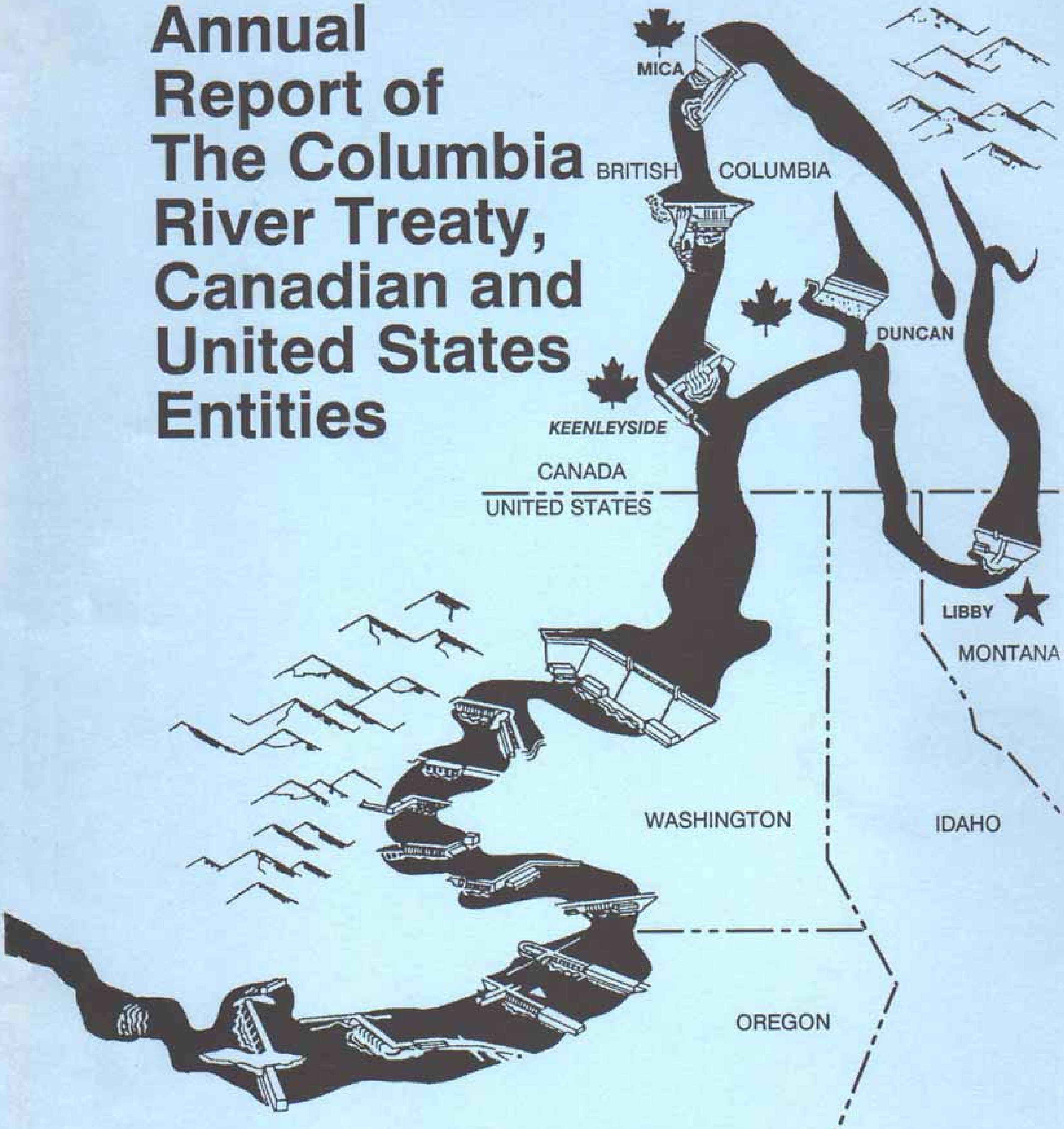
Annual Report of The Columbia River Treaty, Canadian and United States Entities



1 October 1989 through
30 September 1990

November 1990

ANNUAL REPORT OF
THE COLUMBIA RIVER TREATY
CANADIAN AND UNITED STATES ENTITIES

FOR THE PERIOD

1 OCTOBER 1989 - 30 SEPTEMBER 1990

Executive Summary

Entity

Agreements approved by the Entities during the period of this report include:

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1989 through 31 July 1990, dated September 1989.
- Entity Agreement relating to use of the Columbia River non-Treaty storage, Mica and Arrow reservoir enhancement and initial filling of non-Treaty storage, dated July 1990.

System Operation

The coordinated system filled to 87.6 percent of capacity by 31 July 1989. As a result, second year firm energy load carrying capability was adopted for the 1989-90 operating year. Between August and December the system proportionally drafted to meet FELCC. Autumn was much drier than normal and virtually no snowpack accumulation occurred in December.

The 1 January water supply forecast for the Columbia River at The Dalles was 86.5 MAF, or 79.6 percent of average. Precipitation and snowfall for the January-July period was above normal causing water supply to increase above January forecast. The May precipitation was 171% of the 1961-85 average. The actual observed runoff was 99.7 MAF or 91.7 percent of average.

The peak daily average flow observed at The Dalles was 371,900 cfs. The lower Columbia River was regulated on a daily basis for flood control between 30 May and 19 June. The system storage content reached 99.1 percent of capacity on 31 July. This is the first time that the system refilled since 1987. Generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement, was 349 average megawatts at rates up to 1017 megawatts. All CSPE power was used to meet Pacific Northwest loads.

Project Operation

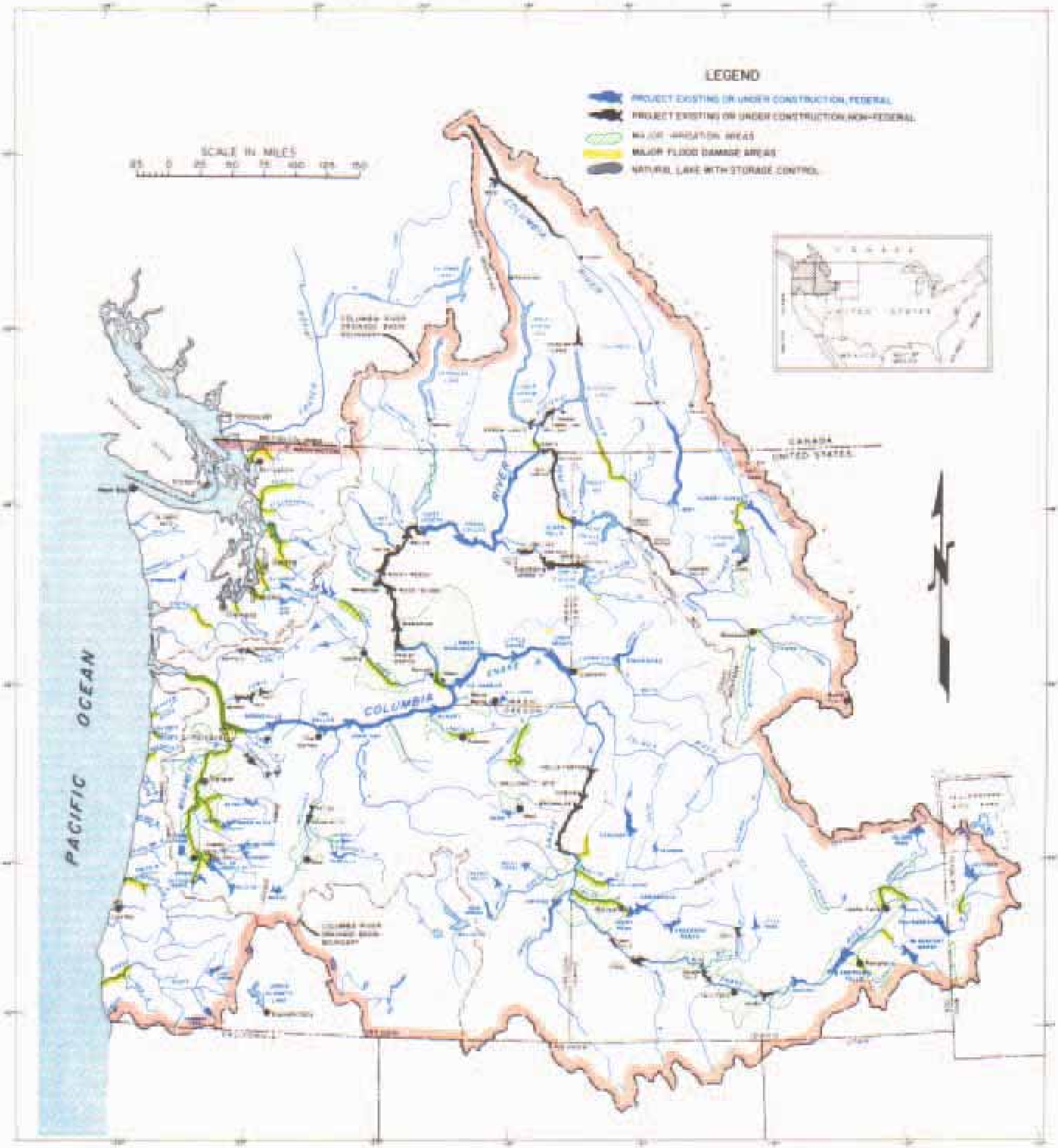
Mica treaty storage reached full content on 17 September 1989. The reservoir reached its lowest level, 2389.6 feet on 17 April 1990. Full treaty storage content was again reached on 10 August 1990. The maximum level for the operating year, 2474.08 feet, was reached on 23 August. This was Mica's highest level since it filled to full pool, elevation 2475 feet in August 1986.

During the 1989 operating year, Arrow reached its maximum level of 1442.9 feet on 23 July 1989. The reservoir drafted throughout autumn and winter, reaching a minimum elevation of 1385.0 feet on 6 April. The maximum level for the 1990 operating year was elevation 1446.0 feet on 11 September as BPA and BCH took advantage of runoff conditions to fill the reservoir above normal full pool, elevation 1444.0 feet.

Duncan reservoir completely filled during the 1989 operating year and remained full until 1 September. During September there was about six feet of draft. However, during October the outflow was reduced to minimum and the reservoir filled to full pool on 10 November. The reservoir remained full until 9 December when it was drafted along the flood control rule curve. Above normal flows in January and February prevented all the flood control space to be removed from Duncan and Libby while allowing Kootenay Lake to meet IJC rule curve requirements. The reservoir reached its lowest level during the operating year, 1822.7 feet, on 23 May 1990. The reservoir reached full pool, elevation 1892.0 feet, on 31 July and remained close to full through August.

During the 1989 operating year, Libby reservoir reached a maximum elevation of 2452.6 feet on 31 July 1989. This was the second consecutive year that the reservoir did not fill. The reservoir was drawn down 10 feet in August and passed inflow during September. On 31 December the reservoir was at elevation 2389.4 feet. A minimum level of 2325.5 feet was reached on 30 March. The reservoir reached full pool, elevation 2459.0 feet on 26 July and remained in its top foot through 16 September.

COLUMBIA RIVER AND COASTAL BASINS



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I Introduction

This annual Columbia River Treaty Entity Report is for the 1990 Water Year, 1 October 1989 through 30 September 1990. It includes information on the operation of Mica, Arrow, Duncan, and Libby reservoirs during that period with additional information covering the reservoir system operating year, 1 August 1989 through 31 July 1990. The power and flood control effects downstream in Canada and the United States are described. This report is the twenty-fourth of a series of annual reports covering the period since the ratification of the Columbia River Treaty in September 1964.

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 for flood control in the United States of America and in Canada. In 1964, the Canadian and the United States governments each designated an Entity to formulate and carry out the operating arrangements necessary to implement the Treaty. The Canadian Entity is the British Columbia Hydro and Power Authority (B.C. Hydro). The United States Entity is the Administrator of the Bonneville Power Administration (BPA) and the Division Engineer of the North Pacific Division, Army Corps of Engineers (ACE).

The following is a summary of key features of the Treaty and related documents:

1. Canada is to provide 15.5 million acre-feet (maf) of usable storage. (This has been accomplished with 7.0 maf in Mica, 7.1 maf in Arrow and 1.4 maf in Duncan.)

2. For the purpose of computing downstream benefits the U.S. hydroelectric facilities will be operated in a manner that makes the most effective use of the improved streamflow resulting from operation of the Canadian storage.

3. The U.S. and Canada are to share equally the additional power generated in the U.S. resulting from operation of the Canadian storage.

4. The U.S. paid Canada a lump sum of the $64.4 million (U.S.) for expected flood control benefits in the U.S. resulting from operation of the Canadian storage.

5. The U.S. has the option of requesting the evacuation of additional flood control space above that specified in the Treaty, for a payment of $1.875 million (U.S.) for each of the first four requests for this "on-call" storage.

6. The U.S. constructed Libby Dam with a reservoir that extends 42 miles into Canada and for which Canada made the land available.

7. Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

8. Differences arising under the Treaty which cannot be resolved by the two countries may be referred to either the International Joint Commission (IJC) or to arbitration by an appropriate tribunal.

9. The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

10. In the Canadian Entitlement Purchase Agreement of 13 August 1964, Canada sold its entitlement to downstream power benefits to the United States for 30-years beginning at Duncan on 1 April 1968, at Arrow on 1 April 1969, and at Mica on 1 April 1973.

11. Canada and the U.S. are each to appoint Entities to implement Treaty provisions and are to jointly appoint a Permanent Engineering Board (PEB) to review and report on operations under the Treaty.

II Treaty Organization

Entities

There was one meeting of the Columbia River Treaty Entities (including the Canadian Entity Representative and U.S. Coordinators) during the year on the morning of 30 November 1989 in Portland, Oregon. The members of the two Entities during the period of this report were:

UNITED STATES ENTITY	CANADIAN ENTITY
Mr. James J. Jura, Chairman Administrator, Bonneville Power Administration Department of Energy Portland, Oregon	Mr. Larry I. Bell, Chairman Chairman, British Columbia Hydro and Power Vancouver, B.C.
Brigadier General Pat M. Stevens IV Division Engineer North Pacific Division Army Corps of Engineers Portland, Oregon	

The Entities have appointed Coordinators and a Representative and two joint standing committees to assist in Treaty implementation activities. These are described in subsequent paragraphs. The primary duties and responsibilities of the Entities as specified in the Treaty and related documents are:

1. Plan and exchange information relating to facilities used to obtain the benefits contemplated by the Treaty.

2. Calculate and arrange for delivery of hydroelectric power to which Canada is entitled and the amounts payable to the U.S. for standby transmission services.

3. Operate a hydrometeorological system.

4. Assist and cooperate with the Permanent Engineering Board in the discharge of its functions.

5. Prepare hydroelectric and flood control operating plans for the use of Canadian storage.

6. Prepare and implement detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under assured operating plans.

7. The Treaty provides that the two governments may, by an exchange of notes, empower or charge the Entities with any other matter coming within the scope of the Treaty.

Entity Coordinators and Representative

The Entities have appointed members of their respective staffs to serve as coordinators or focal points on Treaty matters within their organizations.

The members are:

UNITED STATES ENTITY COORDINATORS

Edward W. Sienkiewicz, Coordinator
Senior Asst. Administrator for Power Management
Bonneville Power Administration
Portland, Oregon

Robert P. Flanagan, Coordinator
Chief, Engineering Division
North Pacific Division
Army Corps of Engineers
Portland, Oregon

Joseph Volpe, Jr., Secretary
Hydraulic Engineer, Hydro Canadian Section
Division of Power Resources
Bonneville Power Administration
Portland, Oregon

CANADIAN ENTITY REPRESENTATIVE

Douglas R. Forrest, Manager
Canadian Entity Services
B.C. Power Export Corporation
Vancouver, B.C.

Mr. Volpe was appointed on 21 November 1989 to succeed Mr. John M. Hyde. Mr. Volpe passed away on 25 July 1990. The US Entity recognizes the significant contributions Mr. Volpe has made to treaty planning studies over the past years. The secretary position has not yet been reassigned.

Entity Operating Committee

The Operating Committee was established in September 1968 by the Entities and is responsible for preparing and implementing operating plans as required by the Columbia River Treaty, making studies and otherwise assisting the Entities as needed. The Operating Committee consists of eight members as follows:

UNITED STATES SECTION

Robert D. Griffin, BPA, Co-Chairman
Nicholas A. Dodge, ACE, Co-Chairman
Russell L. George, ACE
John M. Hyde, BPA

CANADIAN SECTION

Timothy J. Newton, BCH, Chairman
Ralph D. Legge, BCH
Kenneth R. Spafford, BCH
Lawrence E. Nelson, BCH

There were six meetings of the Operating Committee during the year. The dates, places and number of persons attending those meetings were:

Date	Location	Attendees
16 November 1989	Vancouver, B.C.	14
25 January 1990	Portland, Oregon	16
21 March 1990	Vancouver, B.C.	13
31 May 1990	Portland, Oregon	18
26 July 1990	Castlegar, B.C.	14
27 September 1990	Portland, Oregon	12

The Operating Committee coordinated the operation of the Treaty storage in accordance with the current hydroelectric and flood control operating plans. This aspect of the Committee's work is described in following sections of this report which has been prepared by the Committee with the assistance of others. During the period covered by this report, the Operating Committee completed the 1989-90 Detailed Operating Plan (DOP), and completed studies for the 1994-95 Assured Operating Plan.

Entity Hydrometeorological Committee

The Hydrometeorological Committee was established in September 1968 by the Entities and is responsible for planning and monitoring the operation of data facilities in accord with Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Carolyn A. Bohan, BPA, Co-Chairman	William Chin, BCH, Chairman
Douglas D. Speers, ACE, Co-Chairman	John R. Gordon, BCH, Member

Ms. Bohan was appointed to succeed Mr. Mark Maher on 19 July 1990. There was one meeting of the Hydrometeorological Committee on 24 October 1989 in Portland. The committee reviewed the 1989 volume forecast results, hydromet station changes, developments on telemetry and changes in forecast procedures. In general, data was exchanged smoothly with no major problems.

Permanent Engineering Board

Provisions for the establishment of the Permanent Engineering Board (PEB) and its duties and responsibilities are included in the Treaty and related documents. The members of the PEB are presently:

UNITED STATES SECTION	CANADIAN SECTION
Herbert H. Kennon, Chairman, Washington, D.C.	G.M. MacNabb, Chairman Ottawa, Ontario
Ronald H. Wilkerson, Member Tulsa, Oklahoma	Doug H. Horswill, Member Victoria, B.C.
John P. Elmore, Alternate Washington, D.C.	Don A. Kasianchuk, Alternate Victoria, B.C.
Thomas L. Weaver, Alternate Golden, Colorado	E.M. Clark, Alternate & Secretary Vancouver, B.C.
S.A. Zanganeh, Secretary Washington, D.C.	

Mr. Kennon was appointed to succeed Mr. Lloyd Duscha as Chairman of the US Section on 27 March 1990. Mr. John Elmore was appointed to succeed Mr. Kennon on 27 March 1990 as alternate member of the US Section.

In general, the duties and responsibilities of the PEB are to assemble records of flows of the Columbia River and the Kootenay River at the international boundary; report to both governments if there is deviation from the hydroelectric or flood control operating plans, and if appropriate, include recommendations for remedial action; assist in reconciling differences that may arise between the Entities; make periodic inspections and obtain reports as needed from the Entities to assure that Treaty objectives are being met; make an annual report to both governments and special reports when appropriate; consult with the Entities in the establishment and operation of a hydrometeorological system; and, investigate and report on any other Treaty related matter at the request of either government.

The Entities continued their cooperation with the PEB during the past year by providing copies of Entity agreements, operating plans, downstream power benefit computations, corrections to hydrometeorological documents, and the annual Entity report to the Board for their review. The annual joint meeting of the Permanent Engineering Board and the Entities was held on the afternoon of 30 November 1989 in Portland, Oregon.

PEB Engineering Committee

The PEB has established a PEB Engineering Committee (PEBCOM) to assist in carrying out its duties. The members of PEBCOM are presently:

UNITED STATES SECTION

S.A. Zanganeh, Acting Chairman
Washington, D.C.
Gary L. Fuqua, Member
Portland, Oregon
Earl E. Eiker, Alternate Member
Washington, D.C.
Stephen J. Wright, Alternate Member
Washington, D.C.

CANADIAN SECTION

R.O. "Neil" Lyons, Chairman
Vancouver, B.C.
Bill Stipdonk, Member
Victoria, B.C.

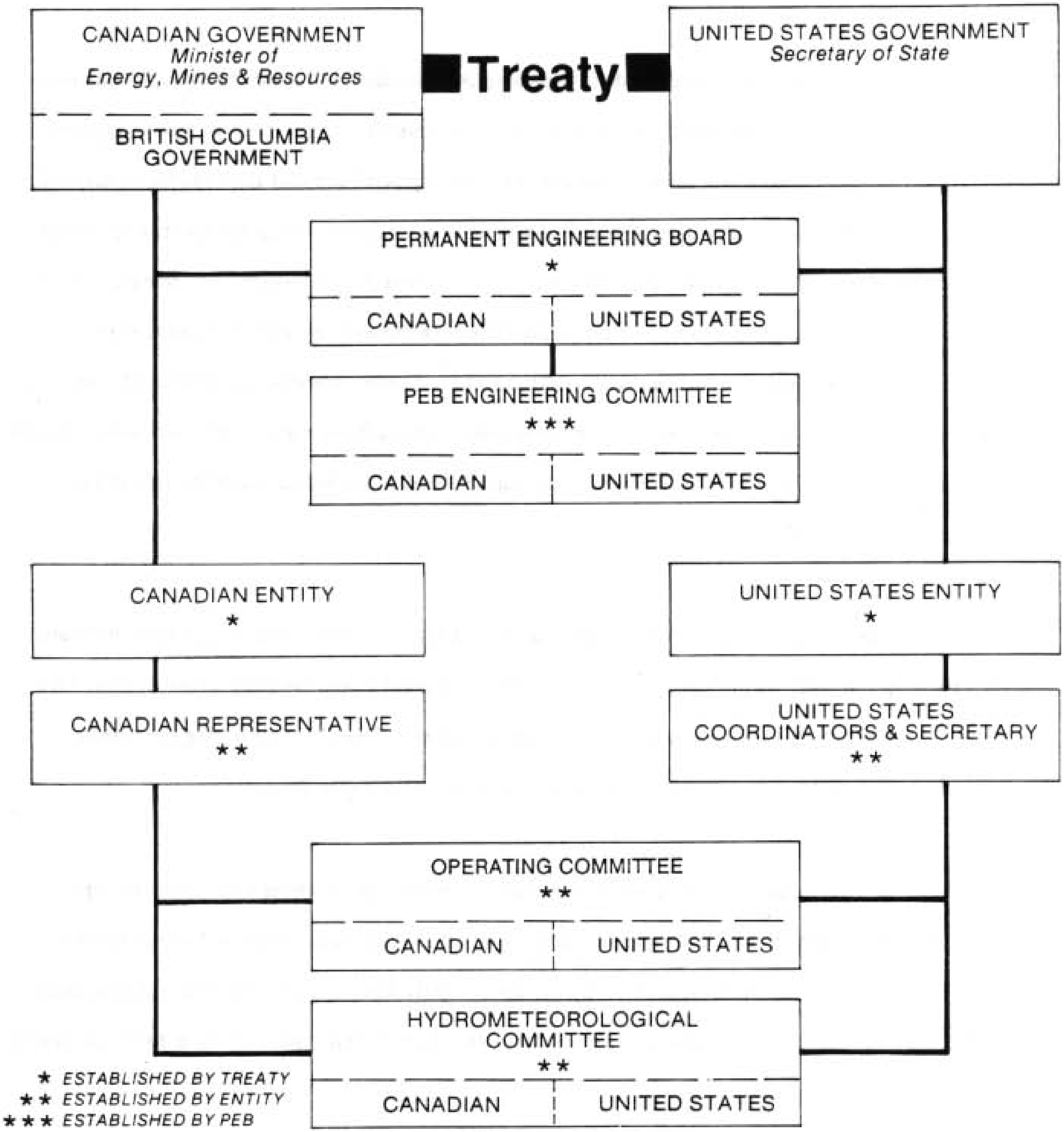
Mr. Eiker was appointed as alternate member of the US Section on 25 June 1990.

International Joint Commission

The International Joint Commission (IJC) was created under the Boundary Waters Treaty of 1909 between Canada and the U.S. Its principal functions are rendering decisions on the use of boundary waters, investigating important problems arising along the common frontier not necessarily connected with waterways, and making recommendations on any question referred to it by either government. If a dispute concerning the Columbia River Treaty could not be resolved by the Entities or the PEB it would probably be referred to the IJC for resolution before being submitted to a tribunal for arbitration.

The IJC has appointed local Boards of Control to insure compliance with IJC orders and to keep the IJC currently informed. There are four such boards west of the continental divide. These are the International Kootenay Lake Board of Control, the International Columbia River Board of Control, the International Osoyoos Lake Board of Control and the International Skagit River Board of Control. The Entities and their committees conducted their Treaty activities during the period of this report so that there was no known conflict with IJC orders or rules.

Columbia River Treaty Organization



III Operating Arrangements

Power and Flood Control Operating Plans

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

The "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans" dated May 1983 together with the "Columbia River Treaty Flood Control Operating Plan" dated October 1972, establish and explain the general criteria used to plan and operate Treaty storage during the period covered by this report. These documents were previously approved by the Entities.

The planning and operation of Treaty Storage as discussed on the following pages is for the operating year, 1 August through 31 July. The planning and operating for U.S. storage operated according to the Pacific Northwest Coordination Agreement is done for a slightly different operating year, 1 July through 30 June. Therefore, most of the hydrographs and reservoir charts in this report are for a 13 month period, July 1989 through July 1990.

Assured Operating Plan

The Assured Operating Plan (AOP) dated October 1984 established Operating Rule Curves for Duncan, Arrow and Mica during the 1989-90 operating year. The Operating Rule Curves provided guidelines for refill levels as well as draft levels. They were derived from Critical Rule Curves, Assured Refill Curves, Upper Rule Curves, and Variable Refill Curves, consistent with flood control requirements, as described in the 1983 Principles and Procedures document. The Flood Control Storage Reservation Curves were established to conform to the Flood Control Operating Plan of 1972.

Determination of Downstream Power Benefits

For each operating year, the Determination of Downstream Power Benefits resulting from Canadian Treaty storage is made five years in advance in conjunction with the Assured Operating Plan. For operating years 1989-90 and 1990-91 the estimates of benefits resulting from operating plans designed to achieve optimum operation in both countries were less than that which would have prevailed from an optimum operation in the United States only. Therefore, in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement, the Entities agreed that the United States was entitled to receive 3.4 average megawatts of energy during the period 1 August 1989 through 31 March 1990, and 2.7 average megawatts of energy during the period from 1 April through 31 July 1990. Suitable arrangements were made between the Bonneville Power Administration and B.C. Hydro for delivery of this energy. Computations indicated no loss or gain in dependable capacity during the 1989-90 operating year.

Detailed Operating Plan

During 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" (DOP), dated September 1989. The DOP established criteria for determining the Operating Rule Curves for use in actual operations. Except for six minor changes at Arrow, the DOP used the AOP critical rule curves for Canadian Projects. The Variable Refill Curves and flood control requirements subsequent to 1 January 1990 were determined on the basis of seasonal volume runoff forecasts during actual operation. Results of the Actual Energy Regulation were used to determine the triggering of high releases from Mica. The regulation of the Canadian storage was conducted by the Operating Committee on a weekly basis throughout the year.

Entity Agreements

During the period covered by this report, two agreements were officially approved by the Entities. The following tabulation indicates the date each of these were signed and gives a description of the agreement:

Date Agreement Signed by Entities	Description
8 November 1989	Detailed Operating Plan on Columbia River Treaty Storage, 1 August 1989 through 31 July 1990, dated September 1989.
9 July 1990	Entity Agreement relating to use of the Columbia River non-Treaty Storage, Mica and Arrow reservoir enhancement and initial filling of non-Treaty storage.

Long Term Non-Treaty Storage Contract

BPA and BC Hydro executed an expanded and extended non-Treaty Storage Agreement on 9 July 1990. The agreement will be implemented on 9 November 1990. This agreement expands the total amount of jointly-managed non-Treaty storage in Mica from 2 maf to 4.5 maf. The entities have reviewed this agreement and are satisfied that mutual benefits can be achieved without adversely affecting the operation of Treaty space in accordance with the Columbia River Treaty or the performance of obligations pursuant to the Canadian Entitlement Purchase Agreement. The Operating Committee will continue to monitor operations under the Agreement.

In accordance with the 9 April 1984 Entity Agreement which approved the contract between B.C. Hydro and BPA relating to the initial filling of non-Treaty storage, coordinated use of non-Treaty storage, and Mica and Arrow refill enhancement, the Operating Committee monitored the storage operations made under this Agreement throughout the last year to insure that they did not adversely impact operation of Treaty storage required by the Detailed Operating Plan.

IV Weather and Streamflow

Weather

Chart 1 is a geographical illustration of the seasonal precipitation in the Columbia River Basin, in percent of normal, for the period 1 October 1989 through 31 March 1990. Chart 2 shows an index of the accumulated snowpack in the Columbia Basin above The Dalles in percent of normal for the period 1 January through 31 May 1990. Indices of temperature and precipitation for the Columbia Basin above the Dalles for the winter and snowmelt seasons are shown on Charts 3 and 4, respectively. Chart 5 illustrates temperature and precipitation indices for the Columbia Basin in Canada during the snowmelt season. The following paragraphs describe significant weather events between 1 August 1989 and 30 September 1990.

Weather during the 1989-90 operating year was highly variable both temporally and areally. The operating year began with unusually heavy rainfall during August. This was caused by a series of low pressure systems that passed through the basin along the US-Canadian border. The first, between 1st-3rd, produced below normal temperatures and very little rainfall. The second, from the 9th-17th, had normal temperatures and rainfall, while the third, 21st-28th, brought unseasonably low temperatures and heavy precipitation. Many subbasins all reported well in excess of 200% of normal precipitation for the month.

September was generally dry with only a narrow band of heavy precipitation extending from southern Oregon, through central Idaho, to western Montana. A high pressure system blocked the flow of moist air into the basin for most of the month. Two exceptions were: the 3rd and 4th when a series of upper atmospheric lows and surface fronts passed through the basin producing moderate precipitation, and on the 18th and 19th when the blocking ridge again broke down and precipitation blanketed the Northwest. The spotty nature of monthly precipitation in the Columbia Basin is indicated by precipitation indices which varied from 111 percent of normal in the Flathead basin to only 63 percent in the adjacent Kootenai basin. A typical procession of weather systems occurred through October although western Oregon did not see much precipitation until the latter portion of the month. Most of the weather systems were directed into northern Washington and southern British Columbia.

In early November an intense low pressure system moved through western Washington, changing the airflow to westerly, and directing surface fronts to the north Cascades across northern Idaho to western Montana. Extremely high 24-hour precipitation totals, coupled with high freezing levels, occurred at some locations in Montana as a result of this storm. Airflow changed to northwesterly by the 14th as a high pressure system built following the passage of the trough. The flow returned to westerly on the 19th as the ridge weakened. The jet stream dropped south by the 23rd and more weak fronts moved through the basin, bringing scattered showers. On the 28th a coastal ridge developed cutting off the source of moisture to the basin. November precipitation indices were extremely high, ranging from 129 percent of normal in the Kootenai basin and 153 percent in the upper Columbia, to 210 percent in the Flathead.

December was proportionally as dry as September. The ridge of high pressure began to weaken by 3 December and the jet stream moved south bringing heavy precipitation to northwestern Washington through the 4th. The coastal ridge temporarily disappeared permitting precipitation to move into Oregon and Idaho from the 5th through the 10th. The ridge rebuilt in the eastern Pacific and covered the west by the 11th. The ridge weakened by the 23rd and westerly flow brought scattered light showers throughout the northwest by month's end. Still, monthly precipitation indices for most sub-basins were only about 50 percent of normal.

A series of frontal systems and short wave troughs continually entered the Northwest for the first week of January. On the 9th on open wave frontal system brought extremely heavy rainfall to western Washington and northwest Oregon.

The moisture source for this storm was cut off on the 11th when a split flow system developed, protecting the Northwest from any new storms. This lasted through the 20th when short waves and frontal systems again began to move across the Northwest. On 8 February a low pressure system over the Aleutian Islands began to force the jet stream farther south over warmer water. This warmer, more moist air moved into Washington and British Columbia producing heavy precipitation. The pattern of regular storm passage remained through 12 February when a ridge of high pressure again moved onto the coast. By mid-month another ridge of high pressure formed in the Gulf of Alaska which cut off the source of moist air and brought the Northwest under the influence of air flowing over the cooler North Pacific waters until 3 March. By 5 March a new low had moved into the Gulf of Alaska, forcing the jet stream into Washington and British Columbia. Periodic fronts passed through the region until the 20th when a ridge began to build along the coast , blocking weather systems from the Northwest through the end of March. Precipitation indices were generally about 125 percent of normal for January, 100 percent for February and only 65 percent of normal for March.

The snowmelt season began with high temperatures averaging 10 to 20 °F above normal for the period 1-22 April. Precipitation was light as a broad stable ridge built over the west coast of the United States. Only a few scattered storms were able to penetrate the ridge and bring precipitation to the Northwest. The ridge began to break down later in April and precipitation spread to the entire Columbia Basin between the 21st and the 29th.

May temperatures were predominantly cool, ranging from 5 to 10 degrees below normal with the lone exception being a brief ridge of high pressure in early May which resulted in temperatures 5 to 20 degrees above normal for three days. This ridge cut off the basin's water supply until 7 May when another low brought with it precipitation for the entire basin. After a one day respite on 10 May another series of lows and upper air troughs began moving through the basin, continuing through 20 June 20. May precipitation varied from a low of 95% of normal in the Upper Snake subbasin (the only area below average) to a maximum of 312% in the Okanogan subbasin.

Cool, unsettled weather continued to dominate the region through mid-June. Well above average precipitation occurred during this time. The moisture source was finally cut off on 20 June when a high pressure ridge began building on the coasts of Oregon and Washington. This ridge moved over the Rocky Mountain states by the 23rd and cut off the supply of warmer moist surface air. Only scattered showers occurred during the remainder of the month. Temperatures returned to above normal levels 20-30 June for the first sustained warming since mid-April.

The first eight days of July were dominated by a weak low off the Washington coast which produced scattered showers mainly in the northern portions of the basin and brief cooling. This low filled and another formed in the western Gulf of Alaska and then a ridge formed on the Washington coast. Although the ridge broke down on 16 July the airflow into the basin remained zonal and without a good moisture source so there was virtually no precipitation in the basin until 31 July when a southwesterly component of the upper air pattern tapped the more moist southern ocean waters. Following the brief cooling early in the month, temperatures ranged from 5 to 10 degrees above normal between 9th and 18th before cooling to 15 degrees below normal late in the month. The month ended with the Columbia basin above Grand Coulee at 122% of normal, The Snake above Ice Harbor 90%, and the Columbia above The Dalles at 110% of normal precipitation.

Temperatures were well above normal during the first half of August and well below normal during the second half. Precipitation was extremely light for the first half of the month and accumulated at an above average rate the latter half. Precipitation indices for the month were generally about 125 percent of average.

The final monthly precipitation indices for the Columbia Basin above The Dalles are shown below for the 1990 water year. These indices are based on 60 stations and are computed at the end of each month after all the data are collected. Also shown in the table are the monthly indices as a percent of the 25-year average (1961-1985).

WY 90 INDICES

MONTH	PRECIPITATION (in.)	PRECIPITATION (%)	MONTH	PRECIPITATION (in.)	PRECIPITATION (%)
OCT 89	1.71	98	APR 90	2.04	124
NOV 89	2.82	101	MAY 90	3.07	171
DEC 89	1.51	45	JUN 90	1.93	100
JAN 90	3.77	122	JUL 90	1.20	113
FEB 90	2.17	99	AUG 90	1.58	125
MAR 90	1.23	64	SEP 90	0.31	21
			WATER YEAR	23.30	96

STREAMFLOW

The observed inflow and outflow hydrographs for the Treaty reservoirs for the period 1 July 1989 through 31 July 1990 are shown on Charts 6 through 9. Observed flows with the computed unregulated flow hydrographs for the same 13-month period for Kootenay Lake, Columbia River at Birchbank, Grand Coulee, and The Dalles are shown on Charts 10, 11, 12, and 13, respectively. Chart 14 is a hydrograph of observed and two unregulated flows at The Dalles during the April through July 1990 period including a plot of flows occurring if regulated only by the Treaty reservoirs. The following paragraphs describe significant streamflow events from the summer of 1989 through September 1990.

Streamflows in the basin above The Dalles was variable for most of the operating year, with November, December, April, and June exceeding the norm. The October through September runoff for The Dalles was 93 percent of the 1961-85 average. The peak regulated discharge for the Columbia River at The Dalles was 372,000 cfs on 8 June 1990.

The 1989-90 monthly natural streamflows and their percent of the 1961-85 average monthly flows are shown in the following table for the Columbia River at Grand Coulee and at The Dalles. These flows have been corrected for storage in lakes and reservoirs to exclude the effects of regulation.

	COLUMBIA RIVER AT GRAND COULEE IN CFS		COLUMBIA RIVER AT THE DALLES IN CFS	
TIME PERIOD	NATURAL FLOW	PERCENT OF AVERAGE	NATURAL FLOW	PERCENT OF AVERAGE
AUG 89	96,100	88	122,980	86
SEP 89	55,840	83	83,540	84
OCT 89	38,590	78	69,950	80
NOV 89	74,800	160	114,650	128
DEC 89	55,330	127	98,150	101
JAN 90	51,700	124	92,800	91
FEB 90	38,750	78	80,200	66
MAR 90	50,070	85	108,910	78
APR 90	168,690	151	275,420	126
MAY 90	227,750	85	330,890	77
JUN 90	361,420	106	493,000	95
JUL 90	222,790	111	273,550	101
YEAR	120,330	104	178,790	92

Seasonal Runoff Forecasts and Volumes

Observed 1990 April through August runoff volumes, adjusted to exclude the effects of regulation of upstream storage, are listed below for eight locations in the Columbia Basin:

Location	Volume In 1000 Acre-Feet	Percent of 1961-85 Average
Libby Reservoir Inflow	7613	117
Duncan Reservoir Inflow	2132	103
Mica Reservoir Inflow	12437	107
Arrow Reservoir Inflow	24688	105
Columbia River at Birchbank	44940	109
Grand Coulee Reservoir Inflow	65955	106
Snake River at Lower Granite Dam	16193	67
Columbia River at The Dalles	91600	96

Forecasts of seasonal runoff volume, based on precipitation and snowpack data, were prepared in 1990 as usual for a large number of locations in the Columbia River Basin and updated each month as the season advanced. Table 1 lists the April through August volume inflow forecasts for Mica, Arrow, Duncan, and Libby projects and for unregulated runoff for the Columbia River at The Dalles. Also shown in Table 1 are the actual volumes for these five locations. The forecasts for Mica, Arrow and Duncan inflow were prepared by B.C. Hydro and those for the lower Columbia River and Libby inflows were prepared by the United States Columbia River Forecasting Service. The 1 April 1990 forecast of January through July runoff for the Columbia River above The Dalles was 96.0 MAF and the actual observed runoff was 99.7 MAF. The following tabulation summarizes monthly forecasts since 1970 of the January through July runoff for the Columbia River above The Dalles compared to the actual runoff measured in millions of acre-feet (MAF):

Year	Jan	Feb	Mar	Apr	May	June	Actual
1970	82.5	99.5	93.4	94.3	95.1		95.7
1971	110.9	129.5	126.0	134.0	133.0	135.0	137.5
1972	110.1	128.0	138.7	146.1	146.0	146.0	151.7
1973	93.1	90.5	84.7	83.0	80.4	78.7	71.2
1974	123.0	140.0	146.0	149.0	147.0	147.0	156.3
1975	96.1	106.2	114.7	116.7	115.2	113.0	112.4
1976	113.0	116.0	121.0	124.0	124.0	124.0	122.8
1977	75.7	62.2	55.9	58.1	53.8	57.4	53.8
1978	120.0	114.0	108.0	101.0	104.0	105.0	105.6
1979	88.0	78.6	93.0	87.3	89.7	89.7	83.1
1980	88.9	88.9	88.9	89.7	90.6	97.7	95.8
1981	106.0	84.7	84.5	81.9	83.2	95.9	103.4
1982	110.0	120.0	126.0	130.0	131.0	128.0	129.9
1983	110.0	108.0	113.0	121.0	121.0	119.0	118.7
1984	113.0	103.0	97.6	102.0	107.0	114.0	119.1
1985	131.0	109.0	105.0	98.6	98.6	100.0	87.7
1986	96.8	93.3	103.0	106.0	108.0	108.0	108.3
1987	88.9	81.9	78.0	80.0	76.7	75.8	76.5
1988	79.2	74.8	72.7	74.0	76.1	75.0	73.7
1989	101.0	102.0	94.2	99.5	98.6	96.9	90.6
1990	86.5	101.0	104.0	96.0	96.0	99.5	99.7

V Reservoir Operation

General

The 1990 operating year was characterized by unusually wet autumn conditions, an extremely dry December with nearly no snowpack accumulation and then near normal rates of snowfall thereafter. At The Dalles, the observed January-July runoff was about 92 percent of average, about four percent higher than the April forecast and twelve percent higher than the January forecast. Although the runoff at The Dalles was below normal, it was the highest runoff since 1986 and much higher than the three previous years.

The operating year began with the coordinated reservoir system officially filled to 87.6 percent of capacity on 31 July 1989. As a result, second year firm energy load carrying capability (FELCC) for the 1989-90 operating year.

Second-year FELCC turned out to be similar to what first year would have been if it were adopted because a large amount of FELCC was shifted to the second year of the critical period in the 1988-89 coordination agreement operating program. This occurred because the 1988-89 coordination agreement operating plan was not finalized until early 1988 and by that time it was apparent to the utilities that the system would probably begin the 1988-89 operating year much less than full and second-year FELCC would likely be adopted.

The system operated in accordance with proportional draft requirements, with draft levels between second and third year critical rule curves July through September. For the October through December period the system was proportionally drafted between first and second year critical rule curves.

The 1 January water supply forecast was 86.5 maf, or 80 percent of the 1961-85 average. Subsequent forecasts through April ranged from 88 to 96 percent of average. As a result of the close-to-average forecasted water supply, no proportional draft was necessary after December to meet FELCC.

Weather in April was much warmer than normal, resulting in higher-than-usual April streamflow. May conditions were the reverse with unusually cool weather and below normal streamflow. Warm weather returned in late May and June runoff was near normal.

Water budget releases on the mid-Columbia to enhance flows for downstream migration of juvenile anadromous fish occurred between 14 and 28 May. During this period the Grand Coulee Dam's outflow was regulated to provide a weekly average flow of 140,000 cfs at Priest Rapids Dam. Flows at The Dalles on the lower Columbia River during this period averaged 203,000 cfs. After 28 May, warmer weather resulted in a major increase in natural flows, prompting flood control regulation of the Columbia, and no further water budget requests were necessary. Between 29 May and 15 June, the Priest Rapids discharge averaged 221,000 cfs and The Dalles discharge averaged 316,000 cfs.

The lower Columbia River was regulated on a daily basis for flood control between 30 May and 19 June. The river was last operated on a daily basis for spring flood control in 1984. The year's observed peak flow at The Dalles was 371,900 cfs on 9 June. Although this peak flow is near the long-term average peak, it was the highest peak flow since 1986 when it was 388,000 cfs.

By 24 July the coordinated system had filled to 98 percent of its full capacity, allowing first-year FELCC to be adopted for the 1990-91 operating year. Due to the recent string of low water years, 1988 was the last operating year in which first-year FELCC has been served.

Mica Reservoir

As shown in Chart 6, Mica Reservoir (Kinbasket Lake) had filled to elevation 2433 feet by 31 July 1989, or 42 feet below full pool. At this time, BPA Non-Treaty storage (BPA NTS) was empty, B.C. Hydro non-Treaty Storage (BCH NTS) contained 87 ksfd, and Mica Treaty storage was approximately 70% full (2490 ksfd). Mica continued to fill through August and September, and Treaty storage had completely filled by 17 September. During August and September, BCH NTS content remained essentially unchanged, but BPA NTS began to fill until late September when it was again drafted back to empty. During this period, the Mica discharge ranged from 0 to 25,000 cfs.

In October, Mica was drafted 0.2 MAF in accordance with its flood control rule curve. In November, the Mica Treaty storage release was triggered, per the Detailed Operating Plan (DOP), to a level above the normal schedule, due to low Treaty storage in Arrow. Both BCH and BPA began storing into NTS in early October and generally stored through 21 January. During this period, the combined NTS content increased from 83 to 619.5 ksfd. Then, during February, March, and early April both parties drafted their NTS to a combined content of 233 ksfd before resuming storing on 7 April. Mica treaty storage continued drafting until 17 April when Mica reached its lowest elevation of the year at 2389.6 feet.

Mica began filling on 18 April. Inflows rose rapidly beginning in late May and peaked at 86,780 cfs on 25 June. The Mica discharge was kept relatively low (below 20,000 cfs) until 1 July to avoid exceeding the flood control rule curve at Arrow. On 1 July, the Mica DOP discharge increased from 10,000 cfs to 34,000 cfs and Mica began discharging maximum capacity to reduce the potential for spill. Both BCH and BPA continued storing into NTS through June and both non-Treaty accounts were filled by 30 June (504.167 ksfd each).

Mica continued filling during July and August. Treaty storage reached its full content on 10 August and remained full through September. Mica reached its highest elevation of the year, 2474.08 feet, on 23 August. This was Mica's highest level since it filled to elevation 2475.39 in August 1986.

Revelstoke Reservoir

During the past operating year, Revelstoke was generally operated as a run-of-the-river plant, maintaining the reservoir level within five feet of its normal full pool elevation of 1880.0 feet.

In early March Revelstoke reservoir was drawn down approximately seven feet in preparation for dredging in the project's tailrace. The first phase of the dredging was completed between March and June 1989 and the second phase took place from 16 March to 30 April, 1990. Once the dredging was completed, the reservoir was refilled to near full pool.

On 12 June, two mudslides near Ashton Creek, B.C. destroyed the two 500 kV transmission lines from Revelstoke. With no transmission capability, Revelstoke was unable to generate in excess of the small local load. The reservoir quickly filled to full pool and Revelstoke began spilling on 14 June. Revelstoke continued to spill until 17 June when one of the 500 kV transmission lines was repaired.

On 19 July, Revelstoke was again drawn down about nine feet in order to minimize the potential for spill at Revelstoke in case Mica began to spill. By mid-August the potential of spill at Mica had reduced and Revelstoke began refilling, reaching full pool late in the month.

Arrow Reservoir

As shown in Chart 7, Arrow reservoir reached its highest level of 1989, elevation 1442.9 feet, about 1.1 feet below normal full pool, on 23 August. Then, as the runoff receded, Arrow Treaty storage began drafting in early September to meet FELCC. Arrow continued drafting until early November when, due to high inflows and reduced downstream draft requirements, it refilled approximately five feet. However, the 31 October Arrow elevation was low enough to trigger increased Treaty storage releases from Mica as specified by the DOP Mica Operating Criteria. Arrow reservoir elevation remained at around 1435 feet from late November until the end of December.

Beginning in early January, Arrow reservoir began drafting rapidly in accordance with its flood control rule curve. Between January and March, discharges from the project, except for a few periods, ranged from 40,000 cfs to 80,000 cfs. A mid-week change in the Treaty outflow was made on 1-2 February when the Arrow outflow was increased by 15,000 cfs to 80,000 cfs to meet power downstream requirements. On 19 February, the lock at Keenleyside Dam was forced out of service and the discharge was shaped on an hourly basis for several days to accommodate log loading problems at the sawmill just downstream of the dam. From 13-22 April, the lock was taken out of service for maintenance. To avoid breaking loose the large log rafts which the sawmill was storing downstream of the dam (to permit mill operation to continue during the lock outage), the Arrow discharge was kept below 26,000 cfs 9-22 April. On 21-22 April, the discharge from Arrow was again fluctuated on an hourly basis to reduce the discharge to zero for several hours to complete some diving and sounding work downstream of the dam.

By 6 April, Arrow reservoir reached its lowest elevation of the 1990 operating year, 1385 feet, approximately 7 feet above its minimum level. From 25 April through 31 May, the Arrow discharge remained below 10,000 cfs, except for 25-26 May, when it increased to 14,700 cfs due to a reduction in the amount of water being stored in non-Treaty storage. The low Arrow discharge between 25 April and 31 May was also a result of transferring 2,000 cfs of the Arrow Treaty discharge request to Duncan. This transfer was undertaken to reduce the potential for flooding downstream of Duncan later during the freshet.

After mid-April, Arrow reservoir began refilling quickly due to high inflows. In early May, the City of Revelstoke, which is located at the north end of Arrow reservoir, experienced several severe dust storms caused by wind movement of exposed silt along the drawdown zone of Arrow reservoir. In order to minimize the sand problems, approximately 150 ksfd of Mica water was transferred into Arrow reservoir to increase the Arrow reservoir level and inundate the exposed silt zone. This Mica water remained in Arrow until early July when it was transferred back to Mica by releasing less than the DOP outflow at Mica.

The Arrow discharge progressively increased from about 10,000 cfs on 1 June to 60,000 cfs in early July. The Treaty storage was refilled on 31 July. The reservoir was surcharged thereafter and reached its highest level for 1990, elevation 1446.0 feet on 11 September.

Duncan Reservoir

As shown in Chart 8, Duncan reservoir reached full pool elevation of 1892 feet on 30 July 1989. The project then discharged inflow and maintained full pool until 1 September, when it began drafting. Duncan drafted about six feet during September while its discharge varied from 2000 cfs to 6000 cfs.

On 30 September, the Duncan discharge was reduced to minimum (100 cfs) and remained at minimum until 9 November. During this period, the reservoir refilled to full pool. From 10 November to early December, the project passed inflow and remained at full pool. On 9 December, the project started discharging 8500 cfs to begin drafting the reservoir along the flood control rule curve. The project continued drafting for flood control until early February. At this time, the Duncan discharge began being reduced from 8500 cfs on 5 February to 1000 cfs by 21 February to avoid exceeding the IJC curve for Kootenay Lake. This operation resulted in Duncan reservoir being above its flood control rule curve by approximately 20 feet at the end of February.

From 8 March to 2 April, the Duncan discharge remained at minimum (100 cfs). This caused the reservoir to fill approximately two feet over this period. However, to reduce the amount of storage above the flood control refill curve, the discharge was increased from early April to 23 May and an additional eight feet was drafted. On 23 May, the reservoir reached its lowest elevation of 1822.7 feet, about 28.5 feet above its minimum level of 1794.2 feet.

On 1 June, the discharge was reduced to minimum (100 cfs) and remained at minimum while the project refilled. An inflow peak of 18,810 cfs was recorded on 24 June. The project continued to discharge minimum until 14 July, when the discharge was increased as the reservoir neared full pool. By 31 July, the reservoir refilled to full pool, 1,892 feet, and began passing inflow.

Libby Reservoir

As shown on Chart 9, Libby did not completely refill following the 1989 runoff. Lake Koocanusa reached its maximum level, 2452.6 feet, 6.4 feet from full, on 31 July 1989. This was the second consecutive year the reservoir did not reach full pool. By Labor Day the reservoir had been drawn down to elevation 2442.8 feet as summer draft was necessary to meet FELCC.

No additional draft occurred in September as draft at other US storage reservoirs was sufficient to meet firm power requirements. Between October and December, Lake Koocanusa was drafted steadily, with outflows for this three month period averaging 17,100 cfs. By 31 December, the lake was at elevation 2389.4 feet, nearly forty feet higher than the 31 December elevation for 1988.

In January, the basin-wide Columbia River water supply forecast indicated that no additional proportional draft was necessary for meeting FELCC. A small amount of draft was necessary at Lake Koocanusa to meet the 31 January flood control requirement of 2385 feet but because of a record dry

December and uncertainty about the 1 January forecast, upon which the flood control requirement was based, the Libby outflow was kept at 4000 cfs for most of the month. By late January, "early-bird" water supply projections indicated a significant amount of flood control draft would be necessary in February. Consequently, the outflow was increased in late January to 15,000 cfs. On 31 January Lake Koocanusa was at elevation 2387.0 feet, the highest elevation for this date since 1977 and the second highest since project construction. The February water supply forecast was much higher than January's forecast, prompting a major increase in required flood control draft. Because of the IJC-required draft of Kootenay Lake, which has precedent over Libby and Duncan flood control draft, and the reduced channel capacity of the Kootenay Lake outlet in February and March, it was not possible to draft Libby to its flood control requirement. Libby ran at full powerhouse capacity, averaging 22,000 cfs discharge in February, before its outflow had to be reduced in early March to avoid forcing Kootenay Lake above its IJC requirement. The outflow was progressively reduced in March to as low as 4000 cfs, as the Kootenay Lake outflow capacity steadily dropped.

Libby discharged 8000 cfs for 2-20 April as Lake Koocanusa's refill probability was well above 95 percent. The outflow was reduced to 4000 cfs on 21 April and remained at that level until 10 June. Inflows began rising in mid-April but cool weather throughout May delayed a further rise in flows. Warmer weather returned in late May and the inflow peaked on 1 June at 66,800 cfs. Libby's outflow was gradually increased, beginning 11 June, to slow the reservoir's rate of fill and by 18 June the project was discharging full powerhouse capacity of 23,000 cfs. Inflow to Lake Koocanusa remained unusually high through mid-July and the project discharged near full powerhouse capacity through 12 July to avoid spill. Lake Koocanusa was within five feet of full on 13 July and filled into its top foot on 22 July. The lake was then operated in its top half-foot from 24 July to 10 September.

The January-July observed runoff was 7690 kaf, 118 percent of the 1961-85 average. This runoff volume was the highest since 1974 and the 13th highest in the 1928-90 period of record.

Kootenay Lake

As shown in Chart 10, Kootenay Lake passed inflow in July and August 1989, maintaining the lake level at about elevation 1743.0 feet. In September, the lake discharge was reduced to prevent spill at Brilliant Dam on the lower Kootenay River. The lake filled quickly to elevation 1744.8 by 10 September, slightly below the International Joint Commission Rule Curve. Between October and December the lake remained near elevation 1744.5 and its discharge varied between 15,000 cfs and 35,000 cfs. In early November, unusually heavy rainfall triggered a rapid rise in inflow to 53,200. As a result, the lake filled to 1745.51, briefly exceeding the IJC rule curve, and the outflow was increased to 46,100 cfs.

Between January and March, Kootenay Lake was drafted in accordance with its IJC Rule Curve. In early March, as the lake's outflow capacity began dropping due to its outlet discharge restriction, the rate of flood control draft at both Duncan and Libby was reduced to avoid causing Kootenay Lake to exceed its IJC rule curve. This resulted in both Libby and Duncan exceeding their flood control rule curves by a combined volume of 1.67 maf on 31 March. Kootenay Lake reached its lowest level for the operating year, 1739.40 feet , on 31 March.

Inflow to Kootenay Lake began increasing in early April, causing four feet of fill by 30 April. Between 1 and 23 May, the lake remained near elevation 1743.5 feet as inflows dropped due to unusually cool weather. Inflows rose again in late May causing the lake to resume filling rapidly. Inflows rose further in June, reaching a peak of 81,000 cfs on 25 June. Discharge from Kootenay Lake was as high as 67,000 cfs during this period. The lake level peaked at 1749.5 feet on 27 June. This was the highest lake level since 1981 when the lake filled to 1749.8 feet. Inflow began dropping in late June and the lake then drafted steadily, reaching 1743.05 feet on 28 August. The lake was then maintained near elevation 1743 feet for the remainder of August as inflows and outflows ranged from 15,000 cfs to 25,000 cfs during this period.

Beginning 28 August the Kootenay Lake discharge was reduced to 15,000 cfs to prevent spill at Brilliant. Inflow remained between 15,000 and 20,000 cfs and the lake remained near elevation 1743 feet through September.

VI Power and Flood Control Accomplishments

General

During the period covered by this report, Duncan, Arrow, Mica, and Libby reservoirs were operated in accordance with the Columbia River Treaty. Specifically, the operation of the reservoirs was governed by:

1. "Detailed Operating Plan for Columbia River Treaty Storage - 1 August 1989 through 31 July 1990," dated September 1989.
2. "Columbia River Treaty Flood Control Operating Plan," dated October 1972.

Consistent with all Detailed Operating Plans prepared since the installation of generation at Mica, the 1989-90 Detailed Operating Plan was designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States, in accordance with paragraph 7 of Annex A of the Treaty. The 1989-90 Assured Operating Plan, prepared in 1983, was used as the basis for the preparation of the 1989-90 Detailed Operating Plan.

Power

The Canadian Entitlement to downstream power benefits from Duncan, Arrow and Mica for the 1989-90 operating year had been purchased in 1964 by the Columbia Storage Power Exchange (CSPE). In accordance with the Canadian Entitlement Exchange Agreement dated 13 August 1964, the U.S. Entity delivered capacity and energy to the CSPE participants.

The generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement was 349 average megawatts at rates up to 1,017 megawatts, from

1 August 1989 through 31 March 1990, and 330 average megawatts, at rates up to 1,022 megawatts, from 1 April through 31 July 1990. All CSPE power was used to meet Pacific Northwest loads.

The Coordinated System reservoirs filled to only 88 percent of full by 1 August 1989, and after being drawn down during the 1989-90 operating year, refilled to 99.1 percent of full on 31 July 1990. This is the first time that the Coordinated System has completely refilled since 1987. The following table shows composite storage energy for Coordinated System reservoirs at the end of each month compared to operating rule curves during the 1989-90 operating year. Normal full Coordinated System reservoir storage is approximately 63,700 megawatt-months. All figures are 1000 MWMo.

Month	Operating Rule Curve	Actual	Difference
Aug 89	62.6	53.1	- 9.5
Sep 89	59.1	45.0	-14.1
Oct 89	54.7	47.4	- 7.3
Nov 89	50.6	45.6	- 5.0
Dec 89	45.2	41.5	- 3.7
Jan 90	30.1	35.4	+ 5.3
Feb 90	18.2	27.3	+ 9.3
Mar 90	11.2	20.3	+ 9.1
Apr 90	16.6	24.3	+ 7.7
May 90	32.2	36.8	+ 4.6
Jun 90	52.6	53.9	+ 1.3
Jul 90	63.2	61.9	- 1.3

During the January-June period of 1990, volume runoff forecasts for cyclic reservoirs were sufficient to cause the VECC to be lower than the base energy content curves, and there was no proportional draft necessary during this period.

The following table shows BPA nonfirm and surplus firm sales in megawatt-hours to northwest and southwest utilities during the 1989-90 operating year.

PERIOD	TO NORTHWEST UTILITIES		TO SOUTHWEST UTILITIES	
	NONFIRM	SURPLUS FIRM	NONFIRM	SURPLUS FIRM
AUG 89	0	36,340	0	51,034
SEP 89	0	35,793	0	18,620
OCT 89	0	142,692	0	0
NOV 89	0	144,360	0	0
DEC 89	0	145,272	0	0
JAN 90	0	118,296	0	0
FEB 90	100,245	106,848	606,076	0
MAR 90	21,615	102,305	1,717,854	0
APR 90	23,157	1,080	1,713,310	0
MAY 90	372,252	0	1,438,896	0
JUN 90	1,416,111	0	2,195,110	8,390
JUL 90	375,471	0	720,795	8,400
TOTAL	2,309,351	832,986	8,392,041	86,444

Flood Control

The Columbia River Basin reservoir system, including the Columbia River Treaty projects, was operated on a daily basis for flood control between 30 May and 19 June. This is the first time that daily operation for flood control during the spring runoff has been necessary since 1986. The observed and unregulated hydrographs for the Columbia River at The Dalles between 1 April 1990 and 31 July 1990 are shown on Chart 14. The unregulated peak flow at The Dalles would have been 511,000 cfs on 13 June and it was controlled to a maximum of 371,900 cfs on 9 June 1990.

The observed peak stage at Vancouver, Washington was 12.8 feet on 10 June 1990 and the unregulated stage would have been 18.6 feet on 14 June 1990. Chart 15 documents the relative filling of Arrow and Grand Coulee during the principal filling period, and compares the regulation of these two reservoirs to guidelines in the Treaty Flood Control Operating Plan.

Computations of the Initial Controlled Flow (ICF) for system flood control operation were made in accordance with the Treaty Flood Control Operating Plan. Computed initial controlled flows were 267,000 on 1 January 1990, 363,000 cfs on 1 February, 339,000 cfs on 1 March, 309,000 cfs on 1 April and 285,000 cfs on 1 May. Data for the 1 May ICF computation are given in Table 6.

VII HIGHWATER '89 EXERCISE

A coordinated dam safety exercise was conducted during the week of June 19 through 23, 1989. The exercise, called "Highwater '89", involved the simulated failure of Noxon, Duncan, Revelstoke, and Keenleyside dams and the motion of the resulting flood wave to downstream locations in the basin. The purpose of the exercise was to provide a coordinated interagency test of communications procedures, emergency operation procedures, and flood forecasting, with specific emphasis on the ability to execute established Emergency Action Plans (EAP).

The Northwest Power Pool Coordinating Group's Emergency Action Plan Task Force established general guidance for planning the exercise, while the Corps of Engineers took the lead in planning and implementation. The primary participants were dam owners in the United States and Canada, the Bonneville Power Administration, the National Weather Service Northwest River Forecast Center, and the Federal Energy Regulatory Commission. Participation by state and local agencies was optional; however a number of these agencies did get involved and contributed to the value of the exercise.

The Highwater '89 exercise represented the first time such a large scale exercise had been conducted using realistic simulation of a flood to test regulation and emergency response procedures. Chart 16 shows the simulated dam failure hydrographs of Grand Coulee inflow. Chart 17 shows simulated hydrographs of Grand Coulee outflow and the flow in lower Columbia River as regulated during the exercise. The exercise was considered to be a success as it challenged many of the participants to solve new and unusual problems.

Table 1

Unregulated Runoff Volume Forecasts
Million of Acre-Feet
1990

Forecast Date - 1st of	DUNCAN Most Probable 1 April - 31 August	ARROW Most Probable 1 April - 31 August	MICA Most Probable 1 April - 31 August	LIBBY Most Probable 1 April - 31 August	UNREGULATED RUNOFF COLUMBIA RIVER AT THE DALLES,OREGON Most Probable 1 April - 31 August
January	2.1	23.4	11.5	6.3	76.3
February	2.1	25.5	12.7	7.2	89.5
March	2.2	26.7	13.3	7.5	94.0
April	2.2	25.1	12.6	7.2	86.9
May	2.2	26.0	12.7	7.4	86.9
June	2.2	25.7	12.4	7.8	90.7
Actual	2.1	24.7	12.4	7.6	91.6

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

Table 2

95 Percent Confidence Forecast and Variable Energy Content Curve Mica 1990

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1 PROBABLE FEB 1 - JUL 31 INFLOW, KSFD[1]		4797.8	5266.7	5488.7	5248.0	5306.8	5143.8
2 95% FORECAST ERROR, KSFD		584.5	480.5	444.1	414.4	380.9	378.8
3 95% CONFIDENCE FEB 1 - JUL 31 INFLOW, KSFD[2] ..		4213.3	4786.2	5044.6	4833.6	4925.9	4765.0
4 OBSERVED FEB 1 - DATE INFLOW, KSFD		0.0	0.0	111.0	248.1	597.3	1459.1
5 RESIDUAL 95% DATE - JUL 31 INFLOW, KSFD[3]		4213.3	4786.2	4933.6	4585.5	4328.6	3305.9
ASSUMED FEB 1 - JUL 31 INFLOW, % OF VOLUME ..		100.0					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD[4]		4213.3					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD		2180.0					
MIN. JAN 31 RESERVOIR CONTENT, KSFD[5]		1495.9					
MIN. JAN 31 RESERVOIR ELEVATION, FT[6]		2429.0					
JAN 31 ECC, FT[7]		2429.0					
BASE ECC, FT	2432.2						
LOWER LIMIT, FT	2401.9						
ASSUMED MAR 1 - JUL 31 INFLOW, % OF VOLUME ..		97.8	97.8				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD[4]		4120.6	4680.9				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD		1760.0	1760.0				
MIN. FEB 28 RESERVOIR CONTENT, KSFD[5]		1168.6	608.3				
MIN. FEB 28 RESERVOIR ELEVATION, FT[6]		2421.7	2408.9				
FEB 28 ECC, FT[7]		2421.7	2408.9				
BASE ECC, FT	2421.7						
LOWER LIMIT, FT	2394.2						
ASSUMED APR 1 - JUL 31 INFLOW, % OF VOLUME ..		95.4	95.4	97.6			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD[4]		4019.5	4566.0	4815.2			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD		1295.0	1295.0	1295.0			
MIN. MAR 31 RESERVOIR CONTENT, KSFD[5]		804.7	258.2	9.0			
MIN. MAR 31 RESERVOIR ELEVATION, FT[6]		2413.5	2400.6	2394.4			
MAR 31 ECC, FT[7]		2412.7	2400.6	2394.4			
BASE ECC, FT	2412.7						
LOWER LIMIT, FT	2394.2						
ASSUMED MAY 1 - JUL 31 INFLOW, % OF VOLUME ..		90.7	90.7	92.8	95.1		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD[4]		3821.5	4341.1	4578.4	4360.8		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD		920.0	920.0	920.0	920.0		
MIN. APR 30 RESERVOIR CONTENT, KSFD[5]		627.7	108.1	-129.2	88.4		
MIN. APR 30 RESERVOIR ELEVATION, FT[6]		2409.4	2396.9	2394.2	2396.4		
APR 30 ECC, FT[7]		2405.9	2396.9	2394.2	2396.4		
BASE ECC, FT	2405.9						
ASSUMED JUN 1 - JUL 31 INFLOW, % OF VOLUME ..		73.2	73.2	74.9	76.8	80.8	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD[4]		3084.1	3503.5	3695.3	3521.7	3497.5	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD		610.0	610.0	610.0	610.0	610.0	
MIN. MAY 31 RESERVOIR CONTENT, KSFD[5]		1055.1	635.7	443.9	617.5	641.7	
MIN. MAY 31 RESERVOIR ELEVATION, FT[6]		2419.2	2409.6	2405.0	2409.1	2409.7	
MAY 31 ECC, FT[7]		2411.4	2409.6	2405.0	2409.1	2400.7	
BASE ECC, FT	2411.4						
ASSUMED JUL 1 - JUL 31 INFLOW, % OF VOLUME ..		36.7	36.7	37.5	38.5	40.5	50.1
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD[4]		1546.3	1756.5	1850.1	1765.4	1753.1	1656.3
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]		2292.9	2082.7	1989.1	2073.8	2086.1	2182.9
MIN. JUN 30 RESERVOIR ELEVATION, FT[6]		2445.8	2441.4	2439.5	2441.2	2441.5	2443.5
JUN 30 ECC, FT[7]		2441.5	2441.4	2439.5	2441.2	2441.5	2441.5
BASE ECC, FT	2441.5						
JUL 31 ECC, FT	2470.1	2470.1	2470.1	2470.1	2470.1	2470.1	2470.1

1 DEVELOPED BY CANADIAN ENTITY
2 LINE 1 - LINE 2
3 LINE 3 - LINE 4
4 PRECEDING LINE X LINE 5
5 FULL CONTENT (3529.2 KSFD) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT
6 FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED FEBRUARY 21, 1973
7 LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR

95 Percent Confidence Forecast and Variable Energy Content Curve Arrow 1990

	INITIAL	JAN 1 LOCAL	FEB 1 LOCAL	MAR 1 TOTAL	APR 1 TOTAL	MAY 1 TOTAL	JUN 1 TOTAL
1 PROBABLE FEB 1 - JUL 31 INFLOW, KSFD[1]		5507.5	5945.3	11748.1	11247.6	11702.2	11422.5
2 95% FORECAST ERROR, KSFD		956.5	775.1	936.8	795.5	715.8	779.2
3 95% CONFIDENCE FEB 1 - JUL 31 INFLOW, KSFD[2] ..		4551.0	5170.2	10811.3	10452.1	10986.4	10643.3
4 OBSERVED FEB 1 - DATE INFLOW, KSFD		0.0	0.0	344.8	785.4	1862.6	3908.6
5 RESIDUAL 95% DATE - JUL 31 INFLOW, KSFD[3]		4551.0	5170.2	10466.5	9666.7	9123.8	6734.7
ASSUMED FEB 1 - JUL 31 INFLOW, % OF VOLUME ..		100.0					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD[4]		4551.0					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD[8]		2574.6					
MICA REFILL REQUIREMENTS, KSFD[9]		2180.0					
MIN. JAN 31 RESERVOIR CONTENT, KSFD[5]		-576.8					
MIN. JAN 31 RESERVOIR ELEVATION, FT[6]		1377.9					
JAN 31 ECC, FT[7]		1392.1					
BASE ECC, FT	1418.0						
LOWER LIMIT, FT	1392.1						
ASSUMED MAR 1 - JUL 31 INFLOW, % OF VOLUME ..		96.8	96.8				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD[4]		4405.4	5004.7				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD[8]		2434.6	2076.0				
MICA REFILL REQUIREMENTS, KSFD[9]		1760.0	1760.0				
MIN. FEB 28 RESERVOIR CONTENT, KSFD[5]		-151.2	-1109.1				
MIN. FEB 28 RESERVOIR ELEVATION, FT[6]		1377.9	1377.9				
FEB 28 ECC, FT[7]		1383.8	1383.8				
BASE ECC, FT	1410.9						
LOWER LIMIT, FT	1383.8						
ASSUMED APR 1 - JUL 31 INFLOW, % OF VOLUME ..		93.1	93.1	96.9			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD[4]		4237.0	4813.5	10142.0			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD[8]		2279.6	1921.0	1159.0			
MICA REFILL REQUIREMENTS, KSFD[9]		1295.0	1295.0	3520.2			
MIN. MAR 31 RESERVOIR CONTENT, KSFD[5]		327.2	-607.8	-1883.2			
MIN. MAR 31 RESERVOIR ELEVATION, FT[6]		1385.7	1377.9	1377.9			
MAR 31 ECC, FT[7]		1385.7	1382.3	1382.3			
BASE ECC, FT	1415.9						
LOWER LIMIT, FT	1382.3						
ASSUMED MAY 1 - JUL 31 INFLOW, % OF VOLUME ..		85.2	85.2	90.4	93.3		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD[4]		3877.5	4405.0	9461.7	9019.0		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD[8]		1991.6	1677.2	1009.0	1009.0		
MICA REFILL REQUIREMENTS, KSFD[9]		920.0	920.0	3528.1	3440.8		
MIN. APR 30 RESERVOIR CONTENT, KSFD[5]		773.7	-68.2	-1345.0	-989.6		
MIN. APR 30 RESERVOIR ELEVATION, FT[6]		1395.2	1377.9	1377.9	1377.9		
APR 30 ECC, FT[7]		1395.2	1377.9	1377.9	1377.9		
BASE ECC, FT	1409.5						
ASSUMED JUN 1 - JUL 31 INFLOW, % OF VOLUME ..		61.3	61.3	69.1	71.3	76.4	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD[4]		2789.8	3169.3	7232.3	6892.4	6970.6	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD[8]		1694.0	1425.2	854.0	854.0	1274.0	
MICA REFILL REQUIREMENTS, KSFD[9]		610.0	610.0	3085.3	2911.7	2887.5	
MIN. MAY 31 RESERVOIR CONTENT, KSFD[5]		1873.8	1225.5	286.5	452.9	770.5	
MIN. MAY 31 RESERVOIR ELEVATION, FT[6]		1416.1	1404.1	1384.7	1388.5	1395.1	
MAY 31 ECC, FT[7]		1416.1	1404.1	1384.7	1388.5	1395.1	
BASE ECC, FT	1425.6						
ASSUMED JUL 1 - JUL 31 INFLOW, % OF VOLUME ..		26.7	26.7	32.0	33.0	35.4	46.3
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD[4]		1215.1	1380.4	3349.3	3190.0	3229.8	3118.2
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD[8]		899.0	750.2	434.0	434.0	666.5	434.0
MIN. JUN 30 RESERVOIR CONTENT, KSFD[5]		310.0	310.0	1540.1	1455.4	1443.3	1443.3
MICA REFILL REQUIREMENTS, KSFD[9]		2953.5	2639.4	2204.4	2279.0	2459.6	2338.8
MIN. JUN 30 RESERVOIR ELEVATION, FT[6]		1434.2	1429.1	1421.8	1423.1	1426.1	1424.2
JUN 30 ECC, FT[7]		1434.2	1429.1	1421.8	1423.1	1426.1	1424.2
BASE ECC, FT	1444.0						
JUL 31 ECC, FT	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) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT
6 FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED FEBRUARY 21, 1973
7 LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR
8 FOR ARROW LOCAL: MICA MINIMUM POWER DISCHARGE
9 FOR ARROW TOTAL: MICA FULL CONTENT LESS ENERGY CONTENT CURVE

Table 4

95 Percent Confidence Forecast and Variable Energy Content Curve Duncan 1990

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1 PROBABLE FEB 1 - JUL 31 INFLOW, KSFD[1]		887.7	923.3	968.7	931.9	955.4	952.1
2 95% FORECAST ERROR, KSFD		107.3	98.4	93.8	94.3	84.4	86.7
3 95% CONFIDENCE FEB 1 - JUL 31 INFLOW, KSFD[2] ..		780.4	824.9	874.9	837.6	871.0	865.4
4 OBSERVED FEB 1 - DATE INFLOW, KSFD		0.0	0.0	20.5	40.4	119.9	290.4
5 RESIDUAL 95% DATE - JUL 31 INFLOW, KSFD[3]		780.4	824.9	854.4	797.2	751.1	575.0
ASSUMED FEB 1 - JUL 31 INFLOW, % OF VOLUME ..		100.0					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD[4]		780.4					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD		115.7					
MIN. JAN 31 RESERVOIR CONTENT, KSFD[5]		41.1					
MIN. JAN 31 RESERVOIR ELEVATION, FT[6]		1803.2					
JAN 31 ECC, FT[7]		1803.2					
BASE ECC, FT	1848.6						
LOWER LIMIT, FT	1794.5						
ASSUMED MAR 1 - JUL 31 INFLOW, % OF VOLUME ..		97.9	97.9				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD[4]		764.0	807.6				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD		112.9	81.7				
MIN. FEB 28 RESERVOIR CONTENT, KSFD[5]		54.7	-20.1				
MIN. FEB 28 RESERVOIR ELEVATION, FT[6]		1805.8	1794.2				
FEB 28 ECC, FT[7]		1805.8	1794.6				
BASE ECC, FT	1834.9						
LOWER LIMIT, FT	1794.6						
ASSUMED APR 1 - JUL 31 INFLOW, % OF VOLUME ..		95.4	95.4	97.5			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD[4]		744.5	787.0	833.0			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD		109.8	78.6	12.2			
MIN. MAR 31 RESERVOIR CONTENT, KSFD[5]		71.1	-2.6	-115.0			
MIN. MAR 31 RESERVOIR ELEVATION, FT[6]		1808.7	1794.2	1794.2			
MAR 31 ECC, FT[7]		1808.7	1794.4	1794.4			
BASE ECC, FT	1836.9						
LOWER LIMIT, FT	1794.4						
ASSUMED MAY 1 - JUL 31 INFLOW, % OF VOLUME ..		89.9	89.9	91.9	94.3		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD[4]		701.6	741.6	785.2	751.8		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD		82.8	59.2	9.2	9.2		
MIN. APR 30 RESERVOIR CONTENT, KSFD[5]		87.0	23.5	-70.2	-36.8		
MIN. APR 30 RESERVOIR ELEVATION, FT[6]		1811.5	1799.7	1794.2	1794.2		
APR 30 ECC, FT[7]		1811.5	1799.7	1794.2	1794.2		
BASE ECC, FT	1833.9						
ASSUMED JUN 1 - JUL 31 INFLOW, % OF VOLUME ..		69.4	69.4	71.0	72.8	77.2	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD[4]		541.6	572.5	606.6	580.4	579.8	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD		54.9	39.3	6.1	6.1	30.5	
MIN. MAY 31 RESERVOIR CONTENT, KSFD[5]		219.1	172.6	105.3	131.5	156.5	
MIN. MAY 31 RESERVOIR ELEVATION, FT[6]		1831.8	1825.0	1814.5	1818.7	1822.6	
MAY 31 ECC, FT[7]		1831.8	1825.0	1814.5	1818.7	1822.6	
BASE ECC, FT	1848.4						
ASSUMED JUL 1 - JUL 31 INFLOW, % OF VOLUME ..		32.9	32.9	33.6	34.4	36.5	47.3
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD[4]		256.8	271.4	287.1	274.2	274.2	272.0
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD		27.9	20.0	3.1	3.1	15.5	3.1
MIN. JUN 30 RESERVOIR CONTENT, KSFD[5]		476.9	454.4	421.8	434.7	447.1	436.9
MIN. JUN 30 RESERVOIR ELEVATION, FT[6]		1865.3	1862.6	1858.6	1860.1	1861.7	1860.4
JUN 30 ECC, FT[7]		1865.3	1862.6	1858.6	1860.1	1861.7	1860.4
BASE ECC, FT	1871.9						
JUL 31 ECC, FT		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 KSFD) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
6 FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED FEBRUARY 21, 1973
7 LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR

95 Percent Confidence Forecast and Variable Energy Content Curve Libby 1990

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1 PROBABLE JAN 1 - JUL 31 INFLOW, KSFD		3166.7	3620.1	3795.2	3693.3	3688.7	3953.6
2 95% FORECAST ERROR, KSFD		886.8	606.4	552.5	533.4	474.5	367.5
3 OBSERVED JAN 1 - DATE INFLOW, KSFD		0.0	133.3	244.9	379.9	806.4	1565.9
4 95% CONF DATE - JUL 31 INFLOW, KSFD[1]		2279.9	2880.4	2997.8	2780.0	2407.8	2020.2
ASSUMED FEB 1 - JUL 31 INFLOW, % OF VOLUME		97.1					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD[2]		2214.7					
FEB MINIMUM FLOW REQUIREMENTS, CFS[3]		4000.0					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD[4]		906.7					
MIN. JAN 31 RESERVOIR CONTENT, KSFD[5]		1202.6					
MIN. JAN 31 RESERVOIR ELEVATION, FT[6]		2393.2 — VRC					
JAN 31 ECC, FT[7]		2393.2					
BASE ECC, FT	2418.6						
LOWER LIMIT, FT	2333.3						
ASSUMED MAR 1 - JUL 31 INFLOW, % OF VOLUME		94.4	97.2				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD[4]		2153.8	2801.2				
MAR MINIMUM FLOW REQUIREMENT, CFS[3]		4000.0	4000.0				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD[4]		794.7	871.2				
MIN. FEB 1 RESERVOIR CONTENT, KSFD[5]		1151.4	580.5				
MIN. FEB 1 RESERVOIR ELEVATION, FT[6]		2389.9	2347.0				
FEB 28 ECC, FT[7]		2389.9	2347.0				
BASE ECC, FT	2415.8						
LOWER LIMIT, FT	2322.3						
ASSUMED APR 1 - JUL 31 INFLOW, % OF VOLUME		91.2	93.9	96.6			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD[4]		2080.2	2705.3	2895.3			
APR MINIMUM FLOW REQUIREMENT, CFS[3]		5157.0	5332.0	5400.0			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD[4]		670.7	747.2	922.0			
MIN. MAR 31 RESERVOIR CONTENT, KSFD[5]		1101.1	552.4	537.2			
MIN. MAR 31 RESERVOIR ELEVATION, FT[6]		2386.5	2344.6	2343.3			
MAR 31 ECC, FT[7]		2386.5	2344.6	2343.3			
BASE ECC, FT	2413.0						
LOWER LIMIT, FT	2292.9						
ASSUMED MAY 1 - JUL 31 INFLOW, % OF VOLUME		83.2	85.6	88.0	91.2		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD[4]		1897.1	2467.1	2640.5	2353.3		
MAY MINIMUM FLOW REQUIREMENT, CFS[3]		5432.0	6164.0	8000.0	8000.0		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD[4]		516.0	579.5	736.0	736.0		
MIN. APR 30 RESERVOIR CONTENT, KSFD[5]		1129.4	623.0	606.0	711.2		
MIN. APR 30 RESERVOIR ELEVATION, FT[6]		2388.4	2350.6	2349.2	2357.8		
APR 30 ECC, FT[7]		2388.4	2350.6	2349.2	2357.8		
BASE ECC, FT	2412.1						
ASSUMED JUN 1 - JUL 31 INFLOW, % OF VOLUME		56.8	57.5	59.1	61.2	67.1	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD[4]		1296.3	1656.2	1772.6	1701.9	1616.4	
JUN MINIMUM FLOW REQUIREMENT, CFS[3]		5699.0	6368.0	8000.0	8000.0	6800.0	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD[4]		347.6	388.4	488.0	488.0	414.8	
MIN. MAY 31 RESERVOIR CONTENT, KSFD[5]		1561.8	1242.7	1225.9	1296.6	1308.9	
MIN. MAY 31 RESERVOIR ELEVATION, FT[6]		2414.1	2395.7	2394.7	2399.1	2399.9	
MAY 31 ECC, FT[7]		2414.1	2395.7	2394.7	2399.1	2399.9	
BASE ECC, FT	2431.5						
ASSUMED JUL 1 - JUL 31 INFLOW, % OF VOLUME		19.4	20.0	20.5	21.2	23.3	34.7
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD[4]		442.5	575.5	615.8	591.3	561.5	701.8
JUN MINIMUM FLOW REQUIREMENT, CFS[3]		5699.0	6368.0	8000.0	8000.0	6800.0	8000.0
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD[4]		176.7	197.4	248.0	248.0	210.8	248.0
MIN. JUN 30 RESERVOIR CONTENT, KSFD[5]		2244.6	2132.4	2142.7	2167.2	2159.8	2056.7
MIN. JUN 30 RESERVOIR ELEVATION, FT[6]		2447.3	2442.3	2442.7	2443.8	2443.5	2438.8
JUN 30 ECC, FT[7]		2447.3	2442.3	2442.7	2443.8	2443.5	2438.8
BASE ECC, FT	2453.2						
JUL 31 ECC, FT		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
JAN 1 - JUL 31 FORECAST, EARLYBIRD, MAF[8] (AT THE DALLES)		88.9	91.6	99.5	96.9	96.9	99.5

1 LINE 1 - LINE 2 LINE 3
2 PRECEDING LINE TIMES LINE 4
3 BASED ON POWER DISCHARGE REQUIREMENTS, DETERMINED FROM 8
4 CUMULATIVE MINIMUM OUTFLOW FROM 3, FROM DATE TO JULY
5 FULL CONTENT (2510.5 KSFD) PLUS 4, AND MINUS 2
6 ELEVATION FROM 5, STORAGE CONTENT TABLE, DATED JUNE 1980
7 ELEVATION FROM 6, BUT LIMITED BASE ECC, AND ECC LOWER LIMIT
8 USED TO CALCULATE THE POWER DISCHARGE REQUIREMENTS FOR 3

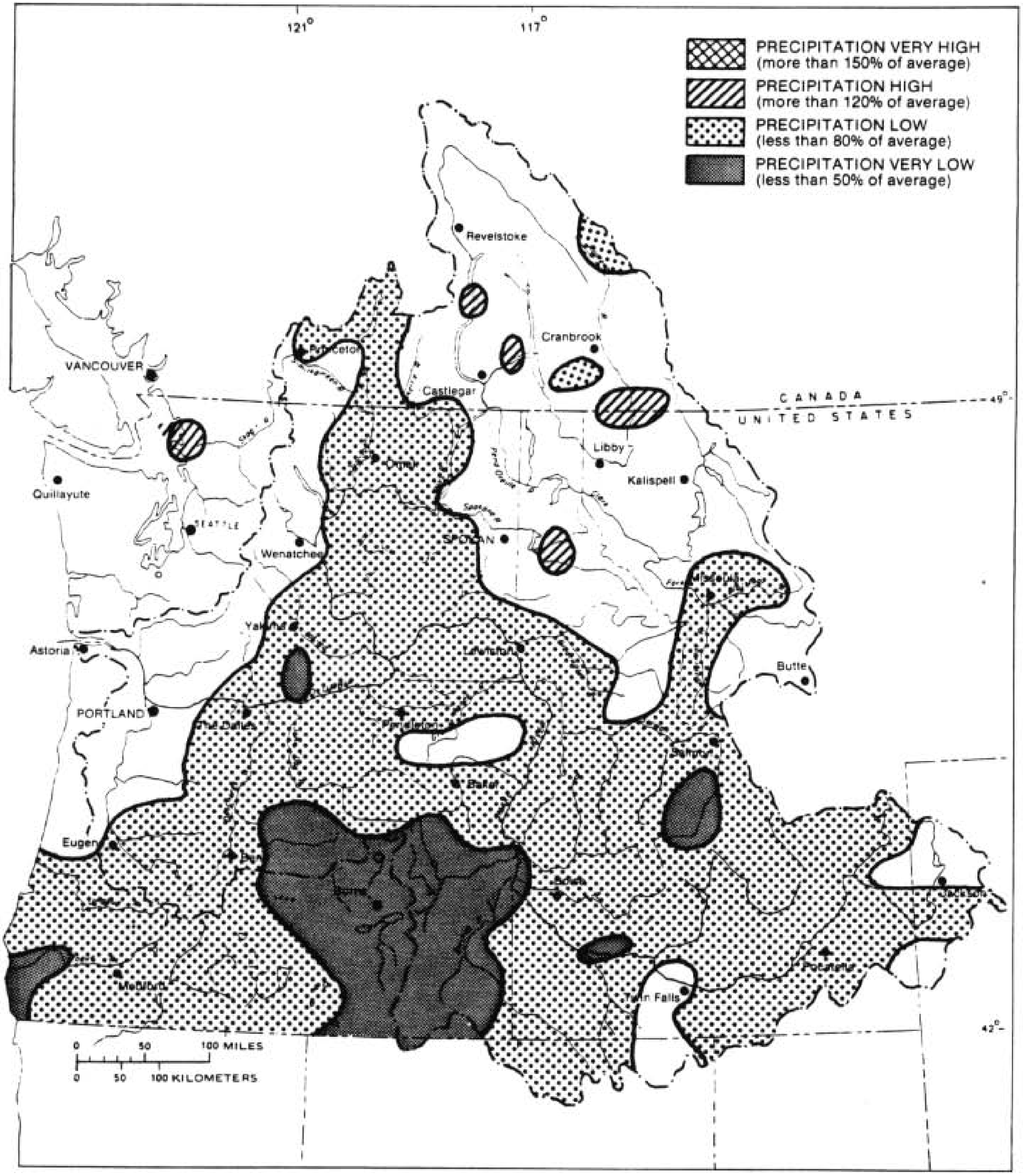
Table 6

Computation of Initial Controlled Flow
Columbia River at The Dalles
1 May 1990

1 May Forecast of May-August Unregulated Runoff Volume, MAF		70.8
Less Estimated Depletions, MAF		1.5
Less Upstream Storage Corrections, MAF		
MICA	7.5	
ARROW	5.0	
DUNCAN	1.3	
LIBBY	4.0	
LIBBY + DUNCAN UNDER DRAFT*	-0.4	
HUNGRY HORSE	1.2	
FLATHEAD LAKE	0.5	
NOXON	0.0	
PEND OREILLE LAKE	0.5	
GRAND COULEE	2.6	
BROWNLEE	0.0	
DWORSHAK	0.6	
JOHN DAY	0.2	
TOTAL	23.0	24.5
Forecast of Adjusted Residual Runoff Volume, MAF		46.3
Computed Initial Controlled Flow from Chart 1 of Flood Control Operating Plan, 1,000 cfs		285.0

* Due to the IJC rule curve requirements at Kootenay Lake, it was not possible to evacuate all the required flood control space at Duncan and Libby.

Seasonal Precipitation Chart 1
Columbia River Basin
October 1989 – March 1990
Percent of 1961 – 1985 Average



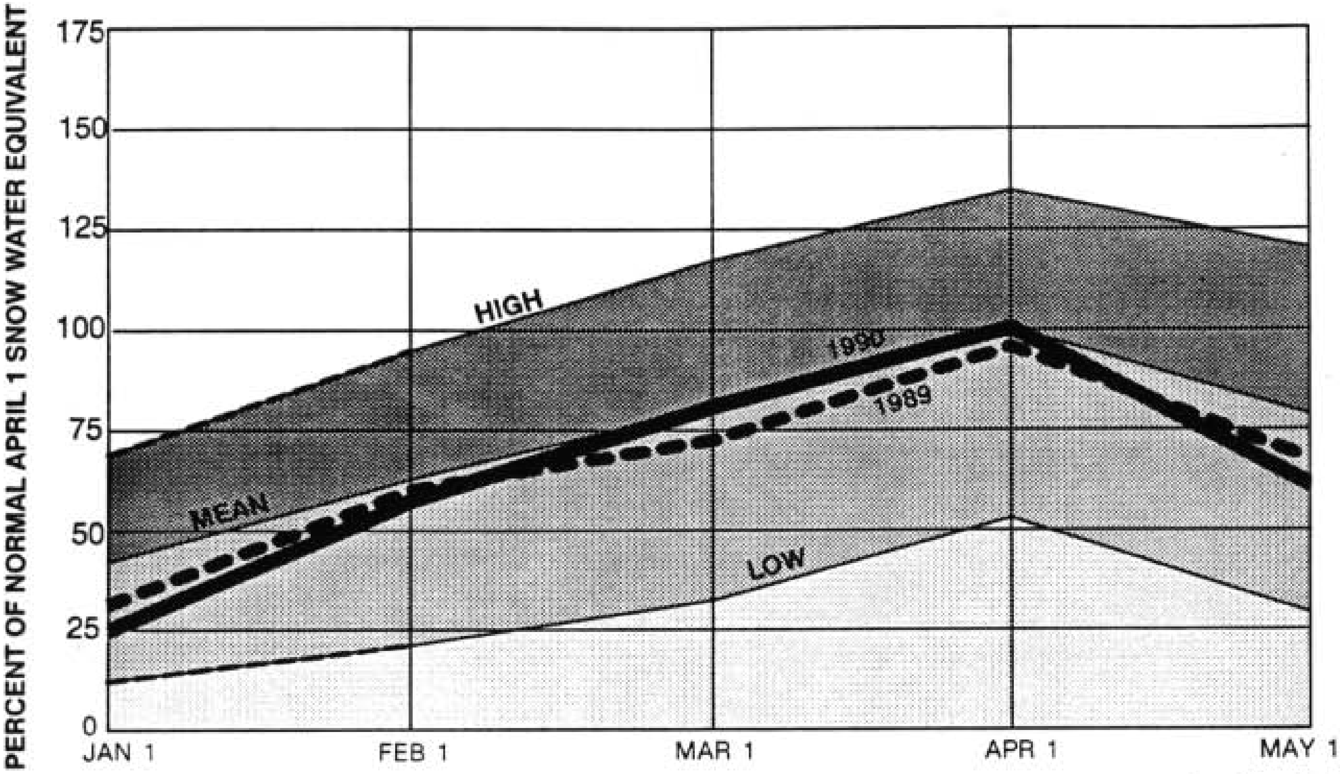
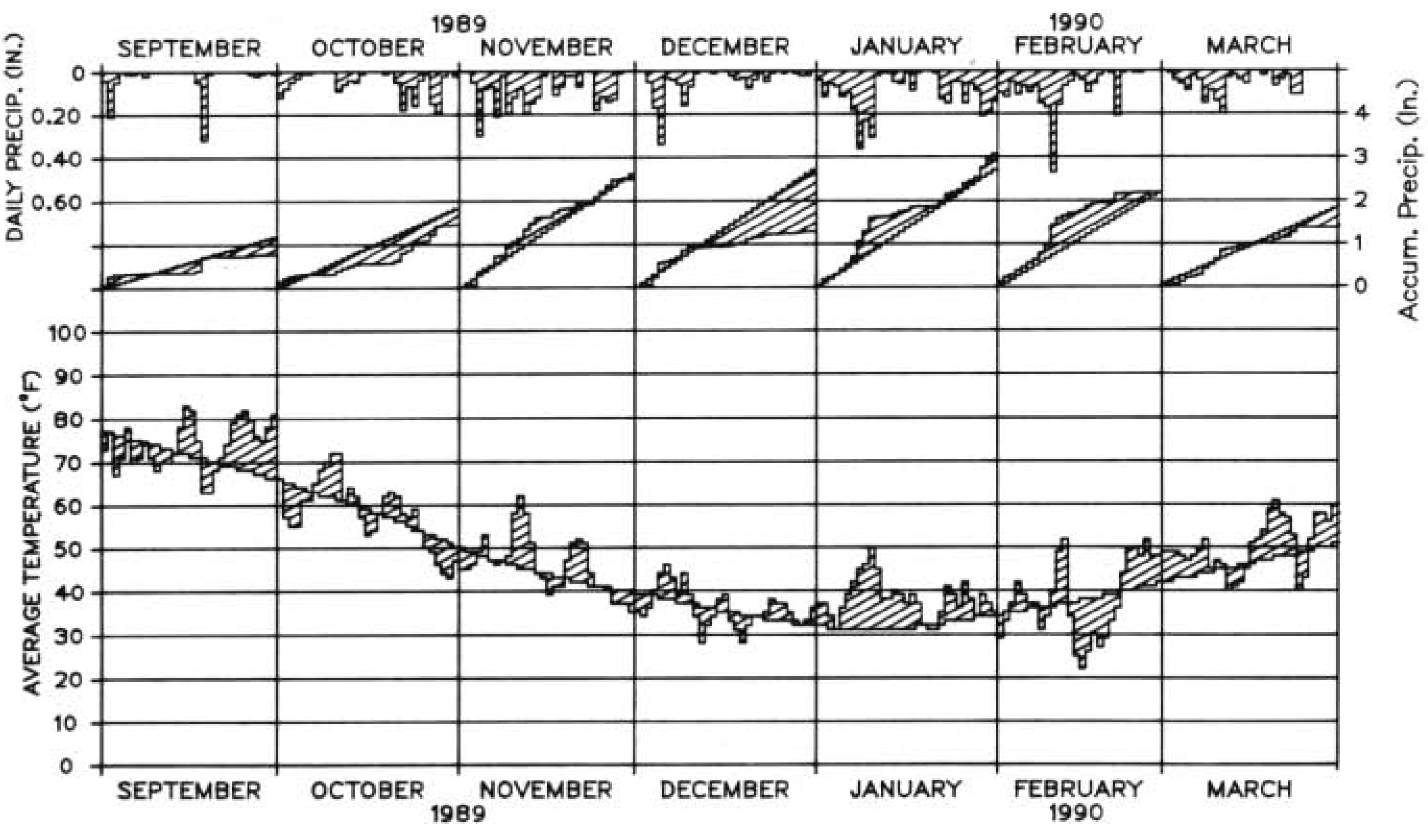
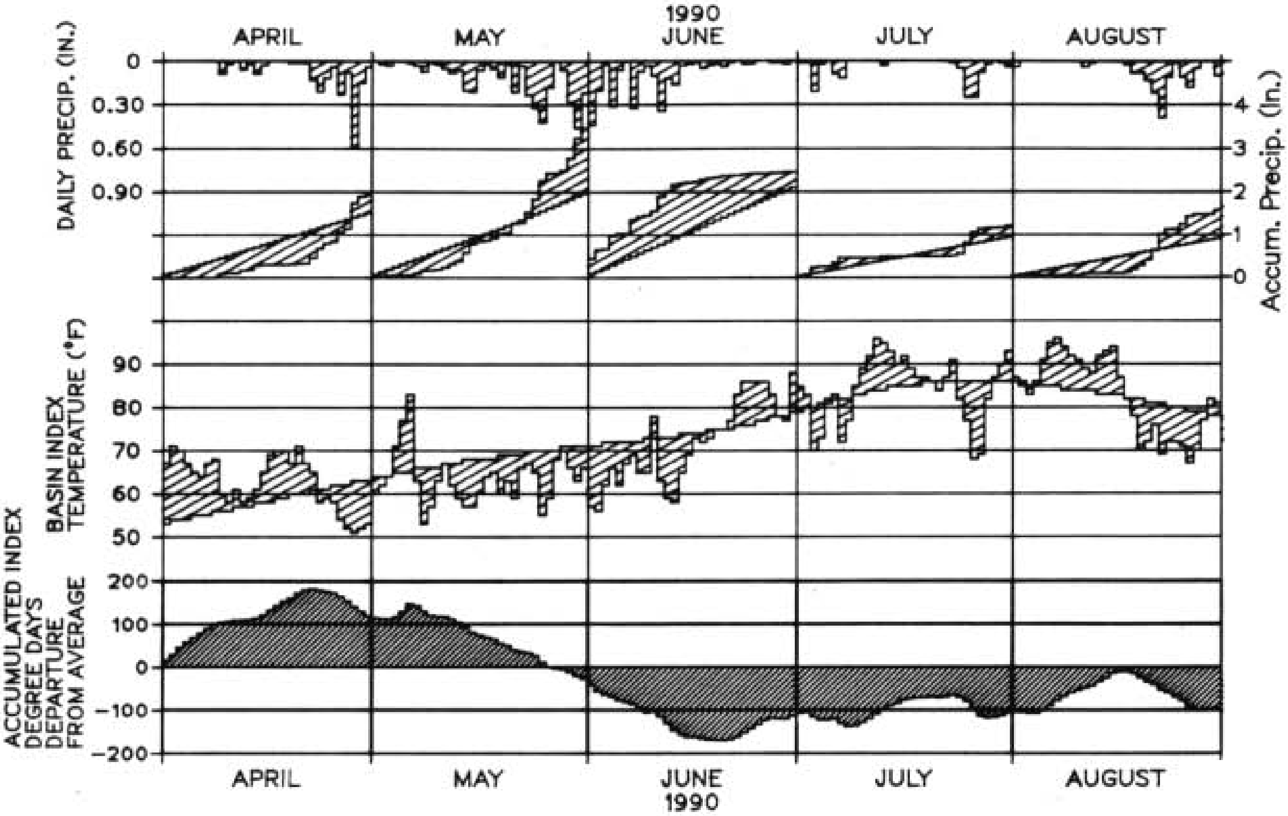


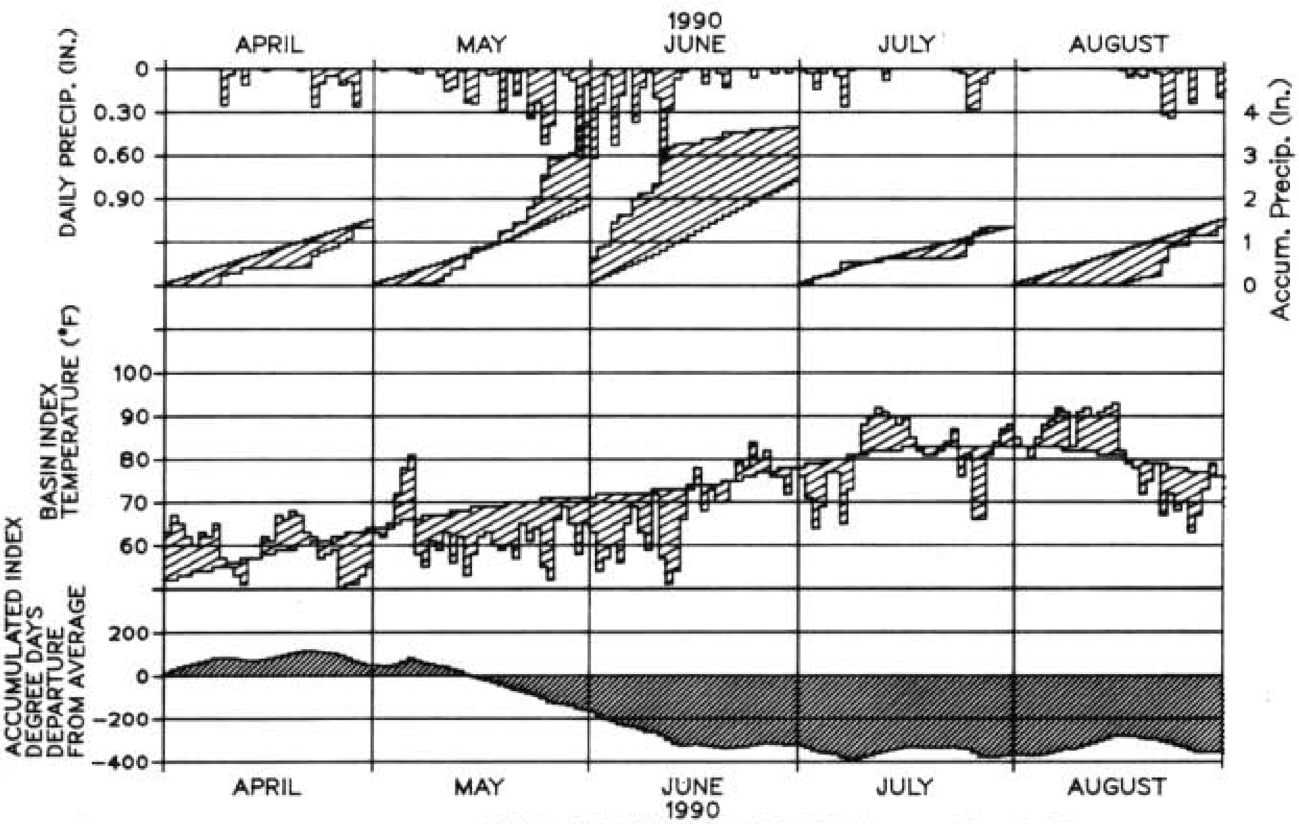
Chart 2
Columbia Basin Snowpack



WINTER SEASON Chart 3
Temperature and Precipitation Index 1989–1990
Columbia River Basin Above The Dalles, OR

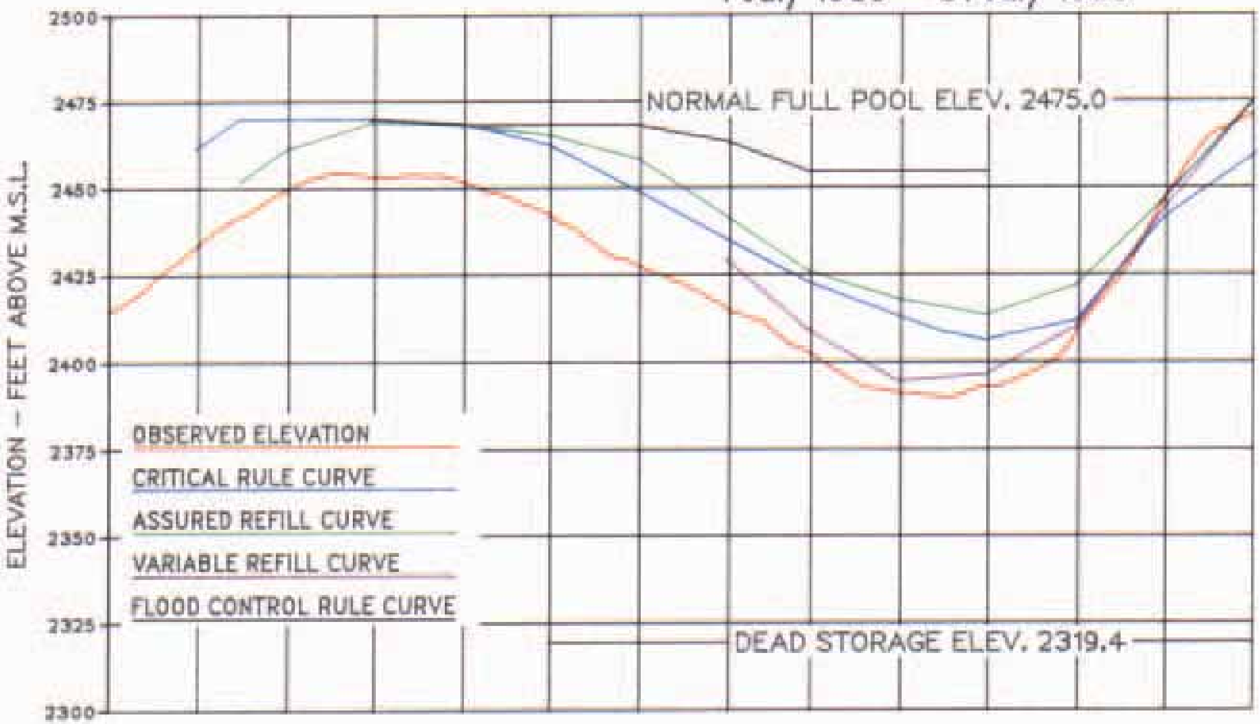


1990 SNOWMELT SEASON CHART 4
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin Above The Dalles, OR



1990 SNOWMELT SEASON Chart 5
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin In Canada

Chart 6
Regulation of Mica
1 July 1989 – 31 July 1990



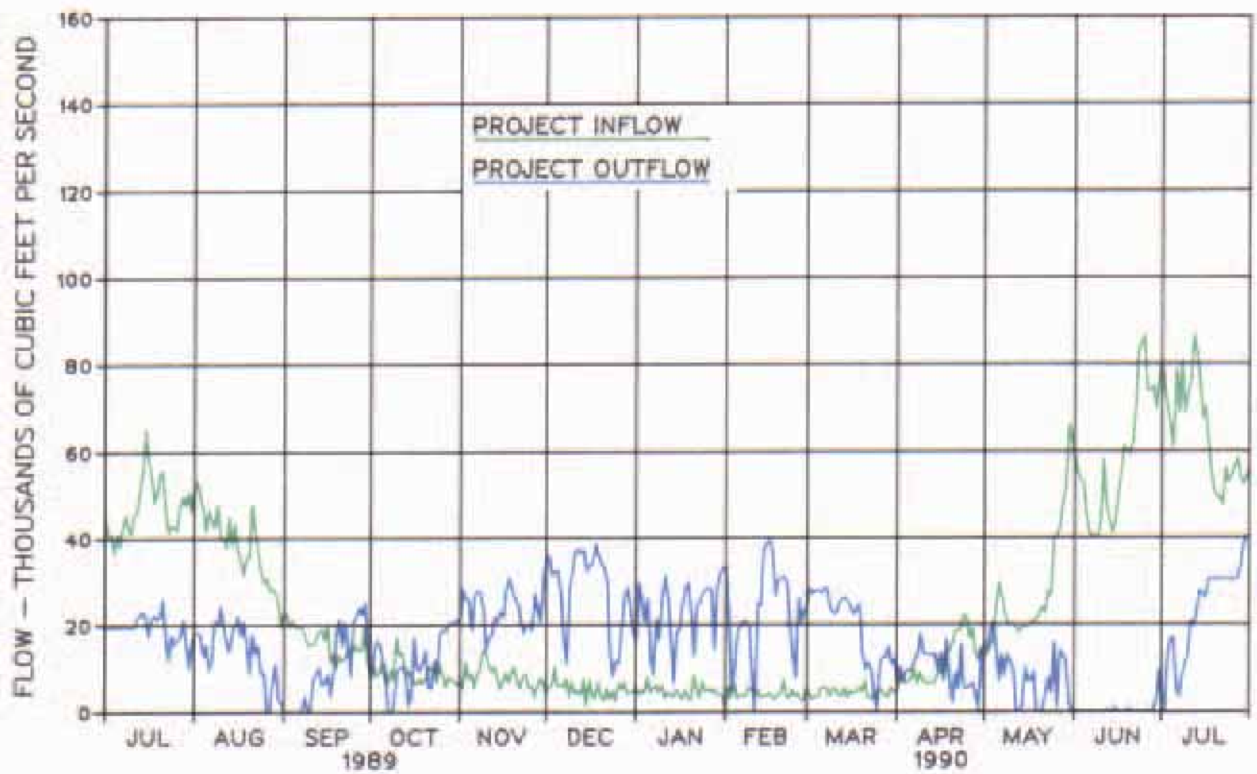


Chart 7
Regulation of Arrow
1 July 1989 – 31 July 1990

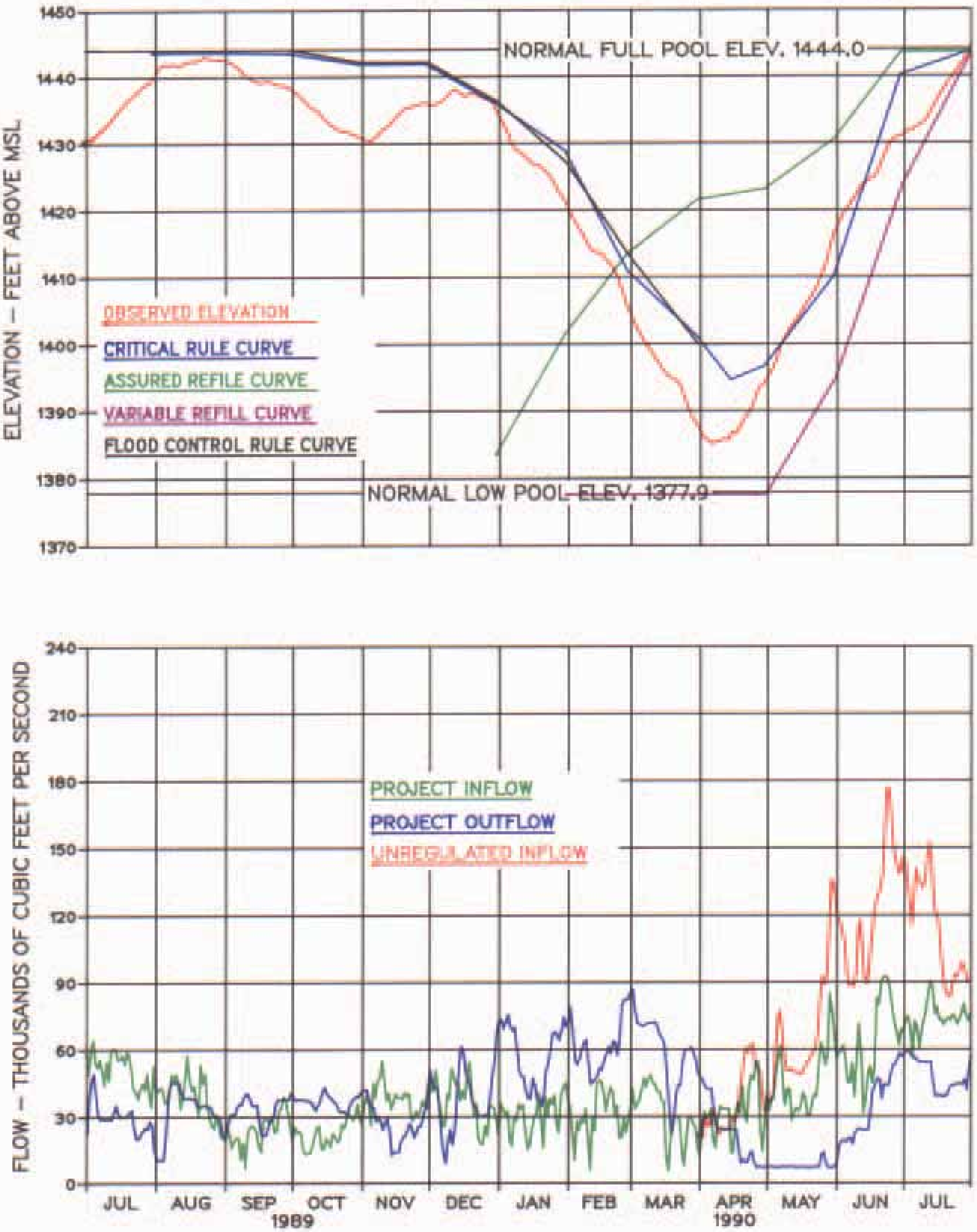
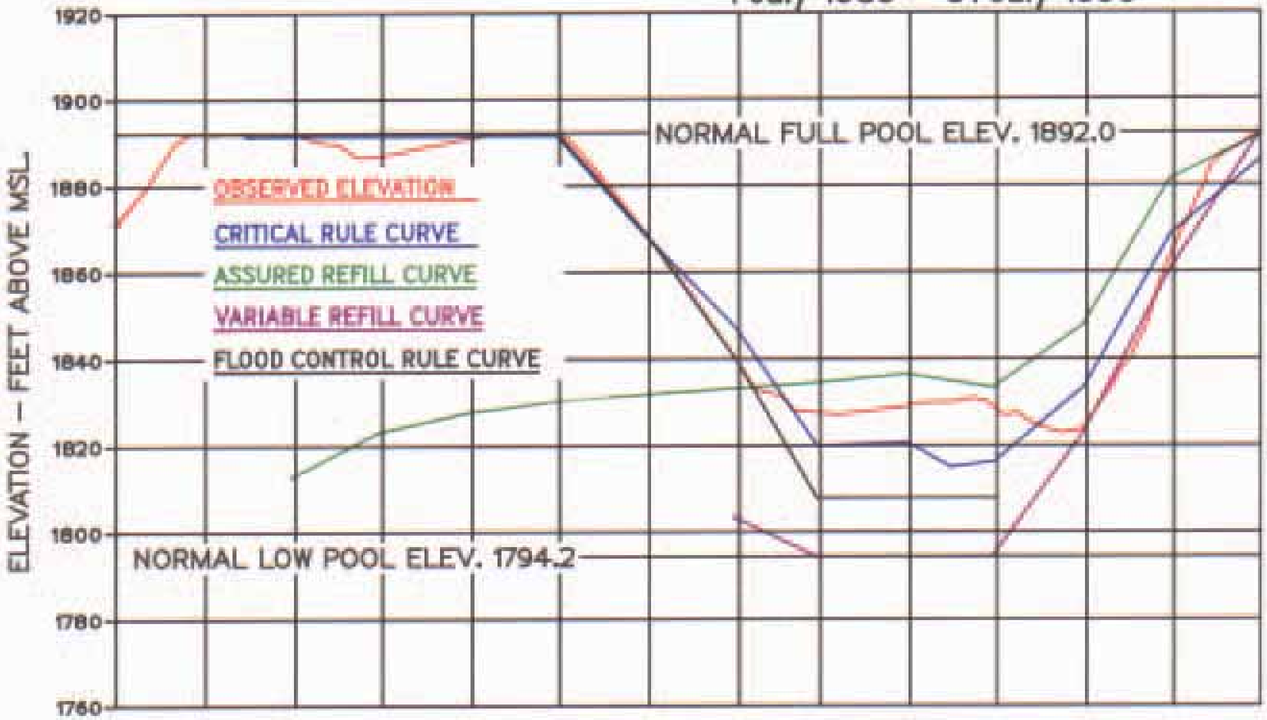


Chart 8
Regulation of Duncan
1 July 1989 – 31 July 1990



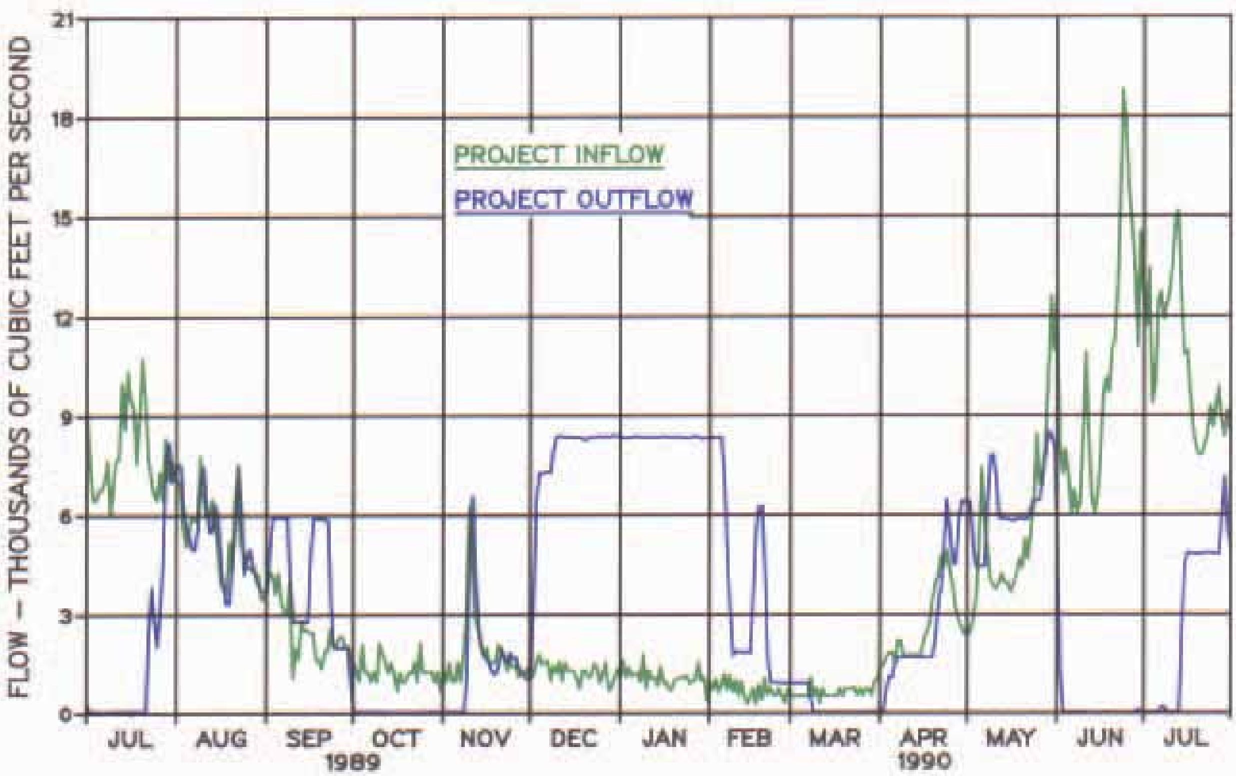
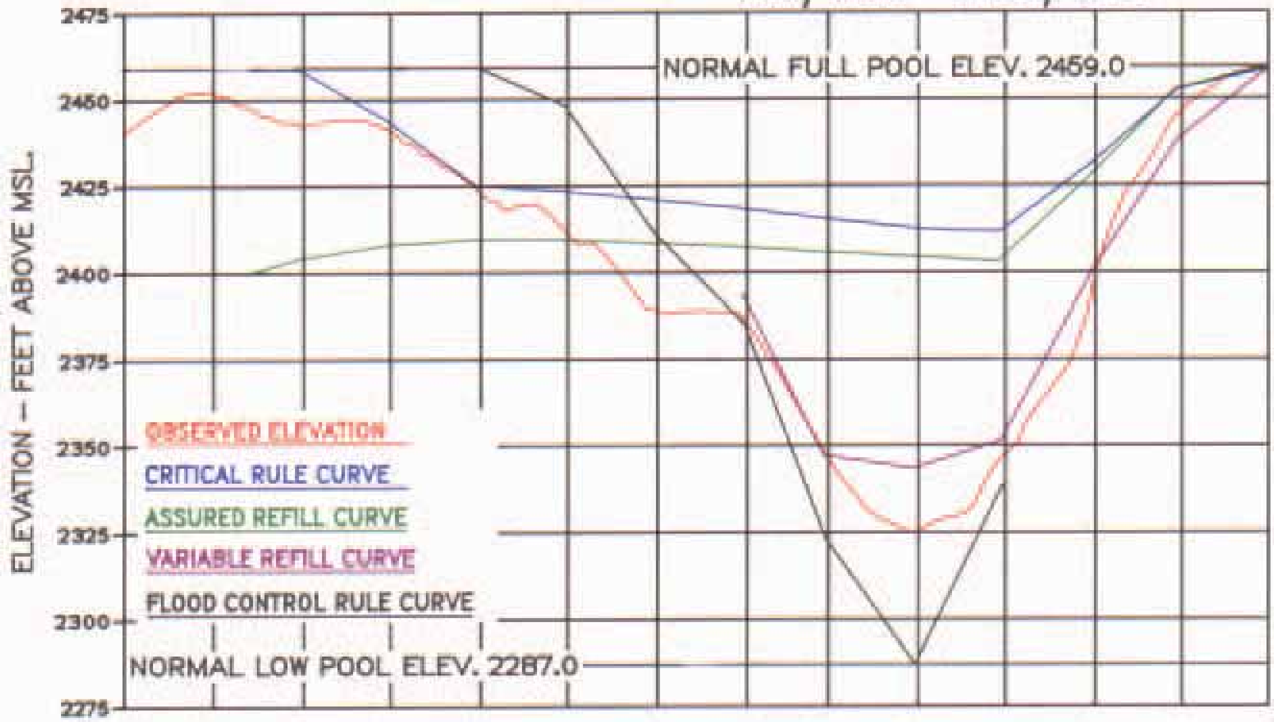


Chart 9
Regulation of Libby
1 July 1989 – 31 July 1990



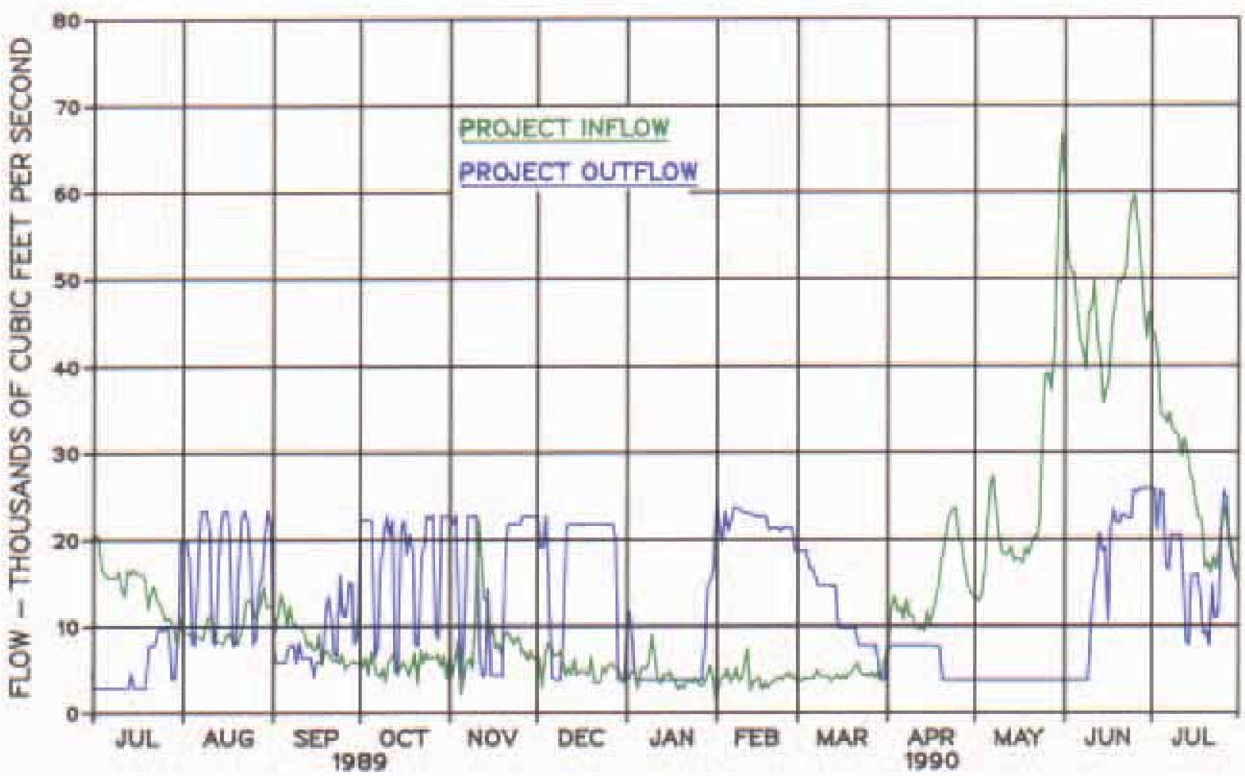


Chart 10
Regulation of Kootenay Lake
1 July 1989 – 31 July 1990

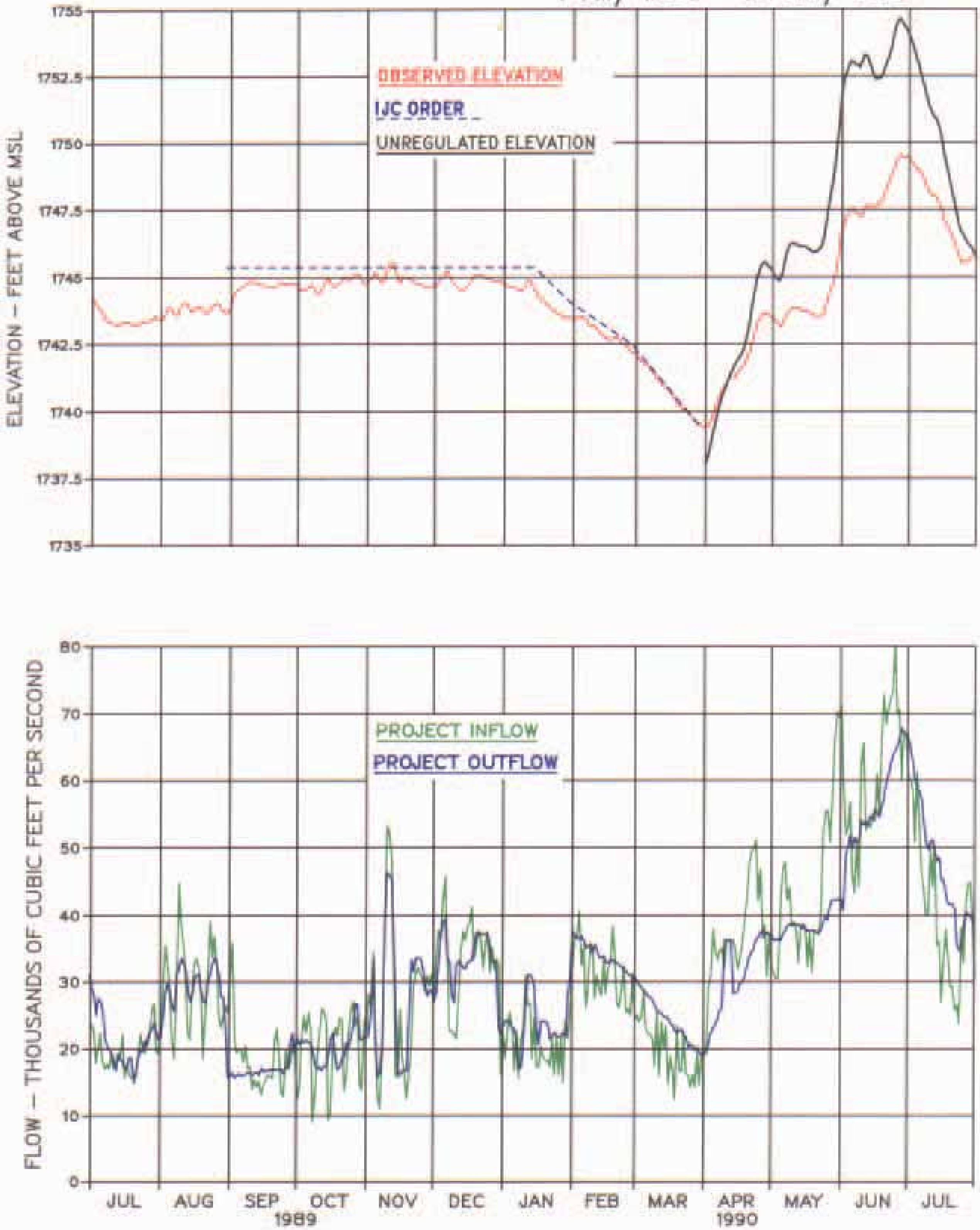


Chart 11
Columbia River at Birchbank
1 July 1989 – 31 July 1990

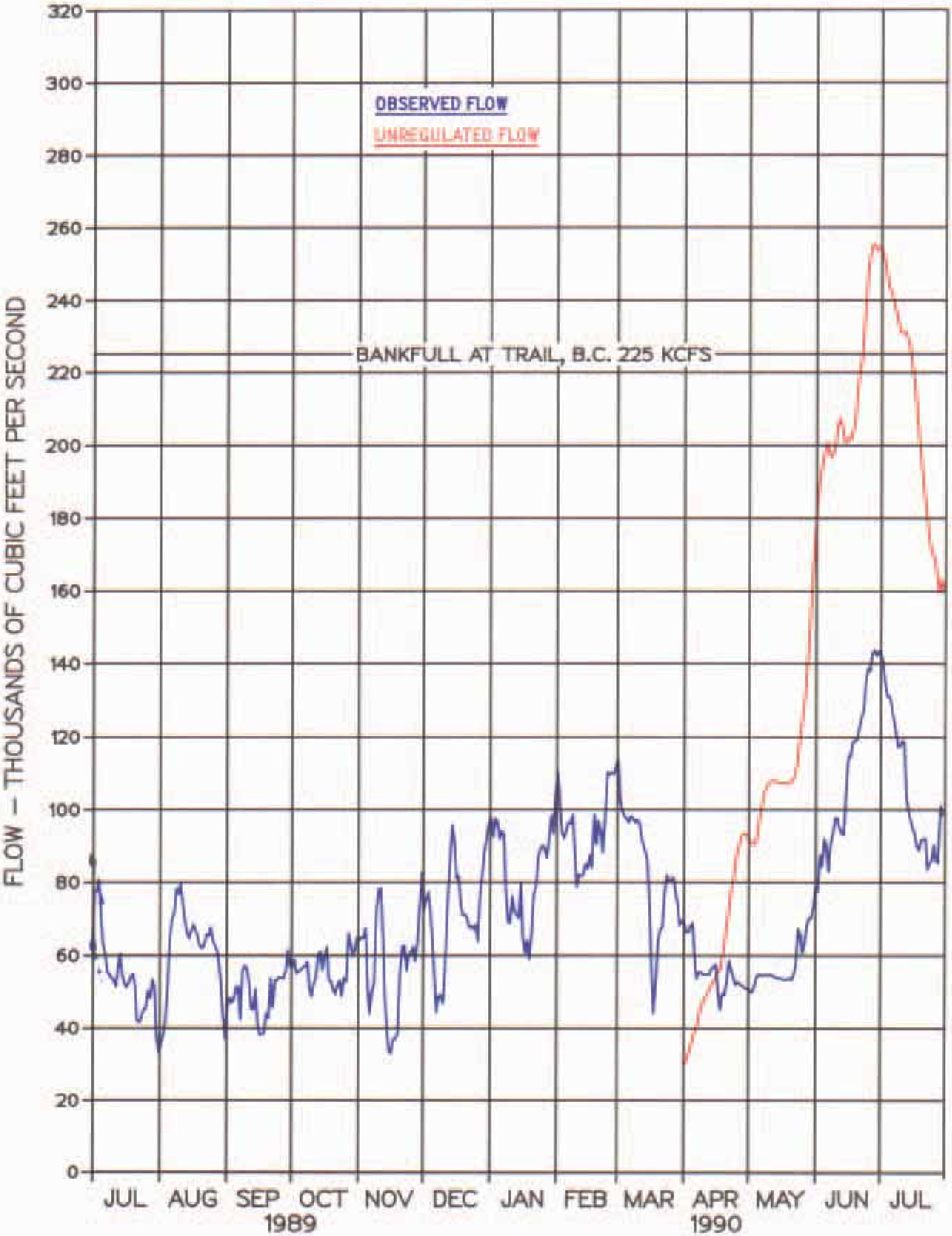
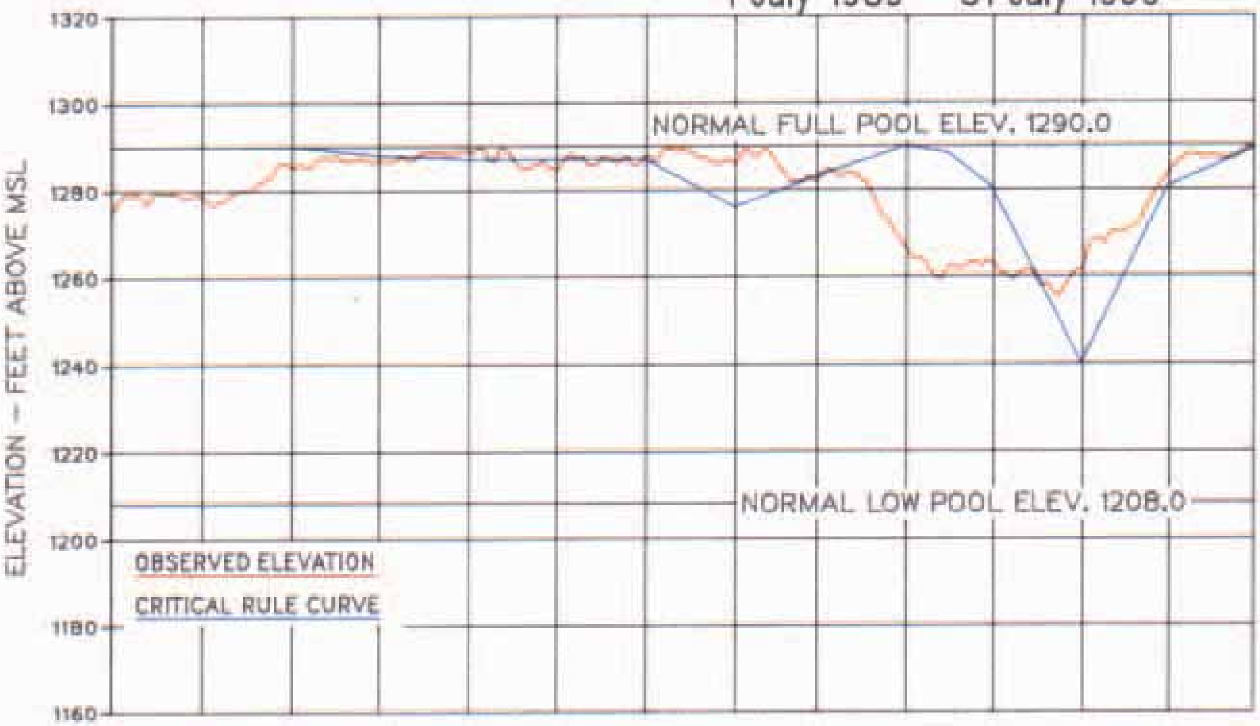


Chart 12
Regulation of Grand Coulee
1 July 1989 - 31 July 1990



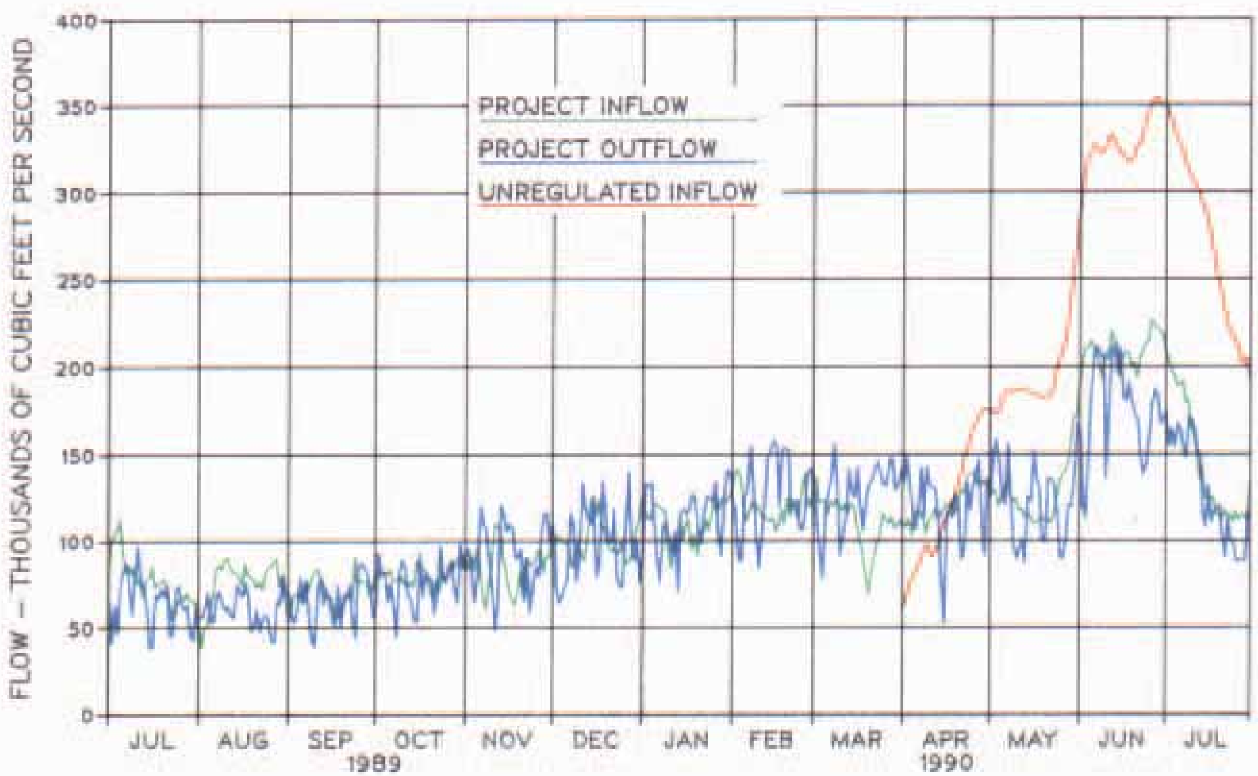


CHART 13
Columbia River at The Dalles
1 July 1989 – 31 July 1990

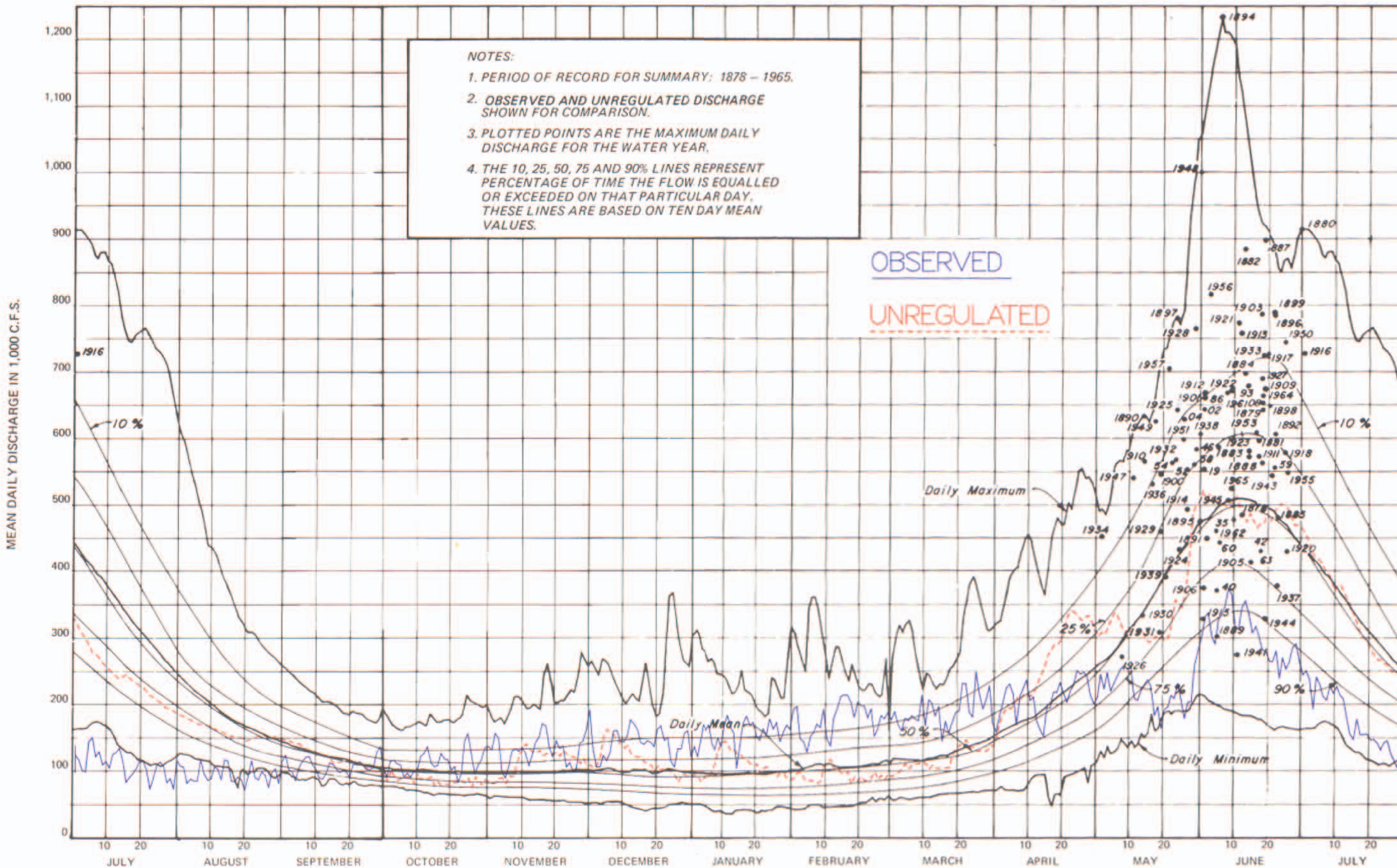


Chart 14
Columbia River at The Dalles
1 April 1990 – 31 July 1990

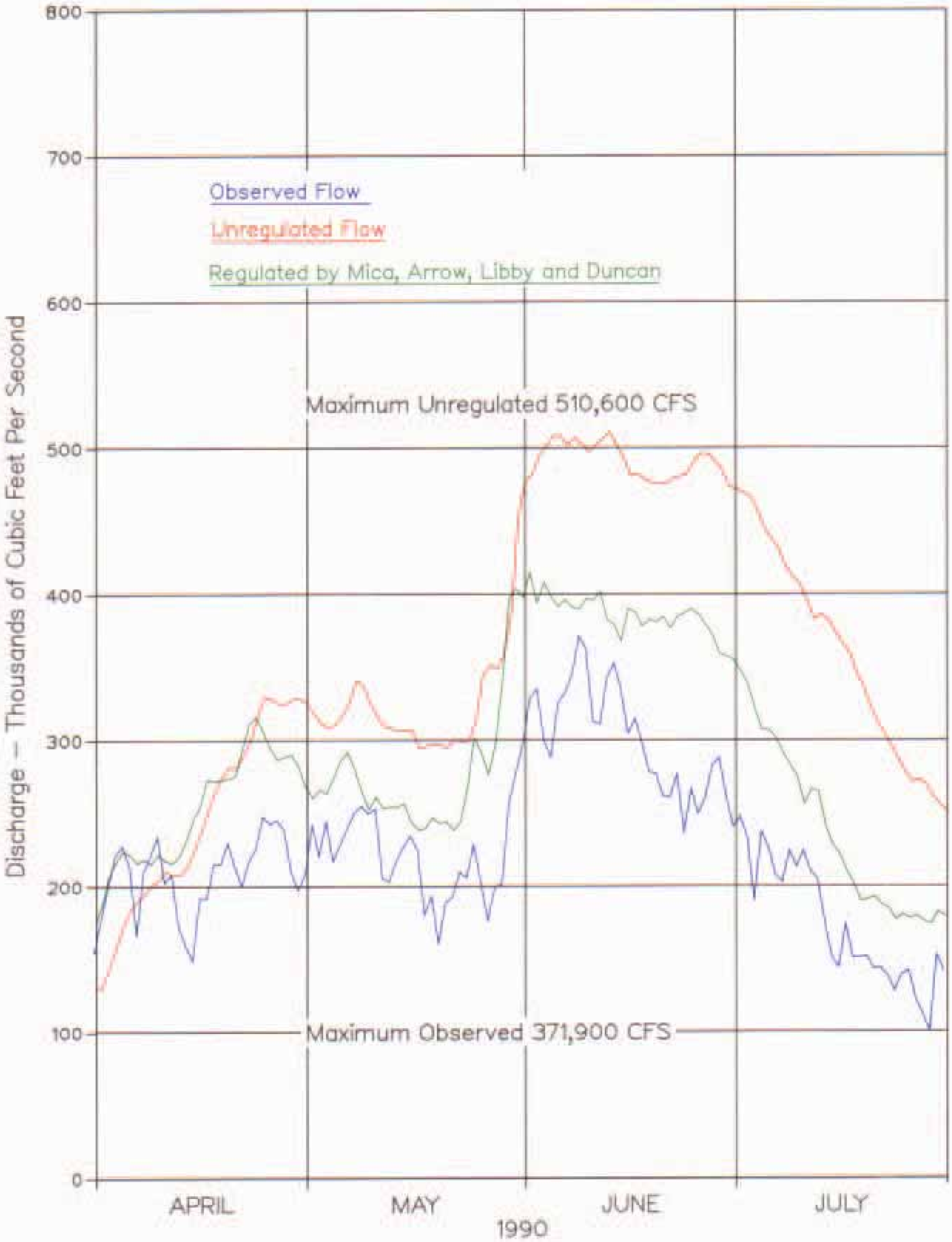


Chart 15
1990 Relative Filling
Arrow and Grand Coulee

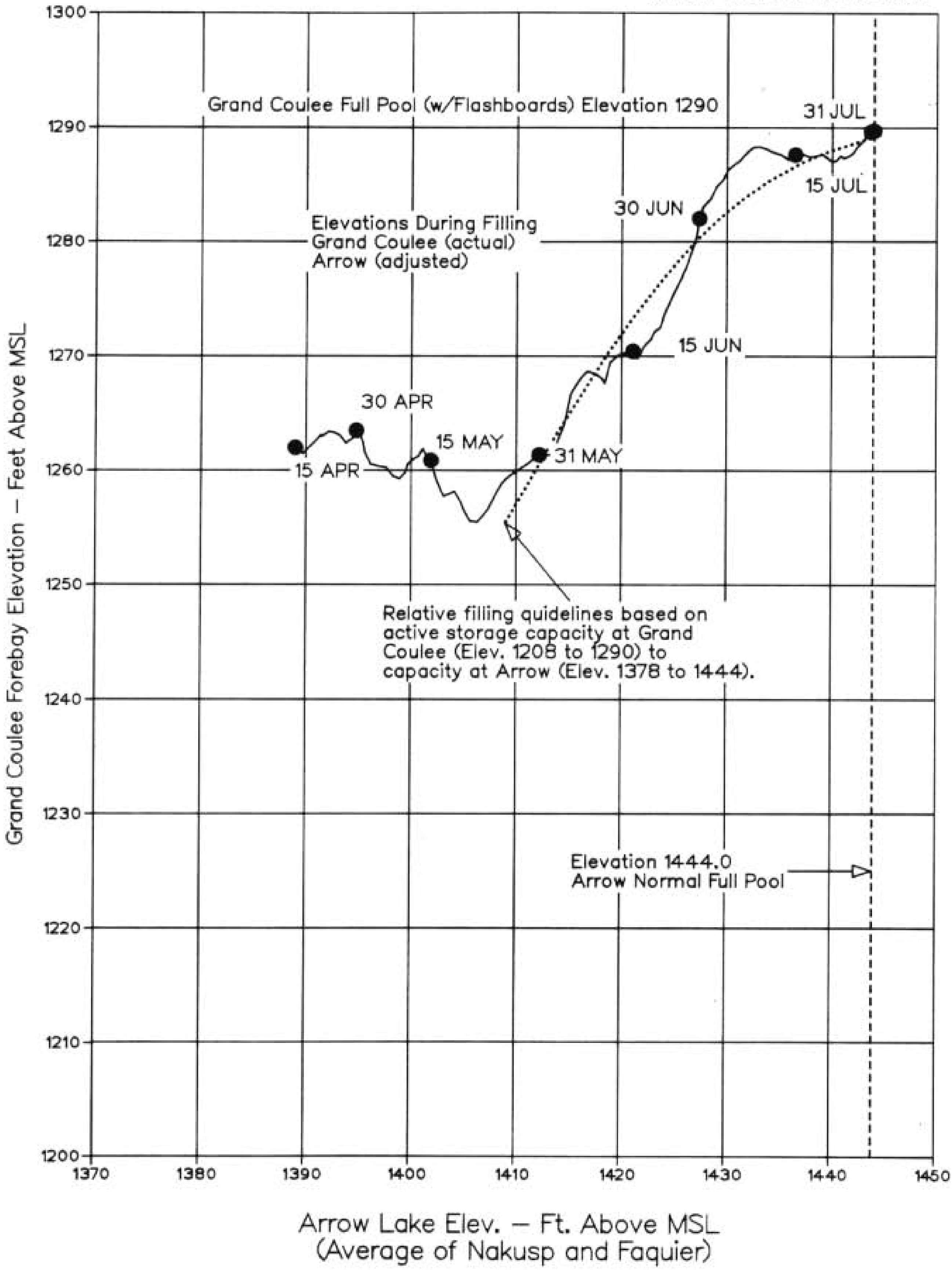


Chart 15
1990 Relative Filling
Arrow and Grand Coulee

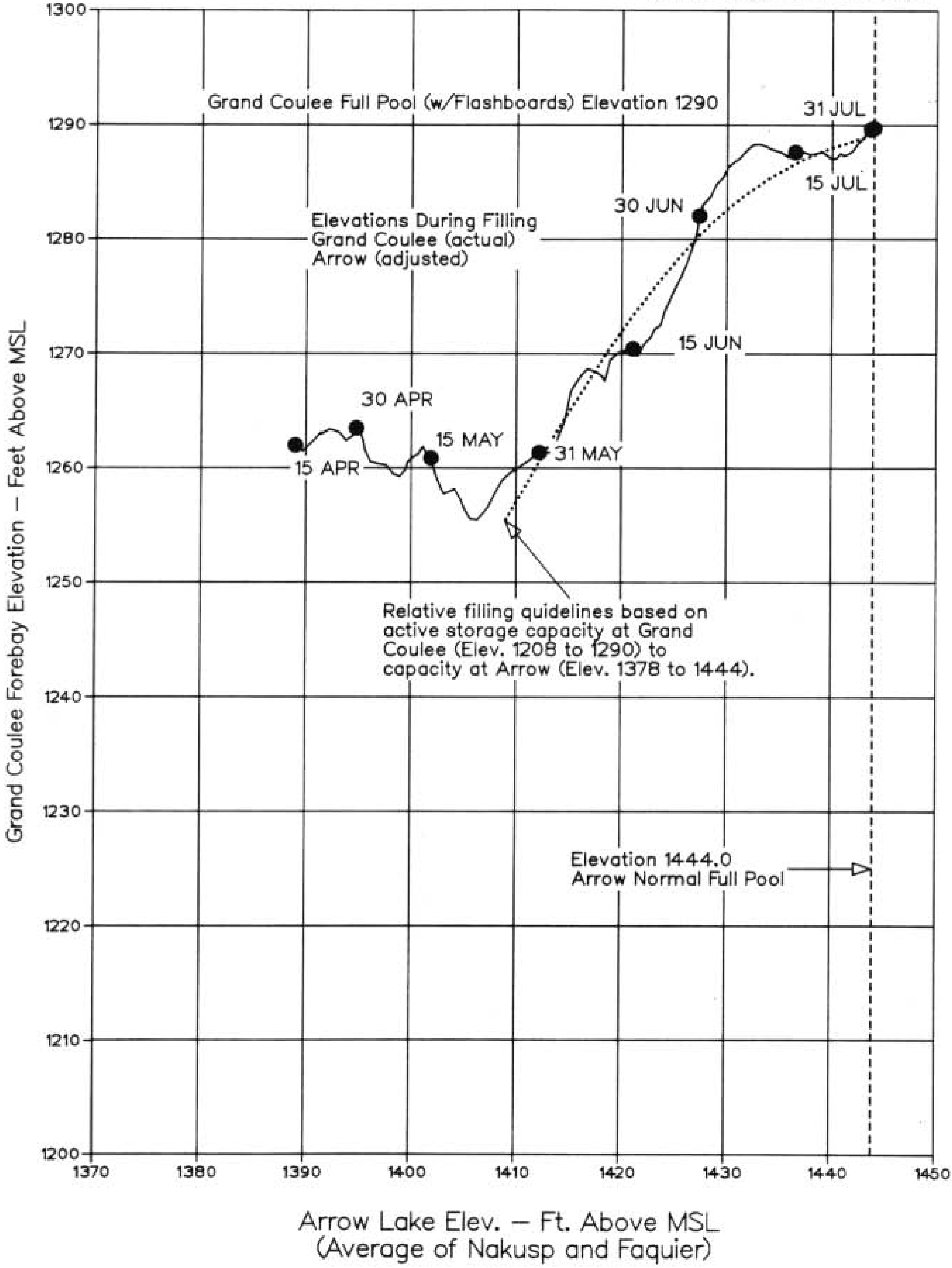


CHART 16
Highwater '89 Exercise
Simulated Dam Failure Hydrographs

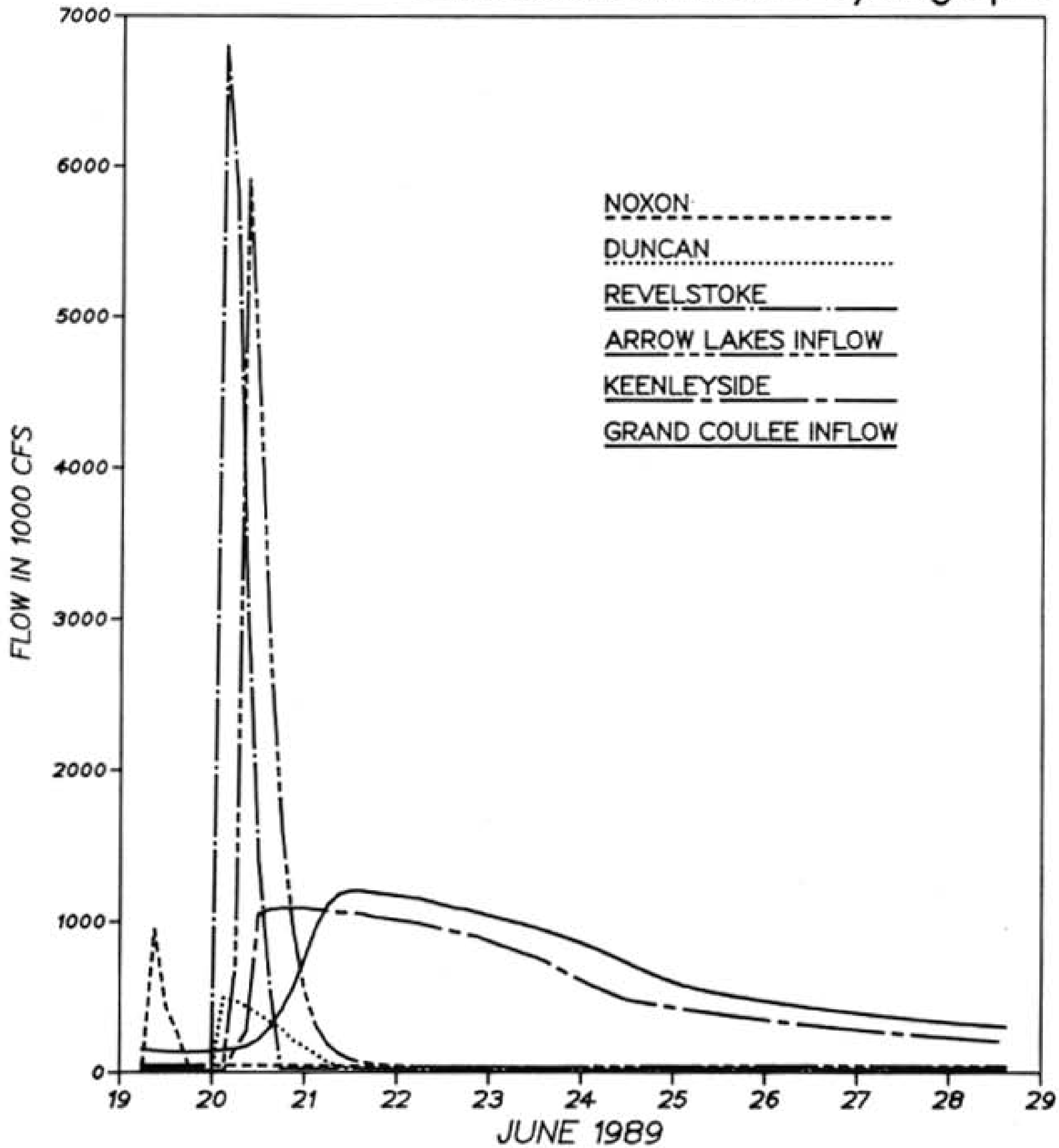


CHART 17
Highwater Exercise '89
Simulated Lower Columbia Hydrograph