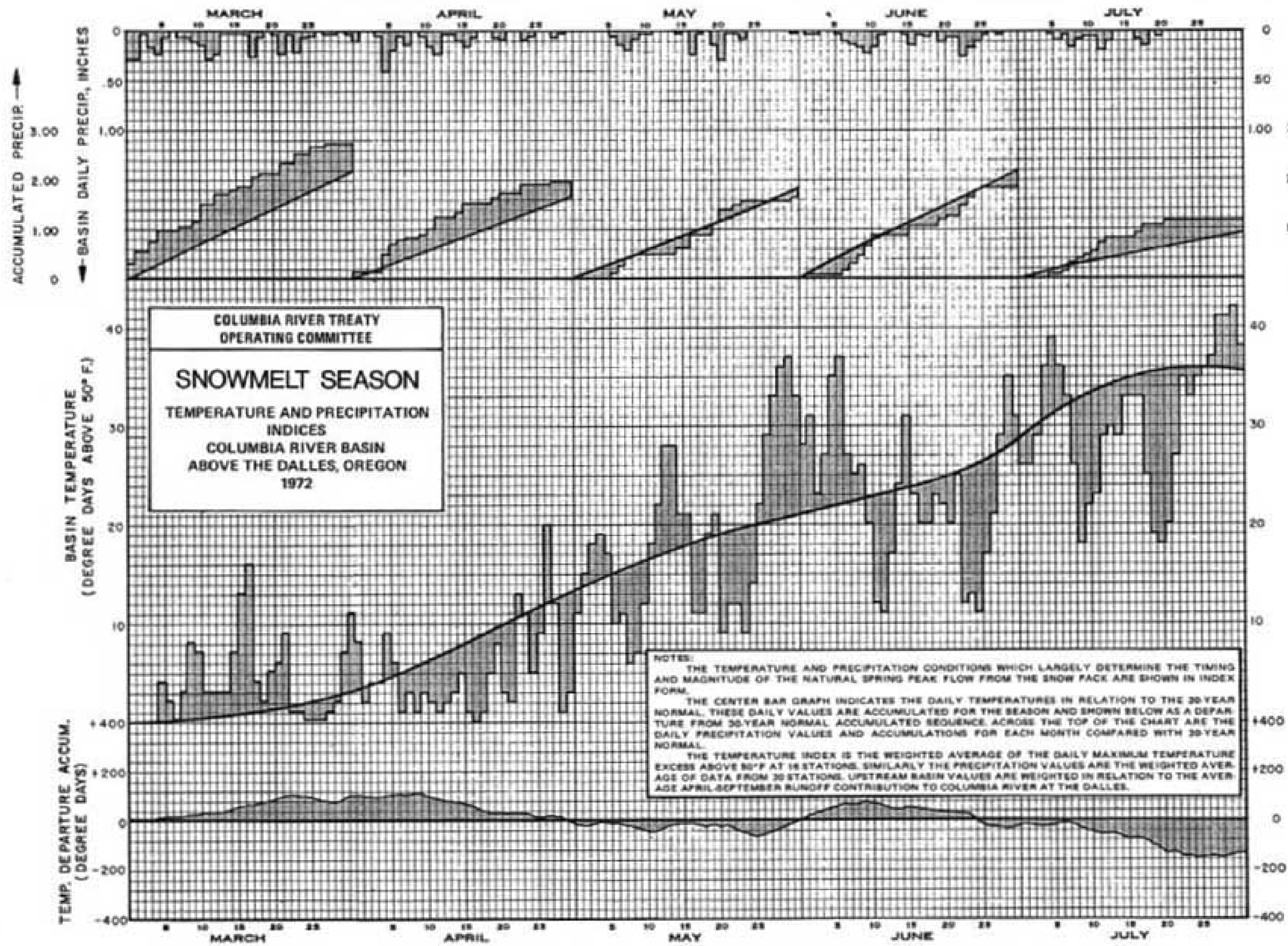
1/ Developed by the Canadian Entity
2/ Line 1 - Line 2
3/ Line 3 - Line 4
4/ Preceding Line x Line 5
5/ Full content (716.2 KSFD) plus preceding line less line preceding that with a minimum content of 4.8
6/ From reservoir elevation - storage content table dated April 24, 1968
7/ Lower of elevation on preceding line or elevation determined prior to year (Initial)

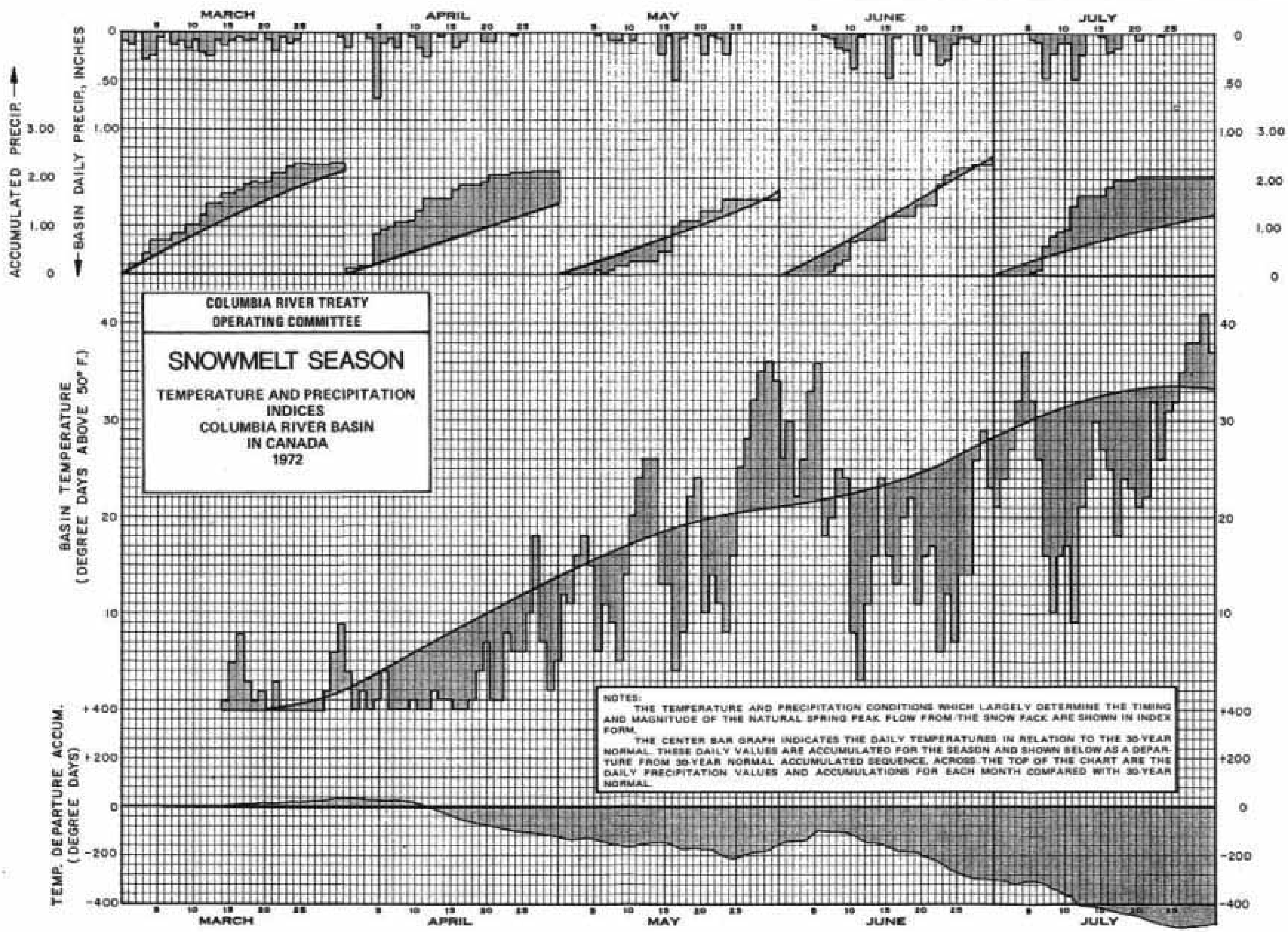
CHART I
SEASONAL
PRECIPITATION

## OCTOBER 1971 – APRIL 1972 PRECIPITATION
## PERCENT OF 1953-67 AVERAGE

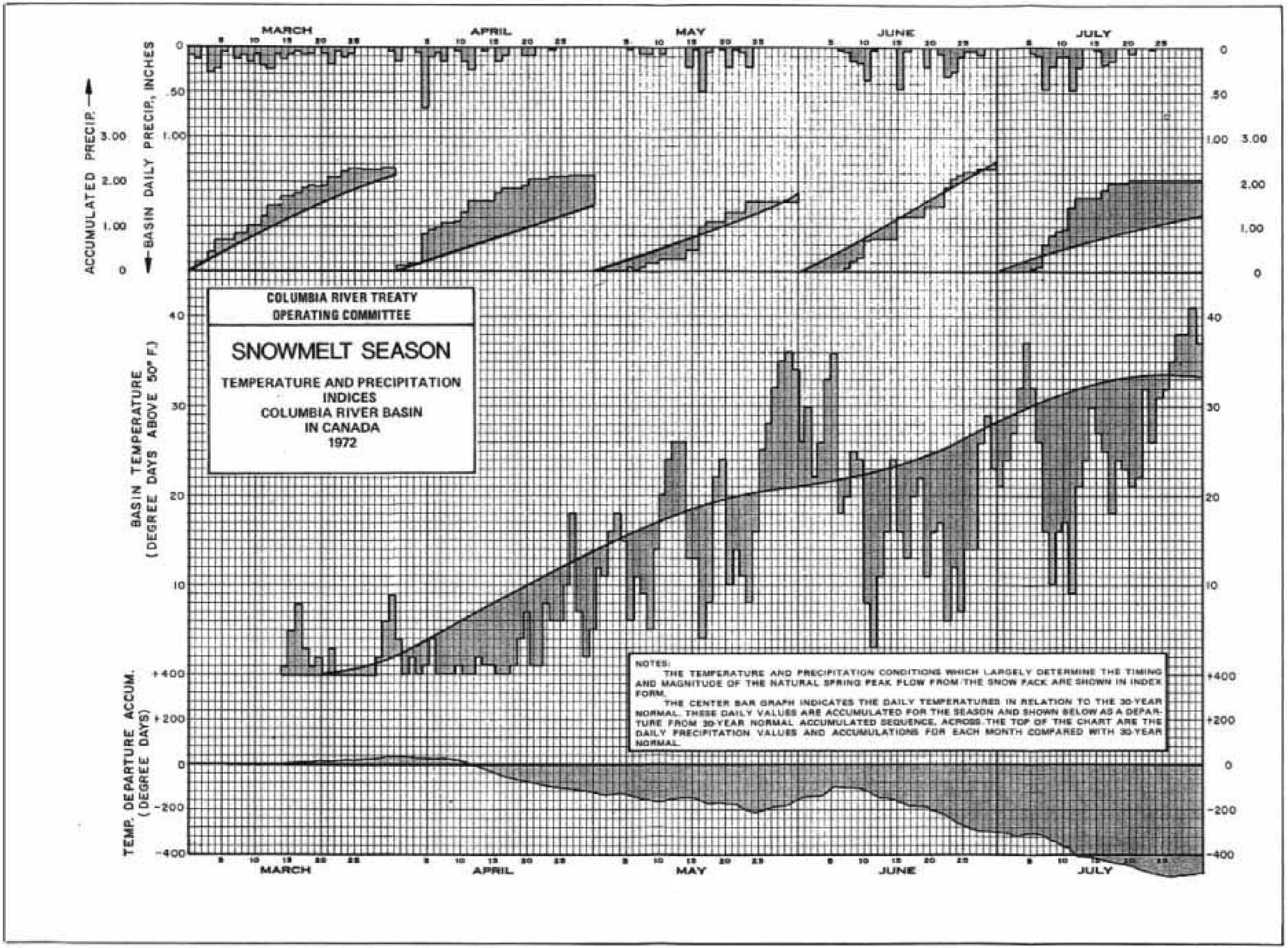



COLUMBIA RIVER TREATY
OPERATING COMMITTEE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDICES
COLUMBIA RIVER BASIN
ABOVE THE DALLES, OREGON
1971 – 72
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUAR
ACCUMULATED PRECIP.
DAILY PRECIP.
AVERAGE TEMPERATURE
30 YEAR NORMAL

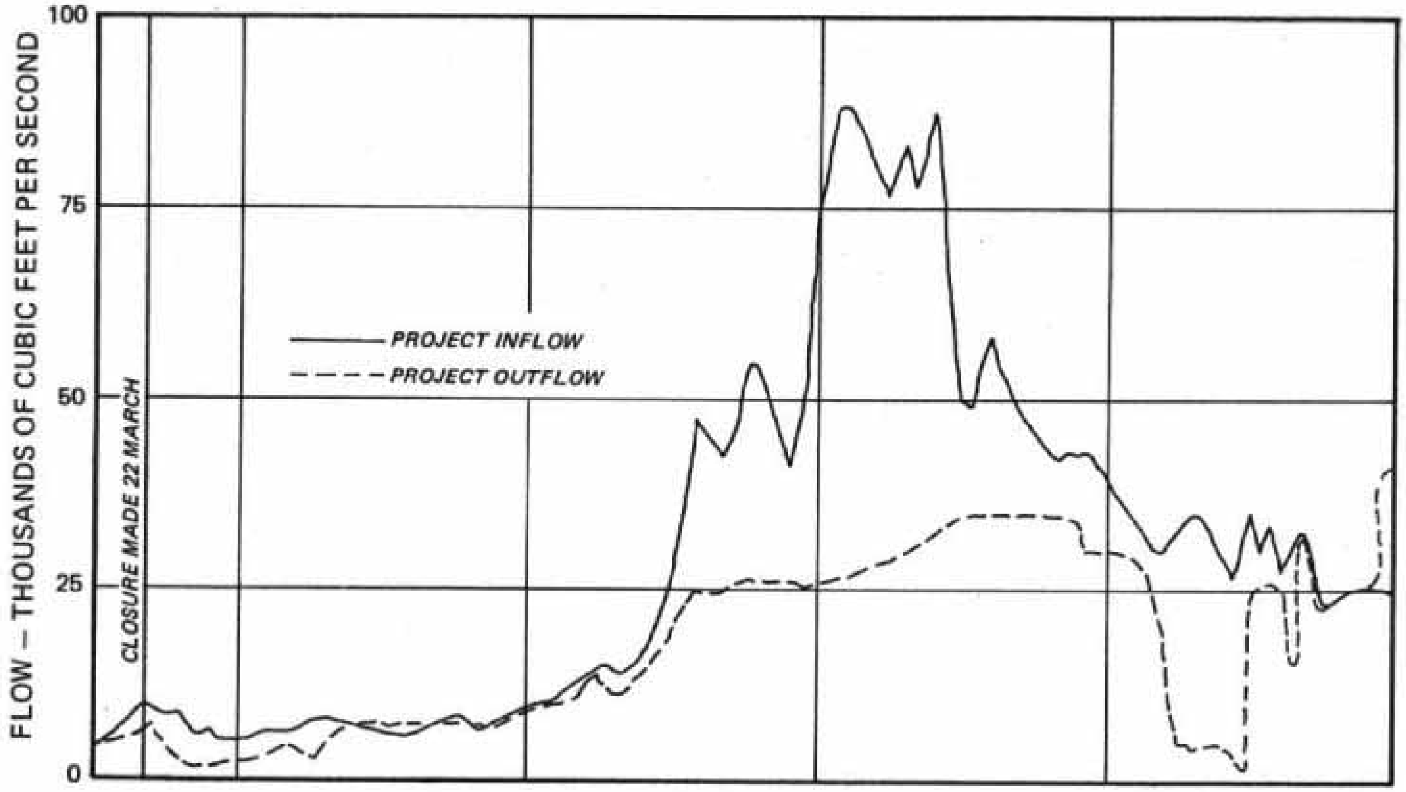

COLUMBIA RIVER TREATY
OPERATING COMMITTEE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION
INDICES
COLUMBIA RIVER BASIN
ABOVE THE DALLES, OREGON
1972
ACCUMULATED PRECIP.
BASIN DAILY PRECIP., INCHES
BASIN TEMPERATURE
(DEGREE DAYS ABOVE 50° F.)
TEMP. DEPARTURE ACCUM.
(DEGREE DAYS)
MARCH
APRIL
MAY
JUNE
JULY
NOTES:
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM.
THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ARE ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL.
THE TEMPERATURE INDEX IS THE WEIGHTED AVERAGE OF THE DAILY MAXIMUM TEMPERATURE EXCESS ABOVE 50°F AT 18 STATIONS. SIMILARLY THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF DATA FROM 30 STATIONS. UPSTREAM BASIN VALUES ARE WEIGHTED IN RELATION TO THE AVERAGE APRIL-SEPTEMBER RUNOFF CONTRIBUTION TO COLUMBIA RIVER AT THE DALLES.

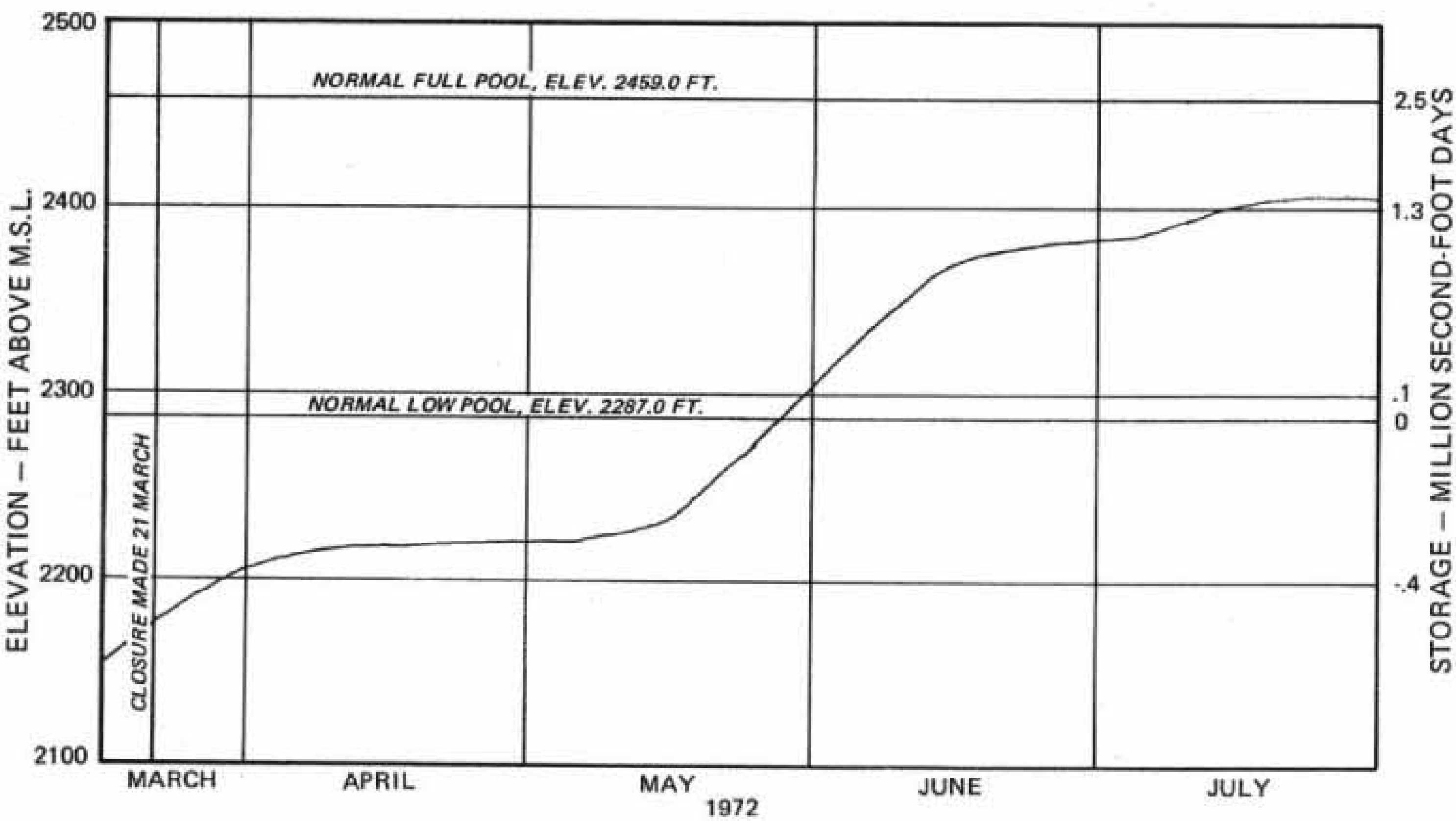


COLUMBIA RIVER TREATY
OPERATING COMMITTEE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION
INDICES
COLUMBIA RIVER BASIN
IN CANADA
1972
MARCH
APRIL
MAY
JUNE
JULY
ACCUMULATED PRECIP.
BASIN DAILY PRECIP., INCHES
BASIN TEMPERATURE
(DEGREE DAYS ABOVE 50° F.)
TEMP. DEPARTURE ACCUM.
(DEGREE DAYS)
0
.50
1.00
3.00
2.00
1.00
0
40
30
20
10
+400
+200
0
-200
-400
NOTES:
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM.
THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ARE ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL.


COLUMBIA RIVER TREATY
OPERATING COMMITTEE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION
INDICES
COLUMBIA RIVER BASIN
IN CANADA
1972
ACCUMULATED PRECIP.
BASIN DAILY PRECIP., INCHES
BASIN TEMPERATURE
(DEGREE DAYS ABOVE 50° F.)
TEMP. DEPARTURE ACCUM.
(DEGREE DAYS)
MARCH
APRIL
MAY
JUNE
JULY
NOTES:
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM.
THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ARE ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL.

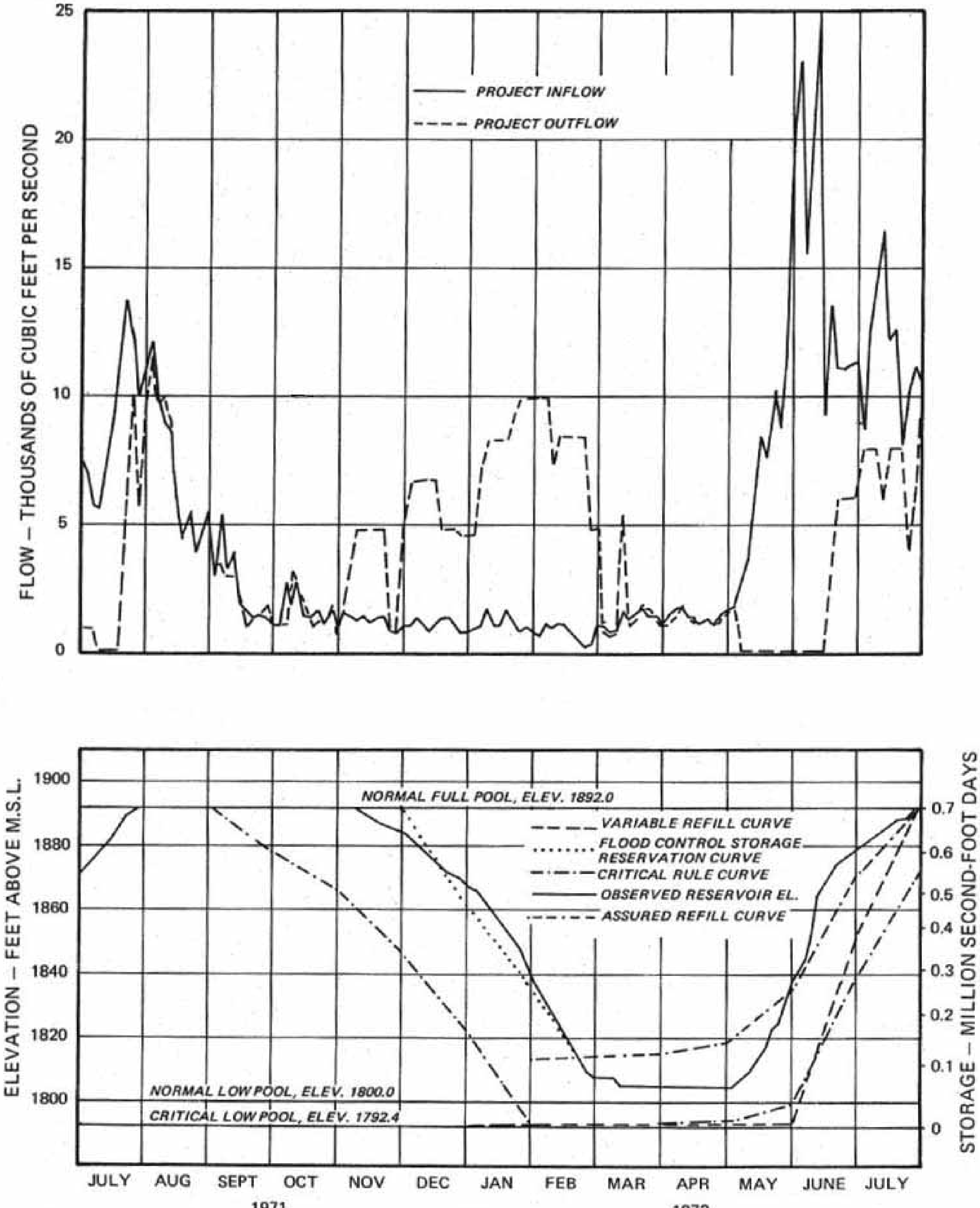
REGULATION OF LIBBY
15 MARCH 1972 – 31 JULY 1972



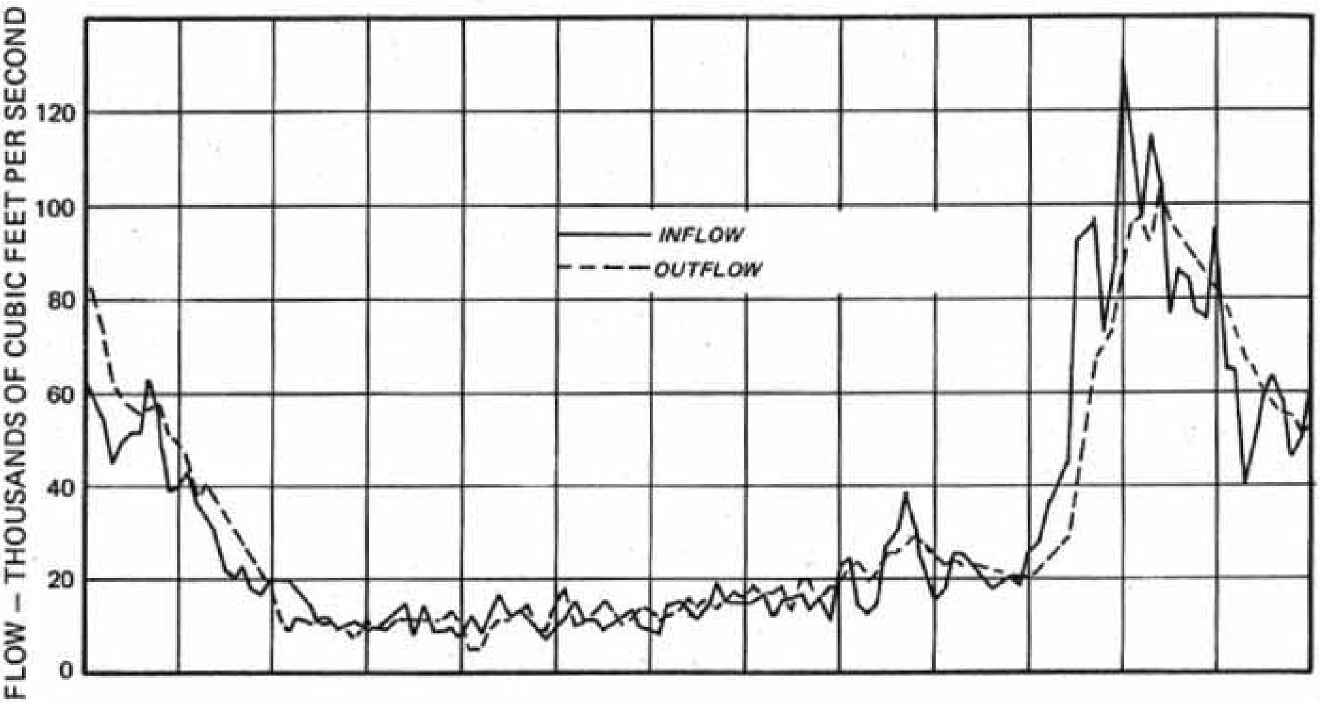



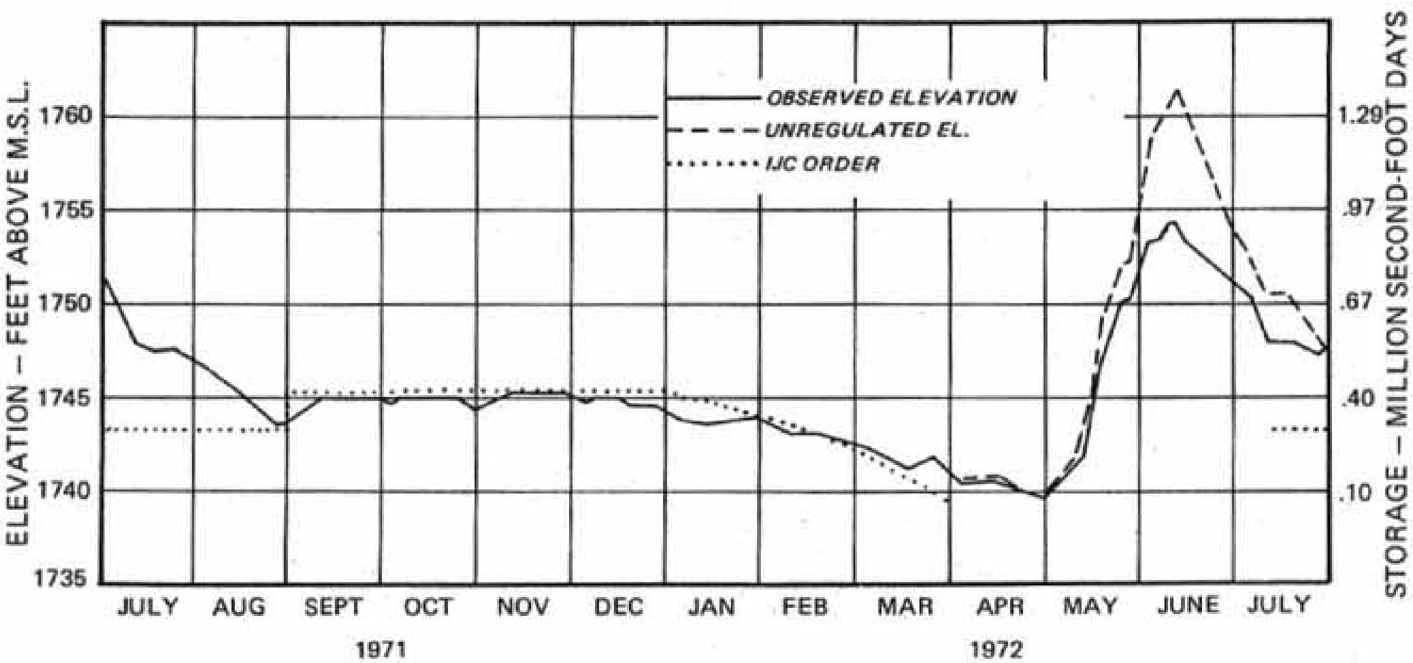
REGULATION OF DUNCAN
1 JULY 1971 – 31 JULY 1972

**CHART 6
DUNCAN**

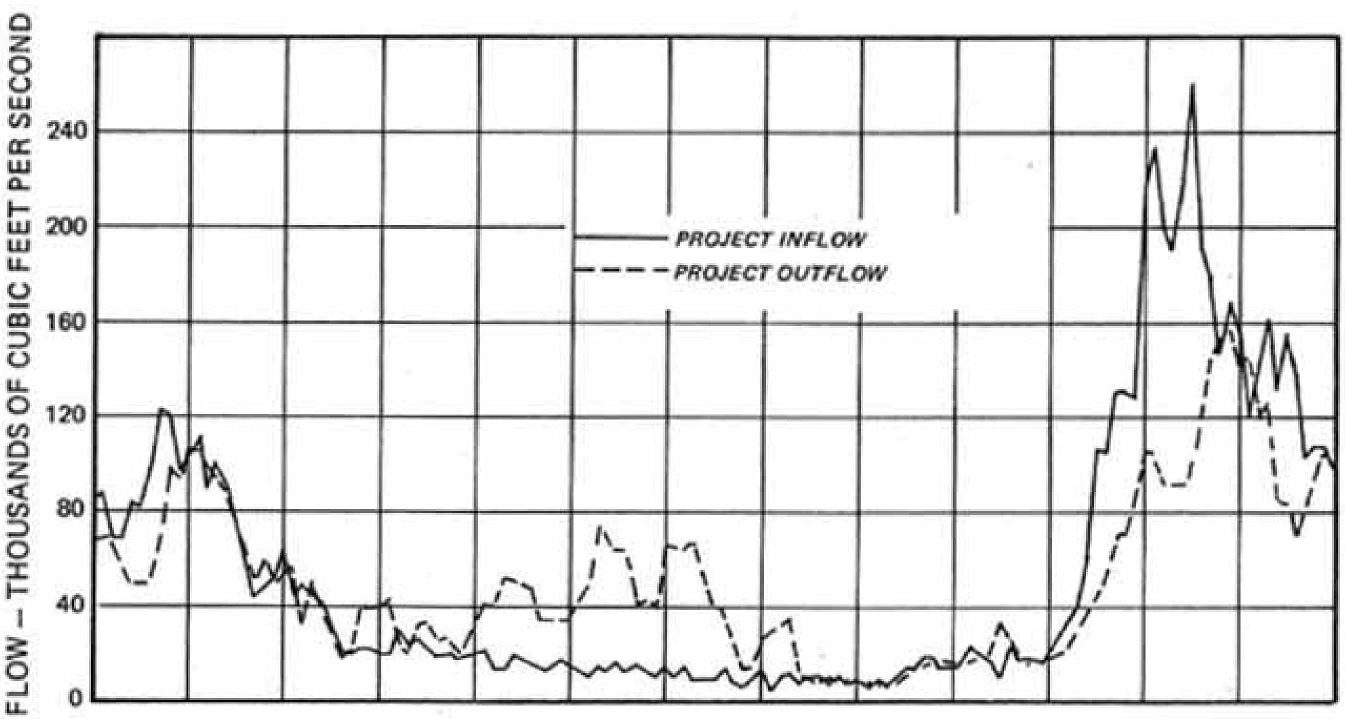


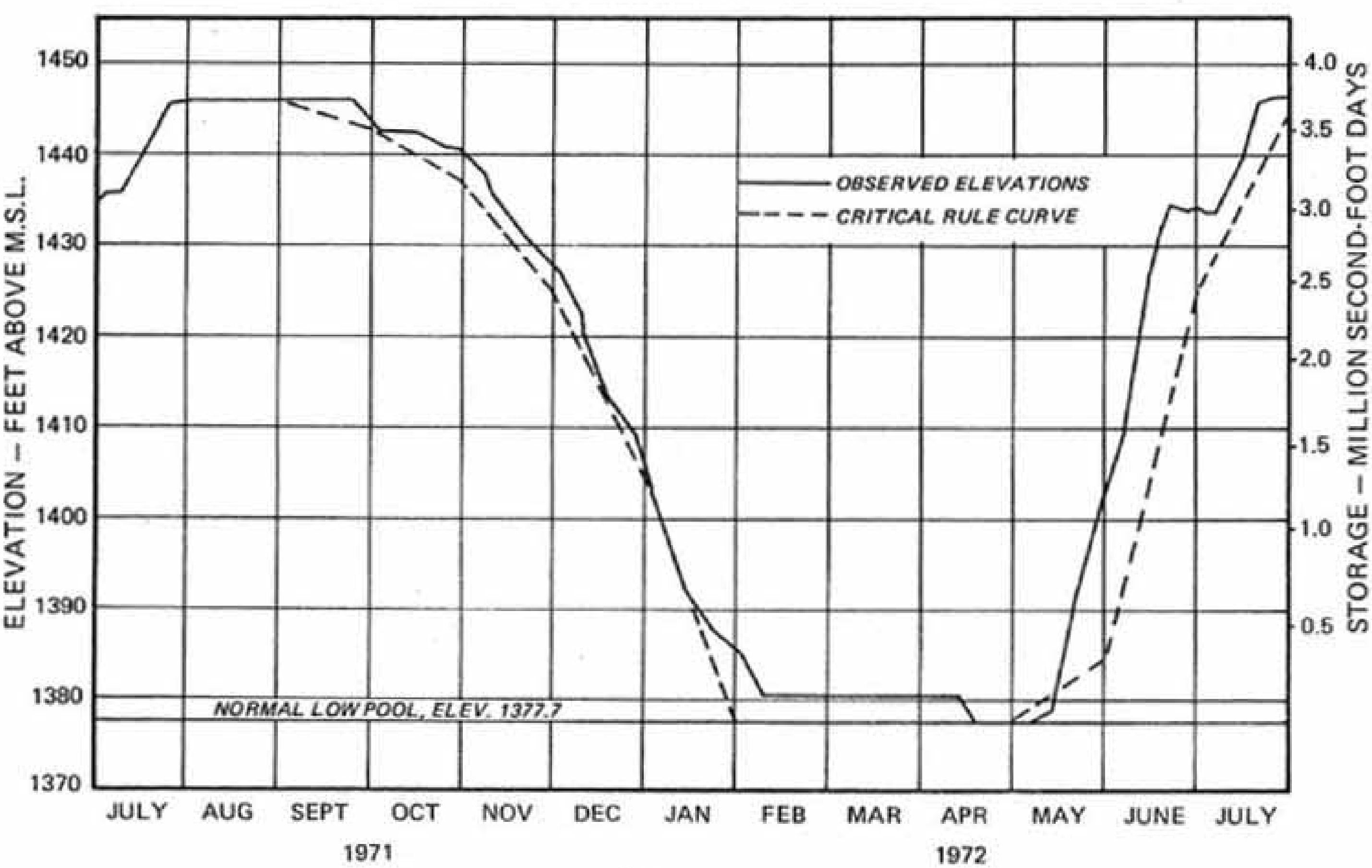
REGULATION OF KOOTENAY LAKE
1 JULY 1972 – 31 JULY 1972



REGULATION OF ARROW
1 JULY 1971 – 31 JULY 1972



COLUMBIA RIVER AT BIRCHBANK
1 JULY 1971 – 31 JULY 1972

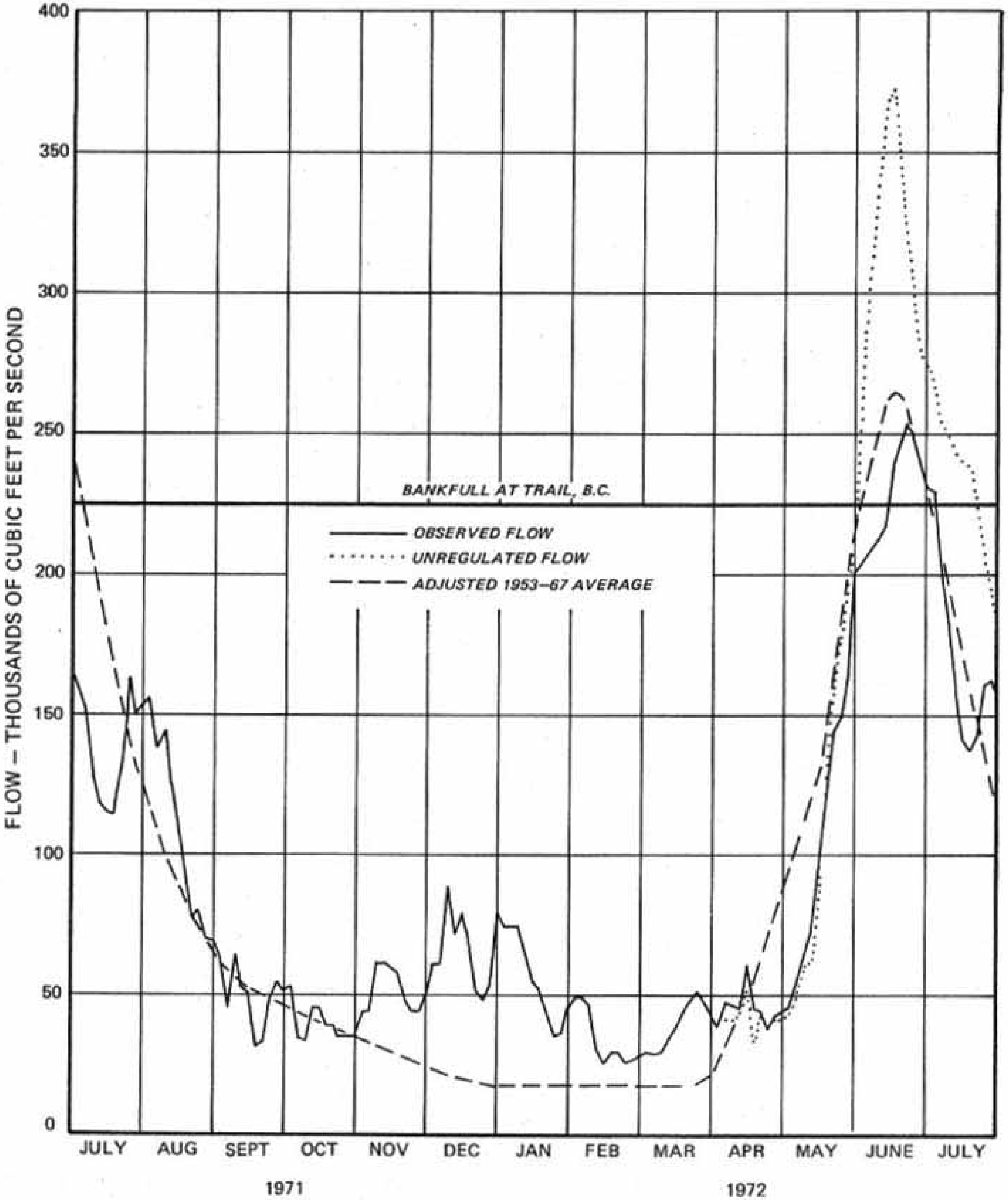
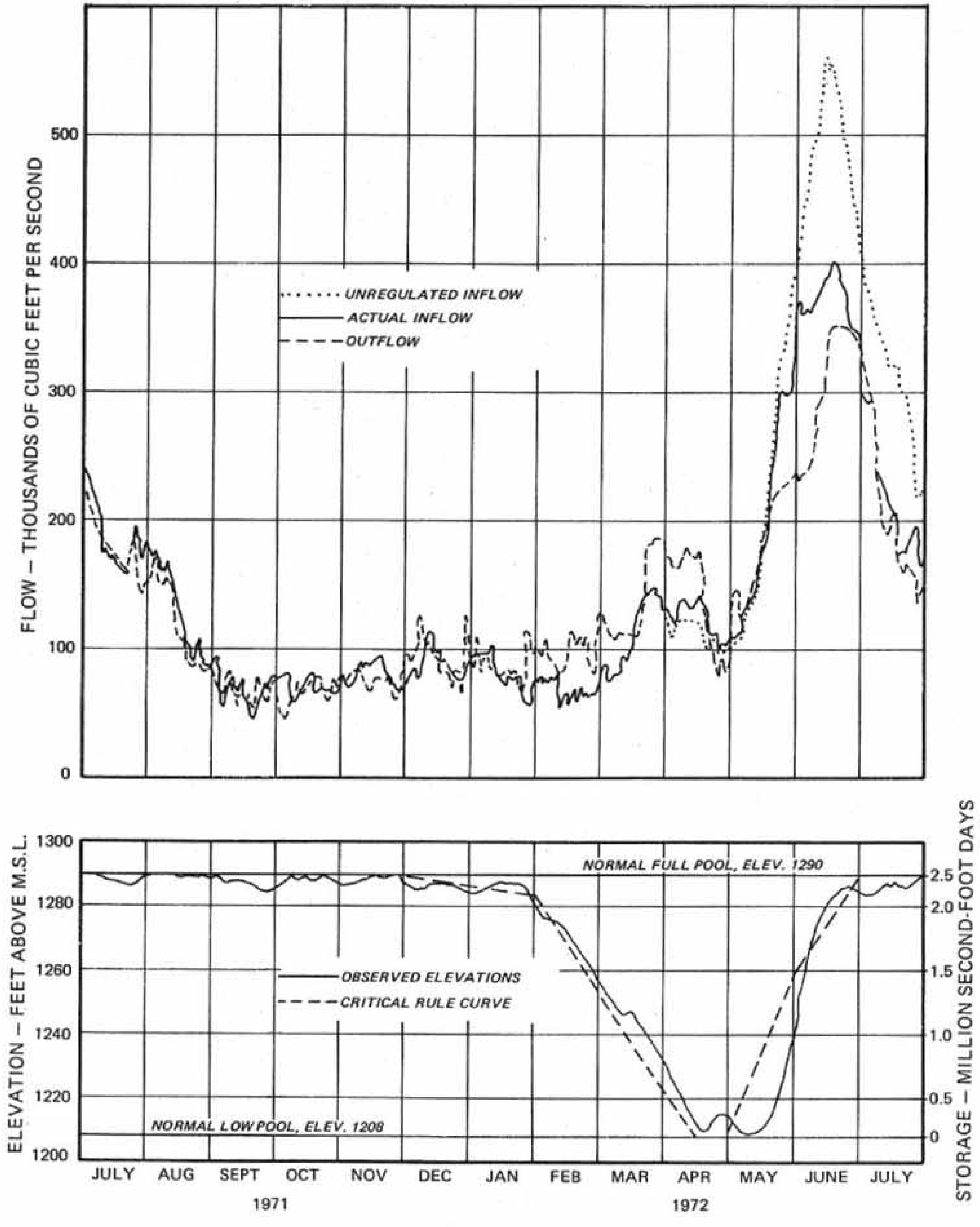
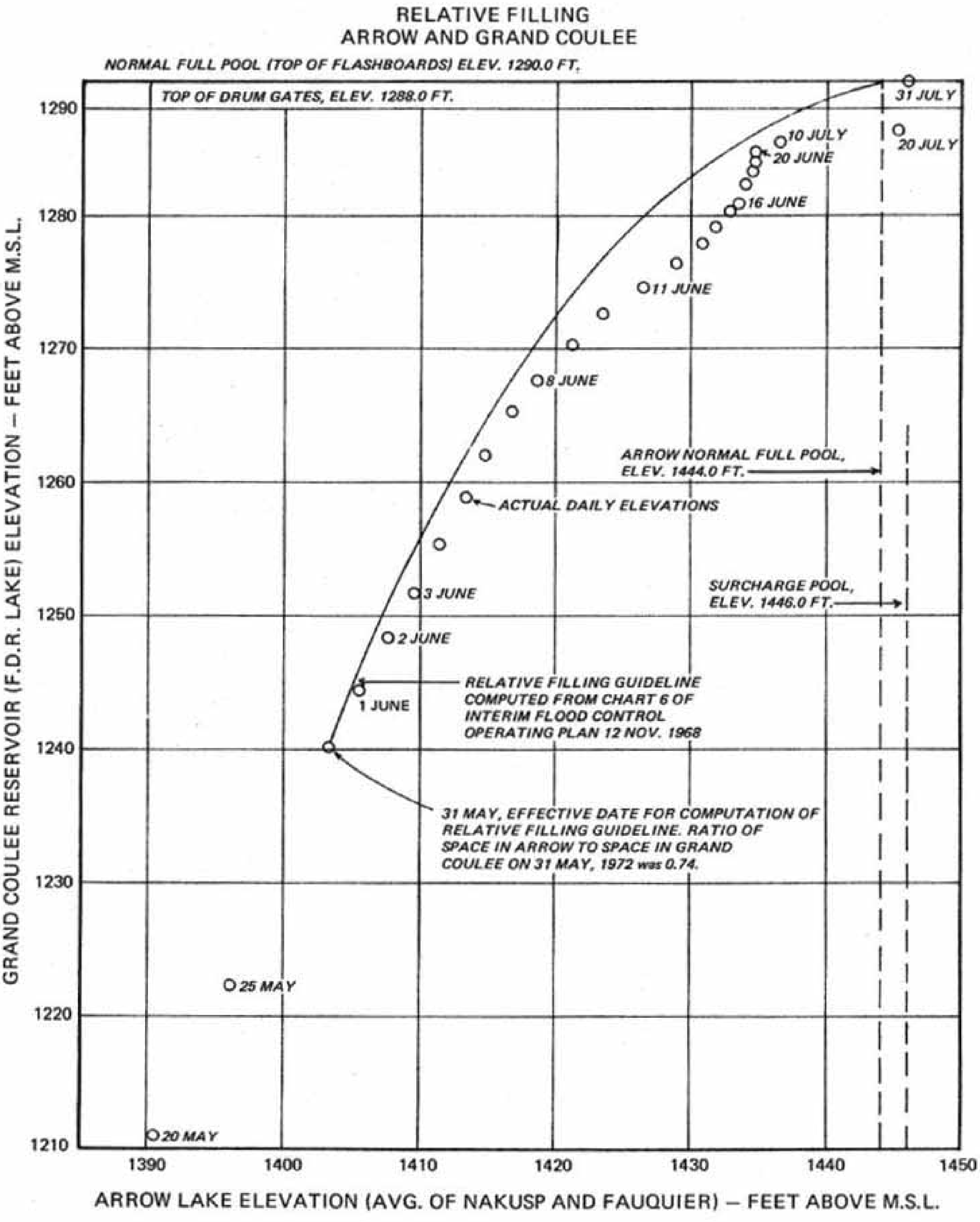


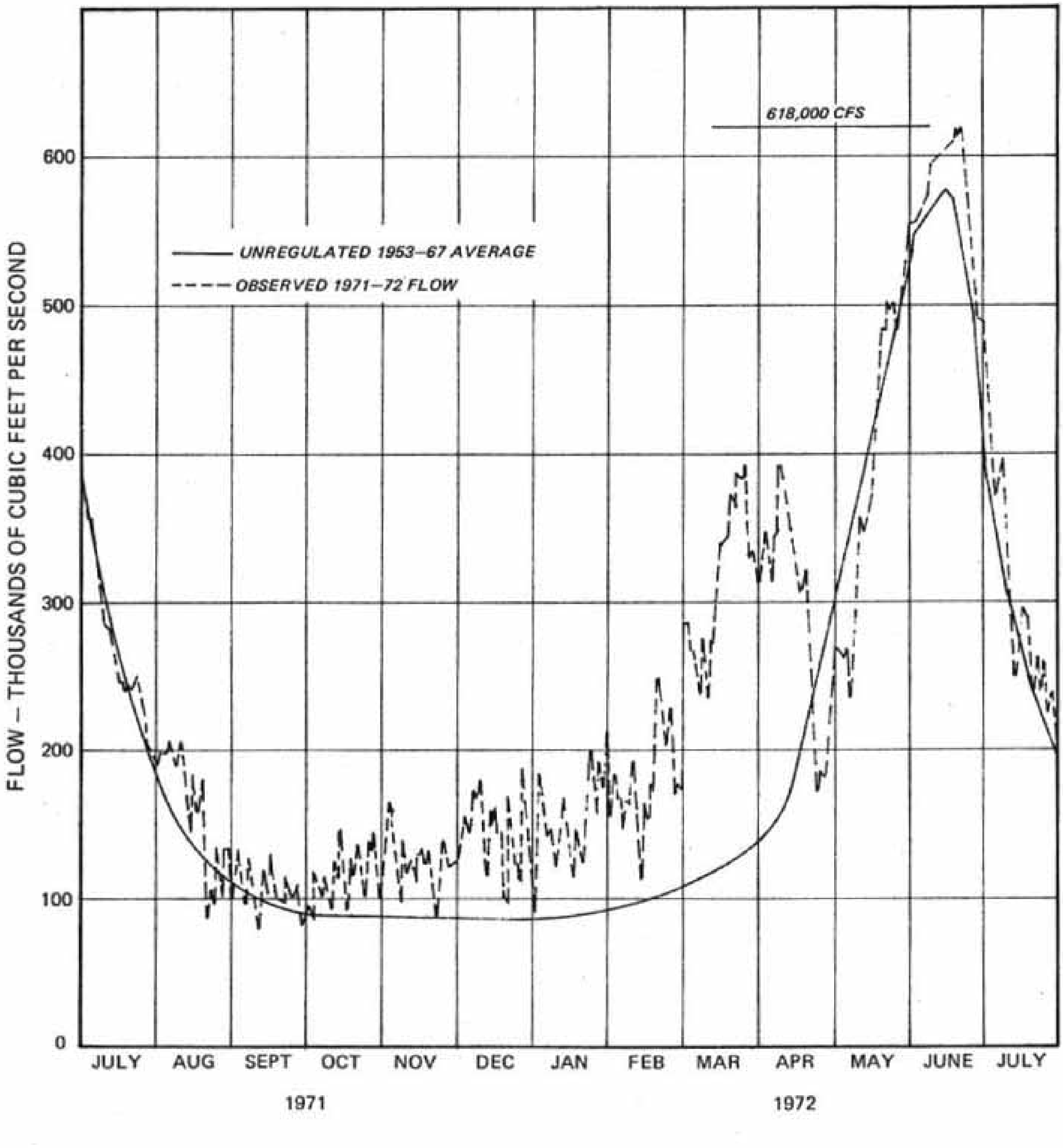
CHART 10
GRAND COULEE

REGULATION OF GRAND COULEE
1 JULY 1972 – 31 JULY 1972



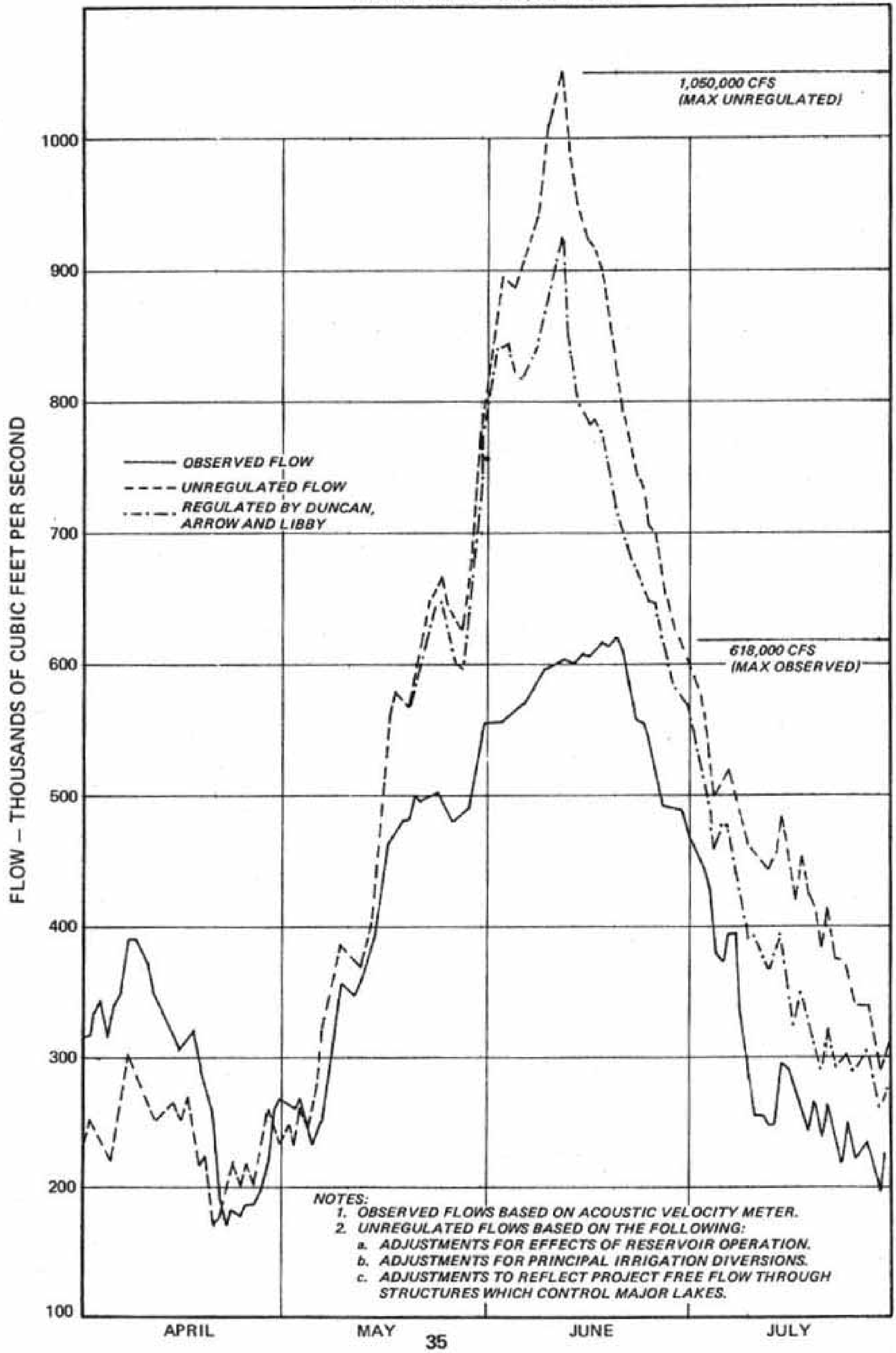

RELATIVE FILLING
ARROW AND GRAND COULEE
NORMAL FULL POOL (TOP OF FLASHBOARDS) ELEV. 1290.0 FT.
TOP OF DRUM GATES, ELEV. 1288.0 FT.
31 JULY
10 JULY
20 JULY
20 JUNE
16 JUNE
11 JUNE
8 JUNE
ARROW NORMAL FULL POOL, ELEV. 1444.0 FT.
ACTUAL DAILY ELEVATIONS
3 JUNE
SURCHARGE POOL, ELEV. 1446.0 FT.
2 JUNE
RELATIVE FILLING GUIDELINE COMPUTED FROM CHART 6 OF INTERIM FLOOD CONTROL OPERATING PLAN 12 NOV. 1968
1 JUNE
31 MAY, EFFECTIVE DATE FOR COMPUTATION OF RELATIVE FILLING GUIDELINE. RATIO OF SPACE IN ARROW TO SPACE IN GRAND COULEE ON 31 MAY, 1972 was 0.74.
25 MAY
20 MAY
GRAND COULEE RESERVOIR (F.D.R. LAKE) ELEVATION – FEET ABOVE M.S.L.
1210
1220
1230
1240
1250
1260
1270
1280
1290
1390
1400
1410
1420
1430
1440
1450
ARROW LAKE ELEVATION (AVG. OF NAKUSP AND FAUQUIER) – FEET ABOVE M.S.L.

COLUMBIA RIVER AT THE DALLES
1 JULY 1971 – 31 JULY 1972



COLUMBIA RIVER AT THE DALLES
1 APRIL 1972 – 31 JULY 1972

CHART 13
THE DALLES



## REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period 1 August 1970 through 31 July 1971:


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 Plans for Canadian Storage, Operating Years 1969-70 through 1974-75", dated 15 February 1969.

3. "Columbia River Treaty Detailed Operating Plan for Canadian Storage, 1 July 1971 through 31 July 1972", dated 19 August 1971.

4. "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", dated 12 November 1968.