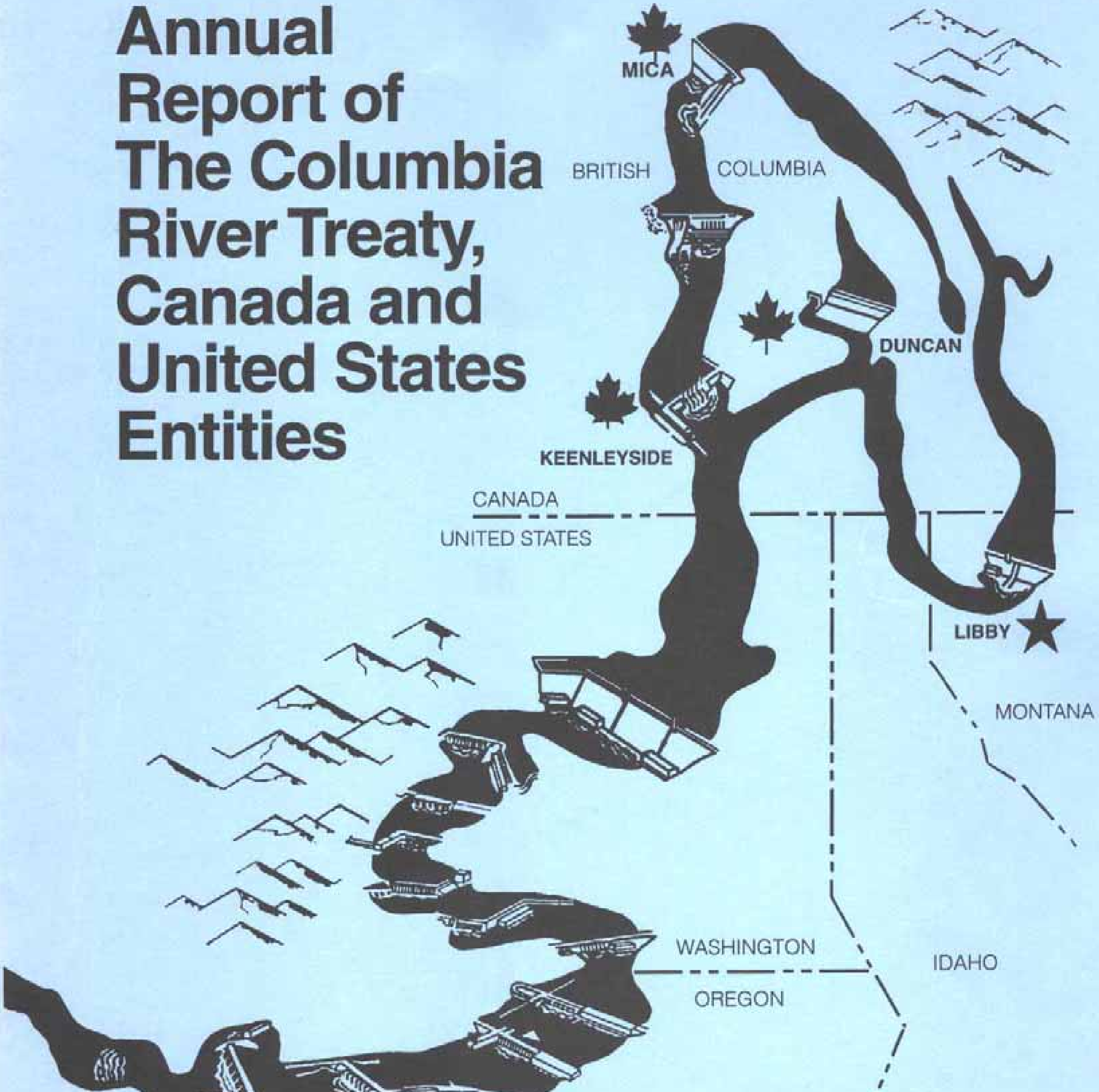
Annual Report of The Columbia River Treaty, Canada and United States Entities



1 October 1993 through
30 September 1994

November 1994

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

FOR THE PERIOD

1 OCTOBER 1993 - 30 SEPTEMBER 1994

Executive Summary

Entity Agreements

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

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994, dated September 1993.
- Columbia River Treaty Entity Agreement on Operation of Treaty Storage for Nonpower Uses for January 1 through July 31, 1994, dated 18 May 1994.
- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1994 through 31 July 1995, dated August 1994.
- Memorandum of Negotiator's Agreement, dated 8 September 1994.

System Operation

The coordinated system filled to 72.9 percent of Actual Energy Regulation (AER) storage capacity by 31 July 1993. As a result, third year firm energy load carrying capability (FELCC) was adopted for the 1993-94 operating year. Actual storage capacity was filled to 77%. Because of persistent low flows, the system continued to proportionally draft from August through April to meet FELCC. During May the system load could be met operating to the Energy Content Curves (ECC) while during June and July proportional draft was required to meet FELCC.

The 1 January 1994 water supply forecast for the Columbia River at The Dalles (Jan-Jul) was 79.7 maf, or 75 percent of average. During the winter, the Federal System was operated conservatively to ensure that about 3 maf above the energy content curve (ECC) would be provided for the 1994 juvenile fish flow augmentation. Energy was purchased to keep the reservoirs (Arrow, Grand Coulee and Libby) above PDP. Although rainfall over all spring months was near normal, the month of March was 58% of normal resulting in forecasted runoff continuing to drop until April when the trend turned upward. The actual observed runoff was 75.0 maf, or 71 percent of average and the ninth lowest since 1929.

The peak daily average flow observed at The Dalles was 228,300 cfs on 15 June 1994.. The lower Columbia River flow was regulated for juvenile fish between 10 April and 31 July, by "In-Season Management Teams". The Executive and Operations teams were responsible for using Water Budget and Flow Augmentation volumes to meet National Marine Fisheries Service's Biological Opinion fish flows at Lower Granite and McNary. The observed coordinated system storage content reached 77 percent of capacity on 31 July 1994. However, the energy content reached in the Actual Energy Regulation (AER) for Firm Energy Load Carrying Capability (FELCC) was only 74.7 percent of full. This value was used to determine the Firm Energy Load Carrying Capability (FELCC), with third year FELCC adopted for the 1994-95 operating year. From 1 August 1993 through 31 March 1994 generation at downstream projects in the United States, delivered to the Columbia Storage Power Exchange (CSPE) participants under the Canadian Entitlement Exchange Agreement, was approximately 293 average megawatts at rates up to 755 megawatts. From 1 April through 31 July 1994 the delivery was 279 average megawatts, at rates up to 666 megawatts. All CSPE power was used to meet Pacific Northwest loads.

Treaty Project Operation

The Treaty projects were operated throughout the year in accordance with the 1993-94 Detailed Operating Plan and the Flood Control Operating Plan.

Mica Treaty storage was 2.13 maf on 31 July 1993, and with continued storing, reached 3.91 maf or 56 percent of full content on 6 October 1993. The actual reservoir elevation reached a high of Elev. 2419.4 feet (55.6 feet below full) on 12 September. This peak level was the lowest peak level on record. By 31 December, Treaty storage was 1.85 maf and the observed reservoir level had dropped to Elev. 2396.9 feet. Treaty storage reached its lowest level on 16 April 1994 at -0.96 maf (Non-Treaty and other storage at Mica kept the total live storage positive). The reservoir reached its lowest level, Elev. 2350.8 feet, on 20 April 1994. From then on, Mica's treaty storage refilled, reaching 83 percent full (2935 ksfd or

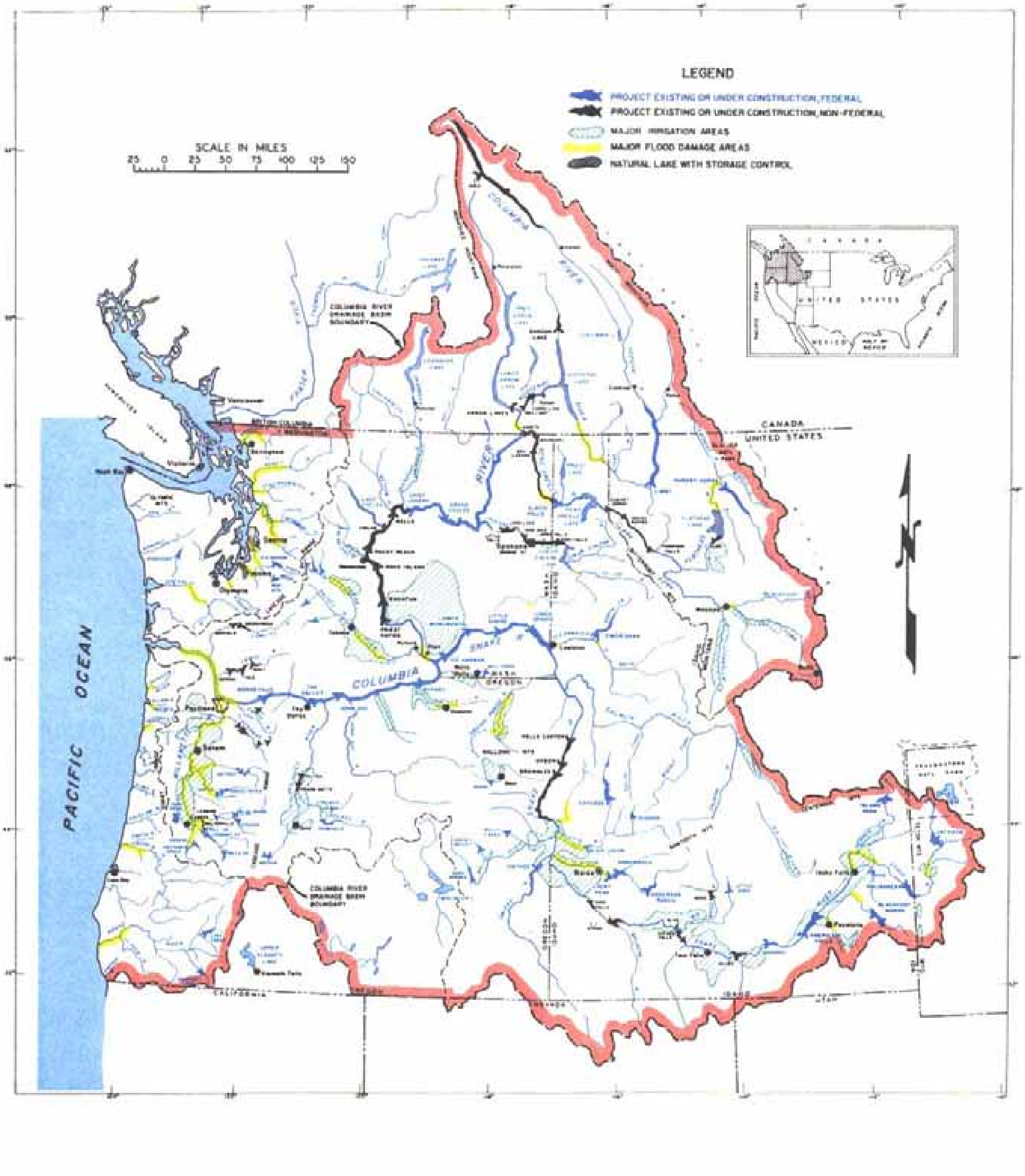
5.82 maf) on 30 September 1994. The maximum level for 1994, Elev. 2437.9 feet, 37.1 feet below full pool, was reached on 15 August.

The Arrow Treaty storage account started the operating year (31 July 1993) at 6.89 maf, or 98% of full. Following the 1993 operating year, Arrow reached its maximum level of Elev. 1433.5 feet on 4 September 1993. By 31 October 1993 the reservoir was at Elev. 1428.0 feet and at year end was Elev. 1415.8 feet. Heavy releases in late January and February 1994, and maintenance of a minimum flow of 26.5 kcfs during most of March to avoid dewatering trout redds drafted Arrow, such that it reached a minimum elevation of 1389.1 feet on 28 March 1994. Arrow Treaty storage also reached its minimum on this date at 1.81 maf or 26% full. During January through July, Arrow operated under an Entity agreement on the operation of Treaty storage for non-power uses. This agreement allowed the operation of Keenleyside Dam to be coordinated for fisheries and recreation benefit on both sides of the border. During April through May, Arrow discharges were held at 20 kcfs. In June, the discharge increased steadily from 20 kcfs to 70 kcfs and by mid-June, the Arrow reservoir was at Elev. 1426.4 feet. During July, Mica discharges were increased to maintain Arrow levels. The Arrow level was maintained in the range of Elev. 1423 to 1426.5 feet for most of the summer with the peak at Elev. 1426.5 on 26 July 1994. During August, the Arrow level sagged to a low of Elev. 1423.0 feet, and reached Elev. 1421.0 feet by 30 September 1994.

Duncan reservoir did not fill by the end of the 1992-93 operating year. The reservoir level was Elev. 1882.4 feet on 31 July 1993 and reached its peak 1993 level of Elev. 1885.4 feet (6.6 feet below full) on 10 August 1993. During September through November, Duncan outflow averaged 2 kcfs to support Kootenay Lake level and by 30 November, the Duncan reservoir level had drafted to Elev. 1877.0 feet. Drawdown continued through February to meet Duncan's flood control requirements of Elev. 1868.4 feet on 31 December and Elev. 1812.8 feet on 28 February 1994. During April, Duncan was operated to draft as much as possible from the reservoir. Duncan reached its lowest level during the 1993-94 operating year of Elev. 1794.9 feet, on 4 May 1994. Minimum releases during May-July helped refill the reservoir to Elev. 1891.5 feet by 30 July 99% of full). By 7 August, Duncan outflow was increased to 10 kcfs to allow a reduction in Arrow outflow and, later, to support the Kootenay Lake level. By 30 September 1994, Duncan had been drafted to Elev. 1852.6 feet.

During the 1992-93 operating year, Libby reached its maximum level, Elev. 2448.2 feet (11 feet below full) on 6 September 1993. The reservoir began its drawdown in mid-September, releasing 13 kcfs for fishery studies. By mid-October, Libby went to full load of 18 kcfs as it began releasing the 96 ksfd of Libby/Duncan transfer, fulfilling requests for Kootenay River fishery research, and drafting to PDP. This resulted in the reservoir being drafted to Elev. 2379.7 feet on 31 December 1993. Due to a low runoff volume forecast and low inflows, Libby outflow was reduced to the minimum flow of 4 kcfs on 10 January 1994. A minimum level, Elev. 2364.9 feet, was reached on 15 March. On 1 May, Libby reservoir was 1.156 maf above PDP. The 4 kcfs minimum continued until 10 May when Libby outflow was adjusted to provide a Bonners Ferry flow of 15 kcfs in May and 20 kcfs in June to enhance white sturgeon spawning. Although a discharge of 11 kcfs was the goal for July, the 1.156 maf of flow augmentation storage available in Libby had been depleted by 10 July and Libby flows were reduced to 4 kcfs. In a agreement with the State of Montana, the 4 kcfs flow was maintained through Labor Day, with the highest level, 2447.2 feet, (11.8 feet below full) reached on Labor Day, 5 September 1994.

COLUMBIA RIVER AND COASTAL BASINS



1994 Report of The Columbia River Treaty Entities
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1994 Report of The Columbia River Treaty Entities
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I Introduction

This annual Columbia River Treaty Entity Report is for the 1994 Water Year, 1 October 1993 through 30 September 1994. 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 1993 through 31 July 1994. The power and flood control effects downstream in Canada and the United States are described. This report is the twenty-eighth 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 purposes of flood control and increasing hydroelectric power generation in Canada and the United States of America. 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 were two meetings of the Columbia River Treaty Entities (including the Canadian Entity and U.S. Entity Coordinators) during the year on the morning of 3 February 1994 in Portland, OR., and the afternoon of 7 June 1994 in Vancouver, B.C. The members of the two Entities at the end of the period of this report were:

UNITED STATES ENTITY	CANADIAN ENTITY
Mr. Randall W. Hardy, Chairman Administrator, Bonneville Power Administration Department of Energy Portland, Oregon	Mr. John N. Laxton, Chair Chair, British Columbia Hydro and Power Authority Vancouver, B.C.
Major General Ernest J. Harrell Division Engineer North Pacific Division Army Corps of Engineers Portland, Oregon	

Mr. Laxton succeeded Mr. Marc Eliesen effective 16 May 1994.

The Entities have appointed Coordinators 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

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

Sue F. Hickey, Coordinator
Chief Operating Officer
Bonneville Power Administration
Portland, Oregon

David A. Geiger, Coordinator
Acting Director, Planning and Engineering
North Pacific Division
Army Corps of Engineers
Portland, Oregon

Pamela A. Kingsbury, Secretary
Resource Optimization
Hydro/Thermal Operations
Bonneville Power Administration
Portland, Oregon

CANADIAN ENTITY COORDINATOR

H.D. Kenneth Epp, Coordinator
President & CEO of POWEREX
Vancouver, B.C.

Graeme L. Simpson, Secretary
Resource Planning Engineer
BC Hydro and Power Authority
Vancouver, BC

Mr. Geiger was appointed to succeed Mr. Robert Flanagan effective 4 January 1994.

Columbia River Treaty 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

Mark Maher, BPA, Co-Chairman
Nicholas A. Dodge, ACE, Co-Chairman
Russell L. George, ACE
Steven A. Montfort, BPA

CANADIAN SECTION

Timothy J. Newton, BCH, Chairman
Ralph D. Legge, BCH
Kenneth R. Spafford, BCH
Henry C. Mark, BCH

Mr. Mark was appointed to succeed Gary H. Young, effective 1 April 1994.

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
22 November 1993	Vancouver, B.C.	19
11 January 1994	Portland, OR.	18
17 March 1994	Vancouver, B.C.	20
17 May 1994	Vancouver, WA.	15
12 July 1994	Vancouver, B.C.	21
20 September 1994	Portland, OR	17

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 have been prepared by the Committee with the assistance of others. During the period covered by this report, the Operating Committee completed the 1993-94 Detailed Operating Plan (DOP), and the 1994-95 DOP.

Columbia River Treaty 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 the Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Gregory K. Delwiche, BPA Co-Chairman	Brian H. Fast, BCH, Chairman
Douglas D. Speers, ACE, Co-Chairman	Heiki Walk, BCH, Member

There was one meeting of the Hydrometeorological Committee, on 22 October 1993, in Vancouver, BC. The committee reviewed the 1993 volume forecast results, hydromet station changes, and developments in telemetry and 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

John P. Elmore, Chairman,
Washington, D.C.
Ronald H. Wilkerson, Member
Missoula, Montana

Paul Barber, Alternate
Washington, D.C.
Thomas L. Weaver, Alternate
Golden, Colorado
S.A. Zanganeh, Secretary
Washington, D.C.

CANADIAN SECTION

David Oulton, Chairman
Ottawa, Ontario
John Allan, Member
Victoria, B.C.

Don A. Kasianchuk, Alternate
Victoria, B.C.
Vic Niemela, Alternate
Vancouver, B.C

David Burpee, Secretary
Ottawa, Ont.

Mr. Elmore was appointed to succeed Mr. Herbert Kennon on 29 January 1994. Mr. Barber was appointed to replace Mr. Elmore as Alternate on 29 January 1994.

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 PEB and the Entities was held on the afternoon of 3 February 1994 in Portland, OR. A special joint meeting of the PEB and the Entities was held on 7 June 1994 in Vancouver, B.C., to discuss the Entities' interpretation of critical streamflow period.

PEB Engineering Committee

The PEB has established a PEB Engineering Committee (PEBCOM) to assist in carrying out its duties. The members of PEBCOM at the end of the period of this report were:

UNITED STATES SECTION

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

CANADIAN SECTION

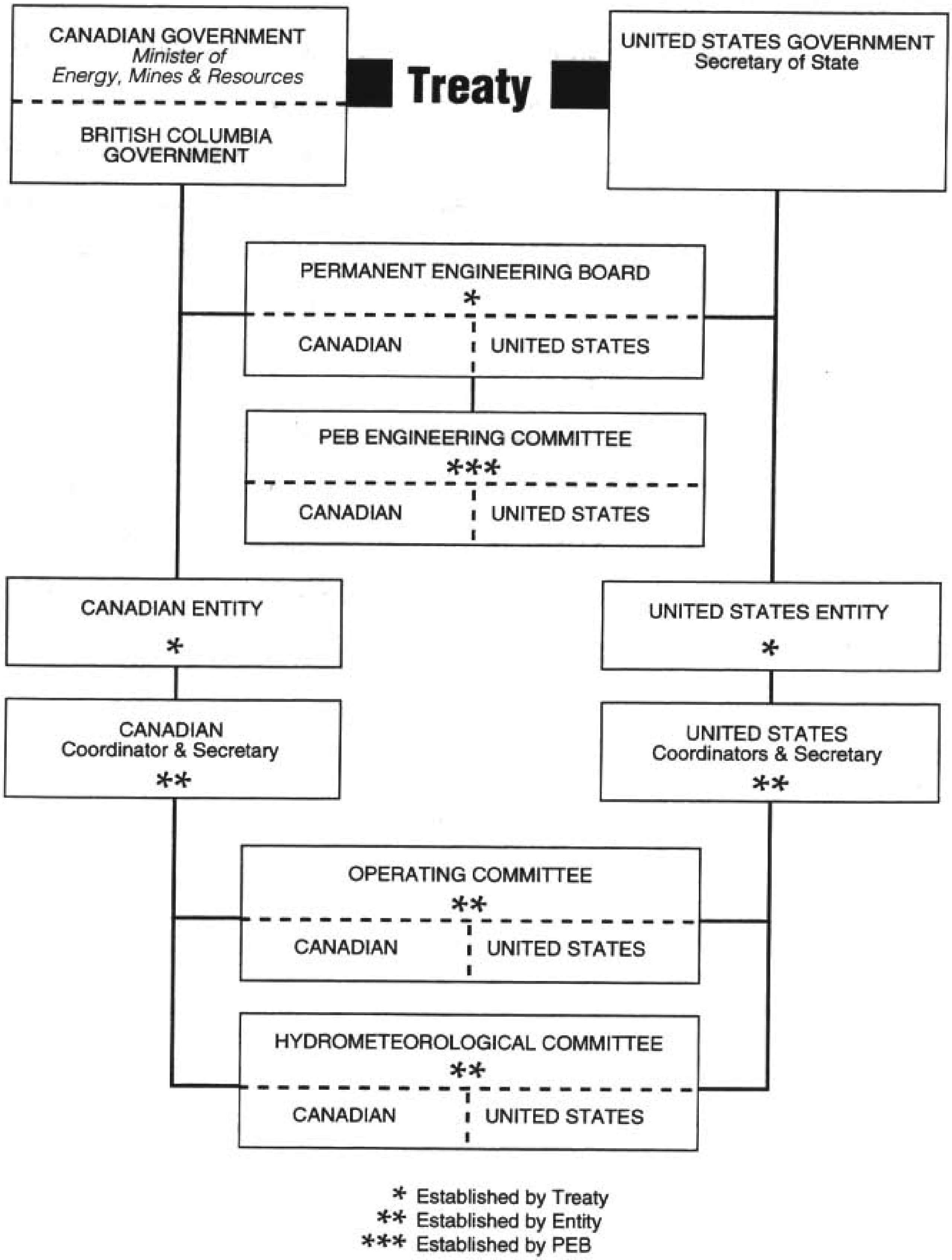
R.O. "Neill" Lyons, Chairman
Vancouver, B.C.
David Burpee, Member
Ottawa, Ont.
Roger McLaughlin, Member
Victoria, B.C.
Bala Balachandran, Member
Victoria, B.C.

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 may 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 December 1991 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 has been changed to the same period. Most of the hydrographs and reservoir charts in this report are for a 13 month period, July 1993 through July 1994.

Assured Operating Plan

The Alternative Operating Plan (AOP) dated July 1989 established Operating Rule Curves for Duncan, Arrow, and Mica during the 1993-94 operating year. The Operating Rule Curves provided guidelines for draft and refill. 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 1991 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 year 1993-94 the estimate of benefits resulting from operating plans designed to achieve optimum operation in both countries was 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 2.3 megawatts of dependable capacity and no energy during the period 1 August 1993 through 31 March 1994 and no dependable capacity and 2 average megawatts of energy during the period 1 April 1994 through 31 July 1994. Suitable arrangements were made between the Bonneville Power Administration and B.C. Hydro for delivery of this capacity and energy.

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 1993. The DOP established criteria for determining the Operating Rule Curves for use in actual operations. Except for minor changes at Arrow during the spring months, the DOP used the AOP critical rule curves for Canadian Projects. The Variable Refill Curves and flood control requirements subsequent to 1 January 1994 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 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, four agreements were 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
10 November 1993	Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994, dated September 1993.
18 May 1994	Columbia River Treaty Entity Agreement on Operation of Treaty Storage for Nonpower Uses for January 1 through July 31, 1994.
8 September 1994	Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1994 through 31 July 1995, dated August 1994
8 September 1994	Memorandum of Negotiators' Agreement for the Delivery and Disposition of the Canadian Entitlement under the Columbia River Treaty.

Long Term Non-Treaty Storage Contract

In accordance with the 9 July 1990 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 operating year to insure that they did not adversely impact operation of Treaty storage required by the Detailed Operating Plan.

IV Weather and Streamflow

Weather

The 1994 Water Year was preceded by a warm September that had less than half its normal precipitation; a situation which proved prophetic for the coming year (Charts 1 and 3). A high pressure ridge located near the Washington coast shifted southward slightly after the first week of October, allowing some weak frontal systems into the basin. This weather pattern lasted through November, producing half the normal monthly precipitation for the two months. December saw the first real shift in the Northwest's weather patterns to the more typical seasonal form. But the southwesterly storm track with its above normal precipitation lasted only ten days and the coastal pressure ridge rebuilt, cutting off the source of moisture. The month ended with only two-thirds the normal precipitation and normal temperatures. January weather was similar: for 10 days the high was replaced with a low pressure system which produced above normal precipitation. This storm pattern too was short-lived and the month ended with only two-thirds its normal monthly precipitation but the temperatures were above normal. This weather pattern continued through the first week of February when another low pressure system moved into the Gulf of Alaska. This pattern proved to be more stable and lasted through the first week in March and produced normal amounts of precipitation. After that the ridge again rebuilt and the moisture source for the basin was cut off, except for a short spell near mid month. March ended with above normal temperatures but only half its normal precipitation. Although April, May, and June saw normal temperature and precipitation (Charts 4 and 5), it was too late in the year to reverse the dry trend, and temperatures were too warm for much accumulation of snowpack from these storms. During July, August, and September temperatures returned to above normal and the precipitation ranged between half and three-fourths of normal.

The final monthly precipitation indices for the Columbia Basin above The Dalles are shown below for the 1994 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 30-year average (1961-1990).

WY 94 Indices

Month	Precipitation (in.)	Precipitation (%)	Month	Precipitation (in.)	Precipitation (%)
Oct 93	1.34	82	Apr 94	1.60	100
Nov 93	1.26	46	May 94	1.84	101
Dec 93	2.09	70	Jun 94	1.64	90
Jan 94	1.87	64	Jul 94	0.56	52
Feb 94	2.31	110	Aug 94	0.53	43
Mar 94	1.09	58	Sep 94	0.63	45
			Water Year	16.76	72

Streamflow

The observed inflow and outflow hydrographs for the Treaty reservoirs for the period 1 July 1993 through 31 July 1994 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 1994 period, including a plot of flows occurring if regulated only by the Treaty reservoirs.

Composite operating year unregulated streamflows in the basin above The Dalles were less than last year, with only April exceeding the norm. The October through September runoff for The Dalles was 72 percent of the 1961-90 average. The peak regulated discharge for the Columbia River at The Dalles was 224,300 cfs on 12 May 1994. The 1993-94 monthly unregulated streamflows and their percent of the 1961-90 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 93	93,870	90	131,210	95
Sep 93	52,210	81	81,400	85
Oct 93	36,640	76	70,530	82
Nov 93	26,030	54	53,890	59
Dec 93	28,490	67	61,430	65
Jan 94	30,070	73	67,020	68
Feb 94	25,620	55	58,770	51
Mar 94	44,460	75	97,040	69
Apr 94	144,880	124	230,380	103
May 94	235,780	90	335,460	79
Jun 94	216,280	66	276,920	56
Jul 94	144,250	75	175,640	68
Year	89,880	79	136,640	72

Seasonal Runoff Forecasts and Volumes

Observed 1994 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 1961-90 Average
Libby Reservoir Inflow	5,220	82
Duncan Reservoir Inflow	2,006	98
Mica Reservoir Inflow	11,109	97
Arrow Reservoir Inflow	22,749	98
Columbia River at Birchbank	37,207	91
Grand Coulee Reservoir Inflow	49,356	81
Snake River at Lower Granite Dam	12,152	53
Columbia River at The Dalles	67,188	72

Forecasts of seasonal runoff volume, based on precipitation and snowpack data, were prepared in 1994 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 U. S. Columbia River Forecasting Service. The 1 April 1994 forecast of January through July runoff for the Columbia River above The Dalles was 73.2 maf and the actual observed runoff was 75.0 maf.

The following tabulation summarizes monthly forecasts since 1970 of the January through July runoff for the Columbia River above The Dalles compared with the actual runoff measured in millions of acre-feet (maf). The average January-July runoff for the 1961-1990 period is 105.9 maf.

The Dalles Volume Runoff Forecasts in MAF (Jan-Jul)

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
1991	116.0	110.0	107.0	106.0	106.0	104.0	107.1
1992	92.6	89.1	83.5	71.2	71.2	67.8	70.4
1993	92.6	86.5	77.3	76.6	81.9	86.1	88.0
1994	79.7	76.3	78.1	73.2	75.5	76.4	75.0

V Reservoir Operation

General

The 1993-94 operating year was characterized by below average precipitation during August-March near normal during April-June, and finishing the year below normal. Temperatures basically were below normal in November and May-June, being near normal the rest of the year. A warm spell in late April depleted much of the snowpack. Although the snowmelt season was characterized by near normal conditions, the dry trend had established itself resulting in low runoff. At The Dalles, the observed January-July runoff was 71 percent of average, two percent higher than the April forecast, and four percent lower than the January forecast.

The operating year began with the coordinated reservoir system officially filling to 72.9 percent of storage capacity on 31 July 1993. As a result, third year firm energy load carrying capability (FELCC) was adopted for the 1993-94 operating year. Because of persistent low flows, the system continued to proportionally draft from August through April the to meet FELCC. During May the system load could be met operating to the Energy Content Curves (ECC) while during June and July proportional draft was required to meet FELCC.

The 1 January 1994 water supply forecast was for The Dalles was 79.7 maf for the January-July period, or 75 percent of the 1961-90 average. Subsequent forecasts through April reflected a slight decreasing trend, with the April forecast being 69 percent of normal. During April through July, near normal precipitation turned the forecasts upward with the June showing runoff forecasts volumes of 72 percent of normal. Actual runoff for January-July was 71% of normal.

In April, the system was in proportional draft between second and third year critical rule curves, however, BPA had more than 3 maf stored in the system above PDP. During the 10 April-31 July flow augmentation period, the water budget and 3 maf were used to augment flows at Lower Granite and McNary. Following the release of National Marine Fisheries Service's Biological Opinion on 16 March 1994, projects were regulated in an attempt to meet the following target flows:

- at Lower Granite, 85,000 cfs during 10 April - 20 June, and 50,000 cfs during 21 June - 31 July;

- at McNary, 200,000 cfs during 20 April - 30 June, and 160,000 cfs during 1-31 July.

Daily flood control regulation was not required during the 1994 snow melt season. The year's observed peak flow at The Dalles was 224,300 cfs on 12 May. Last year's peak was 386,500 cfs. The system reached 74.7 percent of its full energy capacity in the Actual Energy Regulation (AER) on 31 July 1994, resulting in third-year FELCC being adopted for the 1994-95 operating year. The observed refill on 31 July 1994 was 77% of energy capacity, providing some reservoir operating storage above the proportional draft level going into the new operating year.

Mica Reservoir

As shown in Chart 6, the Mica reservoir (Kinbasket Lake) was at Elev. 2414.4 feet on 31 July 1993, 60.6 feet below the full pool elevation of 2475 feet. The reservoir level continued to rise in August and early September, reaching its peak for the year, Elev. 2419.4 feet on 12 September 1993. This peak level was 55.6 feet below full pool, a record low annual maximum level at Mica, and 24 feet lower than the previous low annual maximum. The reservoir level was held in Elev. 2417 - 2419.4 foot range until early November.

Mica Treaty storage was 1075 ksfd (2.13 maf) on 31 July 1993. With a Treaty discharge of 10 kcfs for the months of August through October, Mica Treaty storage continued to refill, reaching a maximum of 1971 ksfd (3.91 maf, 56% of full) on 6 October. During August-September, actual Mica discharges were higher than Treaty discharges, reducing the substantial Treaty discharge underrun that had accumulated prior to 31 July 1993.

The primary cause of the low Mica reservoir levels during the summer of 1993 was a very low snowpack during the winter of 1992-93 and subsequent low runoff. The February-September 1993 runoff volume for Mica was the lowest on record, at 78% of average.

Mica powerhouse discharges during November and December averaged about 20 kcfs, and the reservoir drafted to Elev. 2396.9 feet by 31 December 1993. Treaty storage on that date was 935 ksfd (1.85 maf).

Mica powerhouse actual discharges averaged 13 kcfs during January 1994 and 29 kcfs in February. The reservoir drafted to Elev. 2369.3 feet by 28 February.

The reservoir continued to draft in March and most of April. Discharges during March-April averaged 15 kcfs. The reservoir reached its lowest level for the 1993-94 season, Elev. 2350.8 feet on 20 April. This level was about 10 feet higher than the previous year's record low level, due mostly to the mild winter. Mica Treaty storage reached a minimum of -484 ksfd (-0.96 maf) on 16 April. Arrow and Duncan Treaty storage during this time was well over 484 ksfd, so the total draft on Treaty storage did not exceed 15.5 maf. There was sufficient Non-Treaty and other storage at Mica to keep the total Mica live storage postive.

With the start of the spring freshet in early May, Mica discharges were reduced, and the reservoir began to refill quickly. The Mica Treaty discharge was 12 kcfs in May and 10 kcfs in June. However, actual discharges during May-June averaged 3 kcfs, increasing the Mica Treaty discharge underrun to 825 ksfd by the end of June. The reservoir refilled to Elev. 2416.4 feet by 30 June 1994.

In early July, receding inflows and a strategy of running Mica as much as reasonably possible to mitigate the low Arrow reservoir level combined to slow the refill rate of Mica reservoir. The actual Mica discharge during July was 24 kcfs, and the Mica level reached Elev. 2435.1 feet on 31 July 1994.

During August, Mica continued to run at almost maximum discharge for a monthly average discharge of 36 kcfs. The Mica reservoir continued to fill in early August, reaching the maximum for the year, Elev. 2437.9 feet (37.1 feet below full pool) on 15 August 1994. Although this peak level was 18.5 feet higher than the previous year's record-low peak level, the 1994 peak level was the second-lowest on record. The seasonal (February-September) runoff volume for Mica was nearly average (98%) in 1994.

Treaty storage at Mica continued to fill in August, reaching a maximum of 3210.8 ksfd (6.37 maf, 91% of full) on 31 August 1994. With high actual Mica discharges through the summer months, the Mica Treaty underrun was zeroed by 27 August and an overrun of 331 ksfd had accumulated by 30 September 1994.

Revelstoke Reservoir

During the 1993-94 operating year, Revelstoke project was operated generally as a run-of-river plant, with the reservoir level maintained within two feet of its normal full pool level, Elev. 1880 feet. The reservoir was drawn down to Elev. 1877.7 feet for a short period in February 1994 to help meet system load and exchange obligations. During the spring freshet, April through June, the reservoir level was operated as low as Elev. 1876.7 feet to allow control of high local inflows.

Arrow Reservoir

As shown in Chart 7, the Arrow reservoir (impounded by the Hugh Keenleyside Dam) level was Elev. 1432.0 feet on 31 July, 1993. From late July to early October, Arrow discharges averaged about 30 kcfs, and the Arrow level was maintained in the range of Elev. 1430-1434 feet. The maximum Arrow level for the year was Elev. 1433.5 feet (10.5 feet below normal full pool) on 4 September 1993.

On 31 July 1993, the Arrow Treaty storage account was slightly less than full at 3476 ksfd (6.89 maf, or 98% full). This storage had reduced to 2729 ksfd (5.41 maf) by 31 October 1993.

By 31 October 1993, the reservoir level had dropped to Elev. 1428.0 feet. The reservoir drafted a further 3 feet during November and 9 feet in December to end the 1993 year at Elev. 1415.8 feet. Average discharges in November were 35 kcfs, increasing to 40 kcfs in December.

In early January 1994, the Arrow reservoir draft rate was reduced. However, more rapid drawdown of the reservoir recommenced in late January and February, resulting in elevations of 1406.0 feet on 31 January and 1391.8 feet on 28 February. Average discharges in January and February were 38 and 61 kcfs, respectively.

From late February to late March, the Arrow discharge was held at or above 26.5 kcfs to avoid dewatering rainbow trout redds on the Norns Creek fan, just downstream of Keenleyside. From 29 March to 3 April 1994, Arrow discharges were held at 5 to 10 kcfs to allow recontouring of the fan to proceed. Dewatered redds were kept wet using a pump and sprinkler system.

The Arrow reservoir reached its lowest level for the year, Elev. 1389.1 feet, on 28 March 1994. Arrow Treaty storage also reached its annual minimum on that date, 914 ksfd (1.81 maf, or 26% of full).

During January through July, Arrow was operated under the terms of an Entity agreement on the operation of Treaty storage for non-power uses. This agreement allowed the U.S. to store and release water above the proportional draft point in Canadian Treaty space, and specified non-decreasing discharges from Keenleyside to avoid dewatering rainbow trout redds within Canada. On 4 April 1994, the Arrow discharge was increased from 5 to 15 kcfs. A further increase to 20 kcfs was made on 7 April. The Arrow reservoir level rose to Elev. 1403.8 feet by 30 April 1994.

The Arrow discharge was held at 20 kcfs for the entire month of May and the Arrow reservoir refilled to Elev. 1422.1 feet by 31 May. In June, the discharge increased in steps from 20 to 70 kcfs, with an average discharge of about 50 kcfs for the month. The reservoir refilled to Elev. 1426.4 feet by mid-month and then was held in the range of 1425 - 1426.4 feet for the remainder of June. By the end of June, all trout eggs had hatched and there were no further restrictions on Arrow operation.

Discharges during July averaged 66 kcfs, and the Arrow reservoir remained in the range 1425.5 - 1426.5 feet all month, with the peak level for the summer, Elev. 1426.5 feet occuring on 26 July 1994. The average August discharge was 65 kcfs. Even with Mica and Revelstoke maximum possible (without spill), the Arrow reservoir level dropped to Elev. 1423.0 feet by 28 August 1994. The reservoir rebounded to Elev. 1425.6 feet by 12 september, but then drafted to Elev. 1421.0 feet by 30 September 1994.

Duncan Reservoir

As shown in Chart 8, the Duncan reservoir level was Elev. 1882.4 feet on 31 July 1993. Duncan released minimum flow (0.1 kcfs) until 7 August 1993, at which time discharges were increased to support the Kootenay Lake level. Duncan reached its maximum level for the year, Elev. 1885.4 feet (6.6 feet below full pool) on 10 August. The reservoir level dropped to Elev. 1883.8 feet by 31 August 1993.

During the months of September through November, Duncan discharged an average of 2 kcfs to support the Kootenay Lake level. The 30 November 1993 level was Elev. 1877.0 feet.

Drawdown of the reservoir continued in December. The monthly average discharge was 3 kcfs, resulting in a 31 December 1993 end-of-month level of Elev. 1868.4 feet, meeting the flood control requirement for that date.

The Duncan reservoir continued to draft in January and February 1994 to provide flood control storage space. Discharges during January-February averaged about 8 kcfs, and the reservoir drafted to Elev. 1812.8 feet by 28 February 1994. During March, the Duncan discharge was reduced to about 3 kcfs, slowing the rate of reservoir draft. The 31 March 1994 level was Elev. 1799.5 feet.

During April, the Duncan discharge averaged 4 kcfs to draft as much storage as possible from Duncan. The minimum level for the year, Elev. 1794.9 feet (0.5 feet above empty), was reached on 4 May 1994.

The Duncan discharge was reduced to minimum, 0.1 kcfs, on 7 May to begin refilling the reservoir. The reservoir level reached Elev. 1832.0 feet by 31 May and Elev. 1865.3 feet by 30 June. Duncan remained on minimum discharge until 22 July. At that time, the discharge was increased to slow the rate of reservoir refill. The Duncan reservoir reached its peak level for the year, Elev. 1891.5 feet (0.5 feet below full), on 30 July 1994.

Duncan passed inflow during the first few days of August to maintain the reservoir near full pool. On 6 August, the Duncan discharge was increased to maximum (10 kcfs) to start drafting the reservoir. This action was necessary in early August to allow a reduction of the Arrow Treaty discharge and in support of the Arrow reservoir level. By mid-August, it was necessary to discharge maximum from Duncan to support the Kootenay Lake level. Duncan had drafted to elevation 1852.6 feet by 30 September 1994.

Libby Reservoir

As shown in Chart 9, Libby did not completely refill following the 1993 runoff, with Lake Koocanusa starting the operating year at Elev. 2438.3 feet, one foot lower than last year and 20 feet below full. The lake reached its peak summer level of Elev. 2448.2 feet on 6 September 1993

August to early-September releases from Libby were primarily in the 4.5 to 6.0 kcfs range for continued filming at Kootenay Falls by Universal Studios. This flow was requested for safety purposes at the falls. Flows were then weekly load-factored between 4 kcfs on weekends and increased to near 13 kcfs on weekdays for additional filming and for Montana Department of Fish, Wildlife, and Parks (MDFW&P) to continue transect surveys under a BPA contract. By mid-October, Libby outflow was increased to achieve full efficent load of 18 kcfs, fulfilling a further MDWF&P request, drafting to PDP, and drafting 96 ksfd of Libby/Duncan transfer water, which was completed by 31 October 1993. A late-November cold snap resulted in Libby increasing to full load of 21 kcfs and holding that flow through December. The reservoir on 31 December 1993 was Elev. 2379.7 feet, about 17 feet above the proportional draft point. Inflows during the October-December 1993 period were 100 percent of average.

Although the January 1994 water supply forecasts for the upper Columbia Basin drainages were about 90 percent of average, Libby's forecast was only 86 percent, and with the lake near Elev. 2380 feet, no draft was required to meet the 15 March flood control requirement of Elev. 2398 feet. Following receipt of the below-normal runoff forecast, Libby outflow was maintained at its minimum flow of 4 kcfs from 10 January 1994 until 6 May 1994 when it was increased to attract spawning white sturgeon into the Kootenay River reach near Bonners Ferry, and for Lower Columbia salmon flow augmentation. The reservoir reached its annual minimum level of Elev. 2364.9 feet on 15 March 1994. Warm weather in late-April started the snowmelt runoff, but it was short lived as the below-normal snowpack quickly depleted. The peak inflow of the season was only 44.3 kcfs and occurred very early on 3 May 1994. By the end of April, the reservoir level was near Elev. 2383.8 feet, nearly 46 feet or 1.156 maf above PDP. This water above PDP was to be used as part of the 3.0 maf salmon flow augmentation storage.

On 10 May 1994, Libby began releasing augmentation water for salmon and timed to attract spawning white sturgeon into the river reach between Kootenay Lake and Bonners Ferry. Libby releases were adjusted to maintain Bonners Ferry flows of 15 kcfs in May, 20 kcfs in June, and intended to meet 11 kcfs in July. Because of the 88% of normal April-June runoff and low Bonners Ferry local inflow, higher-than-expected Libby outflows depleted the 1.156 maf of stored augmentation water by 10 July 1994. Even with the augmentation releases, Libby continued to fill and by 10 July, the reservoir was at Elev. 2436.7 feet, 22 feet from full.

An agreement between the State of Montana; and the Corps of Engineers, and Bonneville Power Administration; resulted in no further draft from Libby through Labor Day and on 10 July, Libby outflow was reduced to 4 kcfs and maintained through most of September 1994.

By Labor Day, 5 September, the reservoir had reached its maximum level, Elev. 2447.2 feet, but low inflows during the month resulted in minor September drafting with the minimum 4 kcfs release. The January-July observed runoff was 0.55 maf, 85 percent of average.

Kootenay Lake

As shown in Chart 10, the level of Kootenay Lake at Queens Bay was Elev. 1743.3 feet on 31 July 1993, and the level at Nelson was below the summer IJC maximum operating level of Elev. 1743.32 feet. Corra Linn discharges were adjusted to pass inflow during August.

For the month of September 1993, the Kootenay Lake discharge was adjusted to keep the downstream Brilliant plant at full load without spill. The lake level dropped slightly in early September, reaching Elev. 1743.0 feet on 8 September. From then until late October, the lake refilled very slowly, reaching Elev. 1744.6 feet on 31 October. The Queens Bay level was then maintained below the autumn IJC maximum operating level of Elev. 1745.32 feet. Discharges from the lake during November-December 1993 averaged about 24 kcfs.

Kootenay Lake began drafting according to the IJC curve in early January 1994, with average discharges during the January-March period of 20 kcfs. The lake drafted below the IJC level of Elev. 1739.32 feet on 29 March, and reached its minimum level for 1994, Elev. 1739.12 feet, on 2 April 1994. In mid-April, local inflow to Kootenay Lake began to increase, amd the lake level exceeded Elev. 1739.32 feet on 17 April. The lake filled to Elev. 1742.8 feet by 30 April 1994.

Inflow during May-June averaged 42 kcfs, peaking at 61 kcfs on 12 May. The lake reached its peak level for the year, Elev. 1746.1 feet, on 28 June 1994. The maximum lake discharge for the year was 44 kcfs during the period 7-9 June, resulting in only minor spill at the Kootenay River plants between Corra Linn and South Slocan.

With receding runoff and reduced Libby discharges in July, Kootenay Lake drafted quickly. The lake level at Nelson dropped below the IJC summer level of Elev. 1743.32 feet on 11 July and the lake was then held below this level until the end of August. The average release in July was 26 kcfs, while the average for August and September was 18.0 kcfs. With low Libby discharges during September, the Kootenay Lake level had dropped to Elev. 1742.6 feet by 30 September 1994.

Storage Transfer Agreements

In the 1992-93 operating year, BC Hydro and BPA entered into a storage transfer agreement for the summer of 1993 in which Duncan/Arrow increased releases were used to reduce the outflow from Libby. This operation resulted in about 130 ksfd less water being released from Libby and the lake reaching a level that was about 6 feet higher than it otherwise would have been. This water was returned to Duncan/Arrow by 31 December 1993.

A further 1992-93 operating year agreement between the Entities facilitated the temporary transfer of 54.5 ksfd of storage from Mica to Hungry Horse. The agreement reduced the amount of spill at the Waneta project, resulting in a significant energy gain for Canada. This water was returned to Canadian storage in September 1993.

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. Specially, the operation of the reservoirs was governed by the:

1. "Detailed Operating Plan for Columbia River Treaty Storage - 1 August 1993 through 31 July 1994," dated September 1993.
2. "Columbia River Treaty Flood Control Operating Plan," dated October 1972.

Consistent with all Detailed Operating Plans (DOP) prepared since the installation of generation at Mica, the 1993-94 DOP 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 1993-94 Alternative Operating Plan, prepared in July 1989, was used as the basis for the preparation of the 1993-94 DOP.

Power

The Canadian Entitlement to downstream power benefits from Duncan, Arrow and Mica for the 1993-94 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 was 293 average megawatts from August 1993 through 31 March 1994 and 279 average megawatts from 1 April through 31 July 1994. Capacity deliveries were up to 755 megawatts from 1 August 1993 through 31 March 1994 and 666 megawatts from 1 April through 31 July 1994.

The Coordinated System proportional draft point (PDP) at the beginning of the 1993-94 operating year was 72.9% full which resulted in the system adopting a 3rd-year firm energy load carrying capability (FELCC) from the critical period studies. Due to persistent low inflows, the system continued to proportionally draft from August through April to meet FELCC. The system only produced surplus energy during May when Arrow and Grand Coulee refilled to their Operating Rule Curve (ORC), but most head water reservoirs operated on minimum flow trying to refill and were unable to recover to their ORC elevation by the end of July 1994. The system storage energy reached 74.7% full on 31 July 1994, and the system again adopted 3rd-year FELCC from the critical period studies.

The following table shows the status of the energy stored in Coordinated System and Canadian Treaty reservoirs at the end of each month compared to the ORC or PDP (whichever controlled) during the 1993-94 operating year. Normal full Coordinated System reservoir storage is approximately 63,700 megawatt-months (MWmo), and about 22,100 MWmo for Canadian Treaty storage. All figures are 1000 MWmo.

END OF PERIOD STORAGE ENERGY

	Coordinated System			Canadian Treaty		
Period	ORC/PDP (K-MWmo)	Actual (K-MWmo)	Difference (K-MWmo)	ORC/PDP (K-MWmo)	Actual (K-MWmo)	Difference (K-MWmo
Aug-93	48.1	50.3	2.2	16.4	15.9	-0.5
Sep-93	44.9	48.0	3.1	16.6	15.7	-0.9
Oct-93	40.2	45.0	4.8	15.6	15.1	-0.5
Nov-93	32.8	37.7	4.9	13.3	13.1	-0.2
Dec-93	25.0	32.0	7.0	9.7	10.4	0.8
Jan-94	17.8	26.6	8.8	6.7	7.4	0.7
Feb-94	10.6	20.1	9.5	2.2	3.6	1.4
Mar-94	7.9	17.5	9.6	1.0	1.6	0.6
Apr-94	12.2	25.0	12.8	0.9	3.4	2.5
May-94	28.3	39.1	10.8	9.1	9.6	0.5
Jun-94	42.4	47.0	4.6	12.4	14.8	2.4
Jul-94	47.7	49.0	1.3	17.3	18.2	0.9

During the period August though December 1993, Canadian Treaty storage was operated below PDP as part of the Duncan-Libby and Mica-Hungry Horse storage transfer agreements. The above table shows minor variations from PDP during this period because the PDP's shown were computed after the end of each month with known inflows, which are slightly different than the PDP's used during actual operations which were based on forecasted inflows.

During the January through July 1994 period, water was retained in Arrow above its PDP under the terms of the 1994 Entity Agreement on the Operation of Treaty Storage for Nonpower Uses. By 30 April 1994, Arrow's Treaty elevation was approximately 1.3 maf above the PDP elevation. During the May-June period, this water was released to augment Lower Columbia River streamflows for salmon migration in the U.S. in a manner consistent with Canadian needs for trout spawning and progressive Arrow refill. Arrow outflows were limited to 20 kcfs throughout May, as Lower Columbia River salmon flow targets were met primarily via higher Snake River flows and high tributary flows below Arrow. Arrow's outflow was then gradually increased in June from 20 kcfs to as high as 70 kcfs. The Arrow Treaty storage contents increased from 1546 ksfd on 30 April to 3236 ksfd by 30 June, and no significant draft of Arrow occurred at anytime during the flow augmentation release period. By late June most of the flow augmentation water had been released from Canadian Treaty storage. Approximately ?? was carried over to 31 July 1994. The operation per the Entity agreement was deemed a success by all parties since the flow augmentation storage release occurred in a manner that met both Canadian trout spawning and refill needs and the U.S. salmon responsibilities.

Throughout the 1993-94 operating year, BPA developed and implemented an extensive purchasing strategy to meet projected energy deficits and provide for flow augmentation in the United States and other nonpower requirements during an extremely low streamflow period. The following table summarizes the federal purchases (in MWmo) during August 1993 through July 1994. These purchases are in addition to those provided in the DOP for firm load requirements under critical water conditions

FEDERAL ENERGY PURCHASES (MWmo)

Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
255	782	899	1642	1973	932	710	667	307	0	118	250

The following table shows BPA nonfirm and surplus sales in megawatt hours (MWh) to Northwest and Southwest utilities during the 1993-94 operating year.

BPA NON-FIRM AND SURPLUS SALES (MWh)

Period	To Northwest Utilities		To Southwest Utilities	
	Non-Firm	Surplus Firm	Non-Firm	Surplus Firm
Aug-93	0	0	0	55,770
Sep-93	0	0	0	83,761
Oct-93	0	19,446	0	12,363
Nov-93	0	117,000	0	37,841
Dec-93	0	121,500	0	46,843
Jan-94	0	109,595	0	36,845
Feb-94	0	100,797	0	29,448
Mar-94	0	97,757	0	37,109
Apr-94	2,000	0	125,690	47,153
May-94	132,156	230,480	321,310	490,886
Jun-94	314,176	104,930	338,955	327,030
Jul-94	137,575	104,341	59,822	237,898
TOTAL	585,907	1,005,846	845,777	1,442,947

Flood Control

The Columbia River Basin reservoir system, including the Columbia River Treaty projects, was not operated on a daily basis for flood control in the spring of 1994. The observed and unregulated hydrographs for the Columbia River at The Dalles between 1 April 1994 and 31 July 1994 are shown on Chart 14. The unregulated peak flow at The Dalles would have been 381,000 cfs on 15 May 1994 and it was controlled to a maximum of 224,300 cfs on 12 May 1994.

The observed peak stage at Vancouver, Washington was 7.3 feet on 27 May 1994 and the unregulated stage would have been 13.0 feet on 15 May 1994. 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. Because this year's runoff volume forecast was low and Arrow was drafted deeply for power, there was no flood control operation at Arrow after 30 April 1994 as the curve on Chart 15 did not guide the operation after that date.

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 at The Dalles was 227,000 cfs on 1 January 1994, 200,000 cfs on 1 February, 230,000 cfs on 1 March, 200,000 cfs on 1 April, and 200,000 cfs on 1 May. As mentioned earlier, the observed peak flow at The Dalles was 224,300 cfs. Data for the 1 May ICF computation are given in Table 6.

Table 1
Unregulated Runoff Volume Forecasts
Million of Acre-Feet
1994

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	Columbia River at The Dalles, Oregon Most Probable 1 April - 31 August
January	1.9	21.0	10.7	5.5	70.2
February	1.9	22.0	11.5	5.1	67.4
March	2.0	22.3	11.3	5.1	70.6
April	2.0	22.5	11.4	5.2	65.7
May	2.0	23.2	11.5	5.2	68.2
June	2.0	22.3	11.0	5.4	69.1
Actual	2.0	22.7	11.1	5.2	67.2

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

Table 2
1994 Variable Refill Curve
Mica Reservoir

		Initial	Jan 1	Feb 1	Mar 1	Apr 1	May 1	Jun 1
Probable Jan 1-31 July Inflow,Kaf			8901.7	9682.3	9586.1	9661.7	9895.7	10315.8
& In Ksfd			4487.9	4881.5	4833.0	4871.1	4989.1	5200.9
95% Forecast Error For Date,In Ksfd			682.7	551.3	513.4	460.4	440.9	470.5
95% Conf.Date-31 July Inflow,Ksfd	1/		3805.2	4204.2	4085.2	4067.4	3834.8	2972.9
Assumed Feb 1-Jul 31 Inflow,% Of Vol.			100.00					
Assumed Feb 1-Jul 31 Inflow,Ksfd	2/		3805.2					
Feb Minimum Flow Requirement,Cfs	3/		20000.0					
Min Feb 1-Jul 31 Outflow,Ksfd	4/		4323.0					
Min Jan 31 Reservoir Content,Ksfd	5/		6050.0					
Min Jan 31 Reservoir Content,Feet	6/		2469.8					
Jan 31 ECC,Ft.	7/ ——— >		2461.3					
Base ECC,Ft.		2461.0						
Lower Limit,Ft.		2422.5						
Assumed Mar 1-Jul 31 Inflow,% Of Vol.			97.60	97.60				
Assumed Mar 1-Jul 31 Inflow,Ksfd	2/		3713.9	4103.3				
Mar Minimum Flow Requirement,Cfs	3/		20000.0	20000.0				
Min Mar 1-Jul 31 Outflow,Ksfd	4/		3763.0	3763.0				
Min Feb 28 Reservoir Content,Ksfd	5/		6050.0	5709.7				
Min Feb 28 Reservoir Content,Feet	6/		2469.8	2463.3				
Feb 28 ECC,Ft.	7/ ——— >		2451.7	2451.7				
Base ECC,Ft.		2451.4						
Lower Limit,Ft.		2405.9						
Assumed Apr 1-Jul 31 Inflow,% Of Vol.			95.20	95.20	97.60			
Assumed Apr 1-Jul 31 Inflow,Ksfd	2/		3622.6	4002.4	3987.1			
Apr Minimum Flow Requirement,Cfs	3/		22000.0	22000.0	22000.0			
Min Apr 1-Jul 31 Outflow,Ksfd	4/		3143.0	3143.0	3143.0			
Min Mar 31 Reservoir Content,Ksfd	5/		5570.4	5190.6	5205.9			
Min Mar 31 Reservoir Content,Feet	6/		2460.6	2453.1	2453.4			
Mar 31 ECC,Ft.	7/ ——— >		2441.0	2441.0	2441.0			
Base ECC,Ft.		2440.7						
Lower Limit,Ft.		2394.1						
Assumed May 1-Jul 31 Inflow,% Of Vol.			90.20	90.20	92.50	94.80		
Assumed May 1-Jul 31 Inflow,Ksfd	2/		3432.3	3792.2	3778.8	3855.9		
May Minimum Flow Requirement,Cfs	3/		25000.0	25000.0	25000.0	25000.0		
Min May 1-Jul 31 Outflow,Ksfd	4/		2483.0	2483.0	2483.0	2483.0		
Min Apr 30 Reservoir Content,Ksfd	5/		5100.7	4740.8	4754.2	4677.1		
Min Apr 30 Reservoir Content,Feet	6/		2451.3	2443.9	2444.2	2442.6		
Apr 30 ECC,Ft.	7/ ——— >		2430.8	2430.8	2430.8	2430.8		
Base ECC,Ft.		2430.5						
Assumed Jun 1-Jul 31 Inflow,% Of Vol.			72.30	72.30	74.20	76.00	80.20	
Assumed Jun 1-Jul 31 Inflow,Ksfd	2/		2751.2	3039.6	3031.2	3091.2	3075.5	
Jun Minimum Flow Requirement,Cfs	3/		28000.0	28000.0	28000.0	28000.0	28000.0	
Min Jun 1-Jul 31 Outflow,Ksfd	4/		1708.0	1708.0	1708.0	1708.0	1708.0	
Min May 31 Reservoir Content,Ksfd	5/		5006.8	4718.4	4726.8	4666.8	4682.5	
Min May 31 Reservoir Content,Feet	6/		2449.4	2443.5	2443.6	2442.4	2442.7	
May 31 ECC,Ft.	7/ ——— >		2432.9	2432.9	2432.9	2432.9	2432.9	
Base ECC,Ft.		2432.5						
Assumed Jul 1-Jul 31 Inflow,% Of Vol.			35.80	35.80	36.60	37.60	39.60	49.40
Assumed Jul 1-Jul 31 Inflow,Ksfd	2/		1362.3	1505.1	1495.2	1529.3	1518.6	1468.6
Jul Minimum Flow Requirement,Cfs	3/		28000.0	28000.0	28000.0	28000.0	28000.0	28000.0
Min Jul 1-Jul 31 Outflow,Ksfd	4/		868.0	868.0	868.0	868.0	868.0	868.0
Min Jun 30 Reservoir Content,Ksfd	5/		5555.7	5412.9	5422.8	5388.7	5399.4	5449.4
Min Jun 30 Reservoir Content,Feet	6/		2460.3	2457.5	2457.7	2457.1	2457.3	2458.2
Jun 30 ECC,Ft.	7/ ——— >		2452.9	2452.9	2452.9	2452.9	2452.9	2452.9
Base ECC,Ft.		2452.6						

1/ For Arrow And Duncan: The Lower Limit Will Be The Higher Of The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows Of The Previous Month (V)ECC Less The Quantity One Foot Times The Number Of Days In The Current Month. For Mica: The Lower Limit Will Be The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows....
2/ Line 1 Minus Line 2
3/ Line 3 Minus Line 4
4/ Preceding Line X Line 5
5/ Full Content (3529.2 Ksfd) Plus Line Preceding That Less Line 2
6/ From Reservoir Elevation - Storage Content Table. Dated Feb 21, 1973.
7/ Lower Of Elevation On Preceding Line Or Elevation Determined Prior To Year.

Table 3
1994 Variable Refill Curve
Arrow Reservoir

		Initial	Jan 1 Local	Feb 1 Local	Mar 1 Local	Apr 1 Local	May 1 Local	Jun 1 Local
Probable 1 Jan-31 July Inflow,Kaf			9617.6	10549.5	11232.5	11764.5	13150.3	15436.5
& In Ksfd			4848.9	5318.7	5663.1	5931.3	6629.9	7782.6
95% Forecast Error For Date,In Ksfd			822.5	651.0	572.3	474.5	457.7	508.1
95% Conf.Date-31 July Inflow,Ksfd	1/		4026.4	4314.3	4461.6	4442.4	4034.1	2571.1
Assumed Feb 1-Jul 31 Inflow,% Of Vol.			103.00					
Assumed Feb 1-Jul 31 Inflow,Ksfd	2/		4147.2					
Min Feb 1-Jul 31 Outflow,Ksfd	4/		5785.0					
Mica Refill Requirements, Ksfd	8/		4323.0					
Min Jan 31 Reservoir Content,Ksfd	5/		894.4					
Min Jan 31 Reservoir Content,Feet	6/		1444.0					
Jan 31 ECC,Ft. ----------	7/ ---------- >		1417.9					
Base ECC,Ft		1417.9						
Lower Limit,Ft		1402.2						
Assumed Mar 1-Jul 31 Inflow,% Of Vol.			100.00	100.00				
Assumed Mar 1-Jul 31 Inflow,Ksfd	2/		4026.4	4314.3				
Min Mar 1-Jul 31 Outflow,Ksfd	4/		5505.0	5505.0				
Mica Refill Requirements, Ksfd	8/		3763.0	3763.0				
Min Feb 28 Reservoir Content,Ksfd	5/		1295.2	1007.3				
Min Feb 28 Reservoir Content,Feet	6/		1444.0	1444.0				
Feb 28 ECC,Ft. ----------	7/ ---------- >		1402.6	1402.6				
Base ECC,Ft		1402.6						
Lower Limit,Ft		1381.8						
Assumed Apr 1-Jul 31 Inflow,% Of Vol.			97.20	97.20	100.00			
Assumed Apr 1-Jul 31 Inflow,Ksfd	2/		3913.6	4193.5	4461.6			
Min Apr 1-Jul 31 Outflow,Ksfd	4/		5195.0	5195.0	5195.0			
Mica Refill Requirements, Ksfd	8/		3143.0	3143.0	3143.0			
Min Mar 31 Reservoir Content,Ksfd	5/		1718.0	1438.1	1170.0			
Min Mar 31 Reservoir Content,Feet	6/		1444.0	1444.0	1444.0			
Mar 31 ECC,Ft. ----------	7/ ---------- >		1400.0	1400.0	1400.0			
Base ECC,Ft		1400.0						
Lower Limit,Ft		1381.3						
Assumed May 1-Jul 31 Inflow,% Of Vol.			93.90	93.90	96.50	100.00		
Assumed May 1-Jul 31 Inflow,Ksfd	2/		3780.8	4051.1	4305.4	4442.4		
Min May 1-Jul 31 Outflow,Ksfd	4/		4445.0	4445.0	4445.0	4445.0		
Mica Refill Requirements,Ksfd	8/		2483.0	2483.0	2483.0	2483.0		
Min Apr 30 Reservoir Content,Ksfd	5/		1760.8	1490.5	1235.2	1099.2		
Min Apr 30 Reservoir Content,Feet	6/		1444.0	1444.0	1444.0	1444.0		
Apr 30 ECC,Ft ----------	7/ ---------- >		1403.6	1403.6	1403.6	1403.6		
Base ECC,Ft		1403.6						
Assumed Jun 1-Jul 31 Inflow,% Of Vol.			85.70	85.70	88.20	91.40	100.00	
Assumed Jun 1-Jul 31 Inflow,Ksfd	2/		3450.6	3697.4	3935.1	4060.4	4034.1	
Min Jun 1-Jul 31 Outflow,Ksfd	4/		3050.0	3050.0	3050.0	3050.0	3050.0	
Mica Refill Requrements,Ksfd	8/		1708.0	1708.0	1708.0	1708.0	1708.0	
Min May 31 Reservoir Content,Ksfd	5/		1471.0	1224.2	986.5	861.2	887.5	
Min May 31 Reservoir Content,Feet	6/		1437.8	1434.0	1430.0	1427.9	1428.4	
May 31 ECC,Ft ----------	7/ ---------- >		1417.9	1417.9	1417.9	1417.9	1417.9	
Base ECC,Ft		1417.9						
Assumed Jul 1-Jul 31 Inflow,% Of Vol			61.10	61.10	62.80	65.10	71.20	100.00
Assumed Jul 1-Jul 31 Inflow,Ksfd	2/		2460.1	2636.0	2801.9	2892.0	2872.3	2571.1
Min Jul 1-Jul 31 Outflow,Ksfd	4/		1550.0	1550.0	1550.0	1550.0	1550.0	1550.0
Mica Refill Requrements,Ksfd	8/		868.0	868.0	868.0	868.0	868.0	868.0
Min Jun 30 Reservoir Content,Ksfd	5/		1801.5	1625.6	1459.7	1369.6	1389.3	1690.5
Min Jun 30 Reservoir Content,Feet	6/		1429.6	1426.7	1423.9	1422.4	1422.7	1427.7
Jun 30 ECC,Ft ----------	7/ ---------- >		1429.6	1426.7	1423.9	1422.4	1422.7	1427.7
Base ECC,Ft		1436.7						
Jul 31 ECC, Ft ----------	> ----------		1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

1/ For Arrow And Duncan: The Lower Limit Will Be The Higher Of The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows Of The Previous Month (V)ECC Less The Quantity One Foot Times The Number Of Days In The Current Month. For Mica: The Lower Limit Will Be The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows.. ..2/ Line 1 Minus Line 2.. 3/ Line 3 Minus Line 4...4/ Preceding Line X Line 5.....5/ For Arrow Local: Full Content (3579.6 Ksfd) Less Line Preceding Plus Line Preceding That Less Line Preceding That. For Arrow Total: Full Content (3579.6 Ksfd) Plus Two Preceding Lines Less Line Preceding That.....6/ From Reservoir Elevation - Storage Content Table. Dated Feb 21, 1973. 7/ Lower Of Elevation On Preceding Line Or Elevation Determined Prior To Year....8/ For Arrow Local: Mica Minimum Power Discharges. For Arrow Total: Mica Full Content Less Energy Content Curve.

Table 4
1994 Variable Refill Curve
Duncan Reservoir

		Initial	Jan 1	Feb 1	Mar 1	Apr 1	May 1	Jun 1
Probable Jan 1-31 July Inflow,Kaf			1633.9	1715.1	1745.0	1781.6	1853.5	1984.7
& In Ksfd			823.8	864.7	879.8	898.2	934.5	1000.6
95% Forecast Error For Date,In Ksfd			112.4	97.8	93.4	91.9	84.8	85.7
95% Conf.Date-31 July Inflow,Ksfd	1/		711.4	738.2	738.0	730.7	681.8	496.0
Assumed Feb 1-Jul 31 Inflow,% Of Vol.			100.00					
Assumed Feb 1-Jul 31 Inflow,Ksfd	2/		711.4					
Feb Minimum Flow Requirement,Cfs	3/		400.0					
Min Feb 1-Jul 31 Outflow,Ksfd	4/		305.6					
Min Jan 31 Reservoir Content,Ksfd	5/		300.0					
Min Jan 31 Reservoir Content,Feet	6/		1842.9					
Jan 31 ECC,Ft.	7/ ——>		1837.8					
Base ECC,Ft		1837.6						
Lower Limit,Ft		1794.2						
Assumed Mar 1-Jul 31 Inflow,% Of Vol.			97.90	97.90				
Assumed Mar 1-Jul 31 Inflow,Ksfd	2/		696.4	722.7				
Mar Minimum Flow Requirement,Cfs	3/		400.0	400.0				
Min Mar 1-Jul 31 Outflow,Ksfd	4/		294.4	294.4				
Min Feb 28 Reservoir Content,Ksfd	5/		303.7	277.5				
Min Feb 28 Reservoir Content,Feet	6/		1843.4	1839.9				
Feb 28 ECC,Ft.	7/ ——>		1836.0	1836.0				
Base ECC,Ft		1836.0						
Lower Limit,Ft		1794.2						
Assumed Apr 1-Jul 31 Inflow,% Of Vol.			95.40	95.40	97.50			
Assumed Apr 1-Jul 31 Inflow,Ksfd	2/		678.7	704.2	719.5			
Apr Minimum Flow Requirement,Cfs	3/		400.0	400.0	400.0			
Min Apr 1-Jul 31 Outflow,Ksfd	4/		282.0	282.0	282.0			
Min Mar 31 Reservoir Content,Ksfd	5/		309.1	283.5	268.2			
Min Mar 31 Reservoir Content,Feet	6/		1844.1	1840.8	1838.6			
Mar 31 ECC,Ft.	7/ ——>		1836.7	1836.7	1836.7			
Base ECC,Ft		1836.7						
Lower Limit,Ft		1794.2						
Assumed May 1-Jul 31 Inflow,% Of Vol.			89.50	89.50	91.50	93.80		
Assumed May 1-Jul 31 Inflow,Ksfd	2/		636.7	660.7	675.3	685.4		
May Minimum Flow Requirement,Cfs	3/		2000.0	2000.0	2000.0	2000.0		
Min May 1-Jul 31 Outflow,Ksfd	4/		246.0	246.0	246.0	246.0		
Min Apr 30 Reservoir Content,Ksfd	5/		315.1	291.1	276.5	266.3		
Min Apr 30 Reservoir Content,Feet	6/		1844.9	1841.8	1839.8	1838.4		
Apr 30 ECC,Ft.	7/ ——>		1837.8	1837.8	1837.8	1837.8		
Base ECC,Ft.		1837.8						
Assumed Jun 1-Jul 31 Inflow,% Of Vol.			68.70	68.70	70.20	72.00	71.20	
Assumed Jun 1-Jul 31 Inflow,Ksfd	2/		488.7	507.1	518.1	526.1	485.4	
Jun Minimum Flow Requirement,Cfs	3/		2000.0	2000.0	2000.0	2000.0	2000.0	
Min Jun 1-Jul 31 Outflow,Ksfd	4/		184.0	184.0	184.0	184.0	184.0	
Min May 31 Reservoir Content,Ksfd	5/		401.1	382.6	371.7	363.7	404.4	
Min May 31 Reservoir Content,Feet	6/		1856.0	1853.6	1852.2	1851.2	1856.4	
May 31 ECC,Ft.	7/ ——>		1854.8	1853.6	1852.2	1851.2	1854.8	
Base ECC,Ft.		1854.8						
Assumed Jul 1-Jul 31 Inflow,% Of Vol.			32.10	32.10	32.80	33.70	30.40	46.80
Assumed Jul 1-Jul 31 Inflow,Ksfd	2/		228.4	237.0	242.1	246.3	207.3	232.1
Jul Minimum Flow Requirement,Cfs	3/		4000.0	4000.0	4000.0	4000.0	4000.0	4000.0
Min Jul 1-Jul 31 Outflow,Ksfd	4/		124.0	124.0	124.0	124.0	124.0	124.0
Min Jun 30 Reservoir Content,Ksfd	5/		601.4	592.8	587.7	583.5	622.5	597.7
Min Jun 30 Reservoir Content,Feet	6/		1880.1	1879.1	1878.6	1878.1	1882.5	1879.7
Jun 30 ECC,Ft.	7/ ——>		1880.1	1879.1	1878.6	1878.1	1880.3	1879.7
Base ECC,Ft.		1880.3						
Jul 31 ECC, Ft.	——>		1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ For Arrow And Duncan: The Lower Limit Will Be The Higher Of The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows Of The Previous Month (V)ECC Less The Quantity One Foot Times The Number Of Days In The Current Month. For Mica: The Lower Limit Will Be The Elevation Needed To Protect Against A Recurrence Of 1936-37 Streamflows....2/ Line 1 Minus Line 2.... 3/ Line 3 Minus Line 4......4/ Preceding Line X Line 5..... 5/ Full Content (705.8 Ksfd) Plus Line Preceding That Less Line 2....6/ From Reservoir Elevation - Storage Content Table. Dated Feb 21, 1973.....7/ Lower Of Elevation On Preceding Line Or Elevation Determined Prior To Year.

Table 5
1994 Variable Refill Curve
Libby Reservoir

		Initial	Jan 1	Feb 1	Mar 1	Apr 1	May 1	Jun 1
Probable Jan 1-31 July Inflow,Kaf			5576.0	5261.1	5195.1	5278.1	5310.1	5261.1
& In Ksfd			2811.2	2652.5	2619.2	2661.0	2677.2	2652.5
95% Forecast Error For Date,In Ksfd			886.8	606.4	552.5	533.4	474.5	367.5
Observed Jan 1-Date Inflow, In Ksfd			0.0	94.8	167.4	291.0	668.6	1491.9
95% Conf.Date-31 July Inflow,Ksfd	1/		1924.5	1951.2	1899.2	1836.7	1534.1	793.1
Assumed Feb 1-Jul 31 Inflow,% Of Vol.			97.14					
Assumed Feb 1-Jul 31 Inflow,Ksfd	2/		1869.4					
Feb Minimum Flow Requirement,Cfs	3/		4000.0					
Min Feb 1-Jul 31 Outflow,Ksfd	4/		968.0					
Min Jan 31 Reservoir Content,Ksfd	5/		1609.1					
Min Jan 31 Reservoir Content,Feet	6/		2416.7					
Jan 31 ECC,Ft.	7/	>	2416.7					
Base ECC		2417.7						
Lower Limit		2320.7						
Assumed Mar 1-Jul 31 Inflow,% Of Vol.			94.47	97.25				
Assumed Mar 1-Jul 31 Inflow,Ksfd	2/		1818.0	1897.6				
Mar Minimum Flow Requirement,Cfs	3/		4000.0	4000.0				
Min Mar 1-Jul 31 Outflow,Ksfd	4/		856.0	856.0				
Min Feb 28 Reservoir Content,Ksfd	5/		1548.5	1468.9				
Min Feb 28 Reservoir Content,Feet	6/		2413.4	2409.2				
Feb 28 ECC,Ft	7/	>	2413.4	2409.2				
Base ECC		2415.0						
Lower Limit		2310.6						
Assumed Apr 1-Jul 31 Inflow,% Of Vol.			91.24	93.92	96.58			
Assumed Apr 1-Jul 31 Inflow,Ksfd	2/		1755.9	1832.6	1834.3			
Apr Minimum Flow Requirement,Cfs	3/		6000.0	6000.0	6000.0			
Min Apr 1-Jul 31 Outflow,Ksfd	4/		732.0	732.0	732.0			
Min Mar 31 Reservoir Content,Ksfd	5/		1486.6	1409.9	1408.2			
Min Mar 31 Reservoir Content,Feet	6/		2410.2	2405.8	2405.7			
Mar 31 ECC,Ft.	7/	>	2410.2	2405.8	2405.7			
Base ECC		2412.2						
Lower Limit		2297.5						
Assumed May 1-Jul 31 Inflow,% Of Vol.			83.21	85.65	88.08	91.20		
Assumed May 1-Jul 31 Inflow,Ksfd	2/		1601.3	1671.2	1672.9	1675.1		
May Minimum Flow Requirement,Cfs	3/		6000.0	6000.0	6000.0	6000.0		
Min May 1-Jul 31 Outflow,Ksfd	4/		552.0	552.0	552.0	552.0		
Min Apr 30 Reservoir Content,Ksfd	5/		1461.2	1391.3	1389.6	1387.4		
Min Apr 30 Reservoir Content,Feet	6/		2408.7	2404.7	2404.6	2404.5		
Apr 30 ECC,Ft.	7/	>	2408.7	2404.7	2404.6	2404.5		
Base ECC		2409.7						
Lower Limit		2287.0						
Assumed Jun 1-Jul 31 Inflow,% Of Vol.			56.86	57.50	59.13	61.22	67.13	
Assumed Jun 1-Jul 31 Inflow,Ksfd	2/		1094.2	1122.0	1123.0	1124.43	1029.8	
Jun Minimum Flow Requirement,Cfs	3/		6000.0	6000.0	6000.0	6000.0	6000.0	
Min Jun 1-Jul 31 Outflow,Ksfd	4/		366.0	366.0	366.0	366.	366.0	
Min May 31 Reservoir Content,Ksfd	5/		1782.3	1754.5	1753.5	1752.1	1846.7	
Min May 31 Reservoir Content,Feet	6/		2425.5	2424.1	2424.1	2424.	2428.7	
May 31 ECC,Ft.	7/	>	2425.5	2424.1	2424.1	2424.0	2428.7	
Base ECC		2430.0						
Lower Limit		2287.0						
Assumed Jul 1-Jul 31 Inflow,% Of Vol.			19.41	19.98	20.54	21.27	23.32	34.74
Assumed Jul 1-Jul 31 Inflow,Ksfd	2/		373.5	389.9	390.1	390.7	357.7	275.5
Jul Minimum Flow Requirement,Cfs	3/		6000.0	6000.0	6000.0	6000.0	6000.0	6000.0
Min Jul 1-Jul 31 Outflow,Ksfd	4/		186.0	186.0	186.0	186.0	186.0	186.0
Min Jun 30 Reservoir Content,Ksfd	5/		2323.0	2306.6	2306.4	2305.8	2338.8	2421.0
Min Jun 30 Reservoir Content,Feet	6/		2450.8	2450.1	2450.1	2450.1	2451.5	2455.1
Jun 30 ECC,Ft.	7/	>	2450.8	2450.1	2450.1	2450.1	2451.5	2455.1
Base ECC		2459.0						
Lower Limit		2287.0						
Jul 31 ECC, Ft.		>	2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
Jan 1-Jul 31 Forecast,-Earlybird,Maf	8/		78.5	74.1	76.3	73.0	74.5	75.8

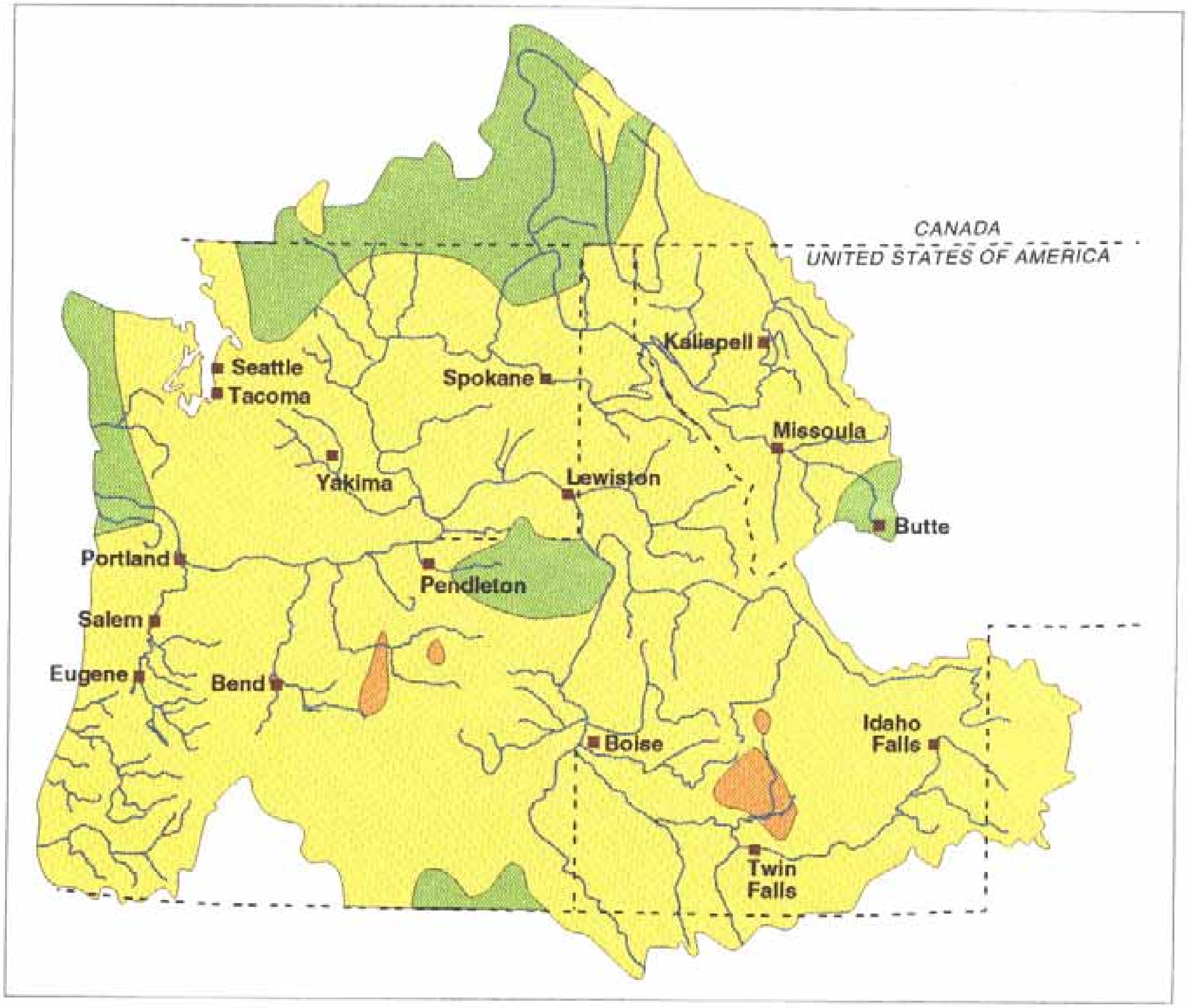
1/ Expected Inflow Minus (95%Error & Jan1-Date Inflow)....2/ Preceeding Line Times Line 1/....3/ Based On Power Discharge Requirements, Determined From 8/....4/ Cumulative Minimum Outflow From 3/, From Date To July....5/ Full Content (2510.5 Ksfd), Plus 4/, And Minus 2/....6/ Elev. From 5/, Interp. From NWPP Storage Content Table....7/ Elev. From 6/, But Limited < Base ECC, & > ECC Lower Limit....8/ Forecast at The Dalles used To Calculate The Power Discharge Requirements For 3/

Table 6

Computation of Initial Controlled Flow
Columbia River at The Dalles
1 May 1994

1 May Forecast of May-August Unregulated Runoff Volume, MAF		54.4
Less Estimated Depletions, MAF		1.5
Less Upstream Storage Corrections, MAF		
MICA	6.656	
ARROW	4.701	
DUNCAN	1.388	
LIBBY	3.213	
LIBBY + DUNCAN UNDER DRAFT	0.000	
HUNGRY HORSE	0.919	
FLATHEAD LAKE	0.500	
NOXON RAPIDS	0.000	
PEND OREILLE LAKE	0.500	
GRAND COULEE	0.995	
BROWNLEE	0.040	
DWORSHAK	0.000	
JOHN DAY	0.100	
TOTAL	18.901	20.4
Forecast of Adjusted Residual Runoff Volume, MAF		34.0
Computed Initial Controlled Flow from Chart 1 of Flood Control Operating Plan, 1,000 cfs		200.0

Chart 1
Seasonal Precipitation
Columbia River Basin
October 1993 - March 1994
Percent of 1961 -1985 Average



- Precipitation very high and more than 150% of average
- Precipitation high and more than 120% of average
- Precipitation low and more than 80% of average
- Precipitation very low and more than 50% of average
- Precipitation very low and less than 50% of average

Information prepared by
NATIONAL WEATHER SERVICE
Northwest River Forcast Center
Portland, Oregon

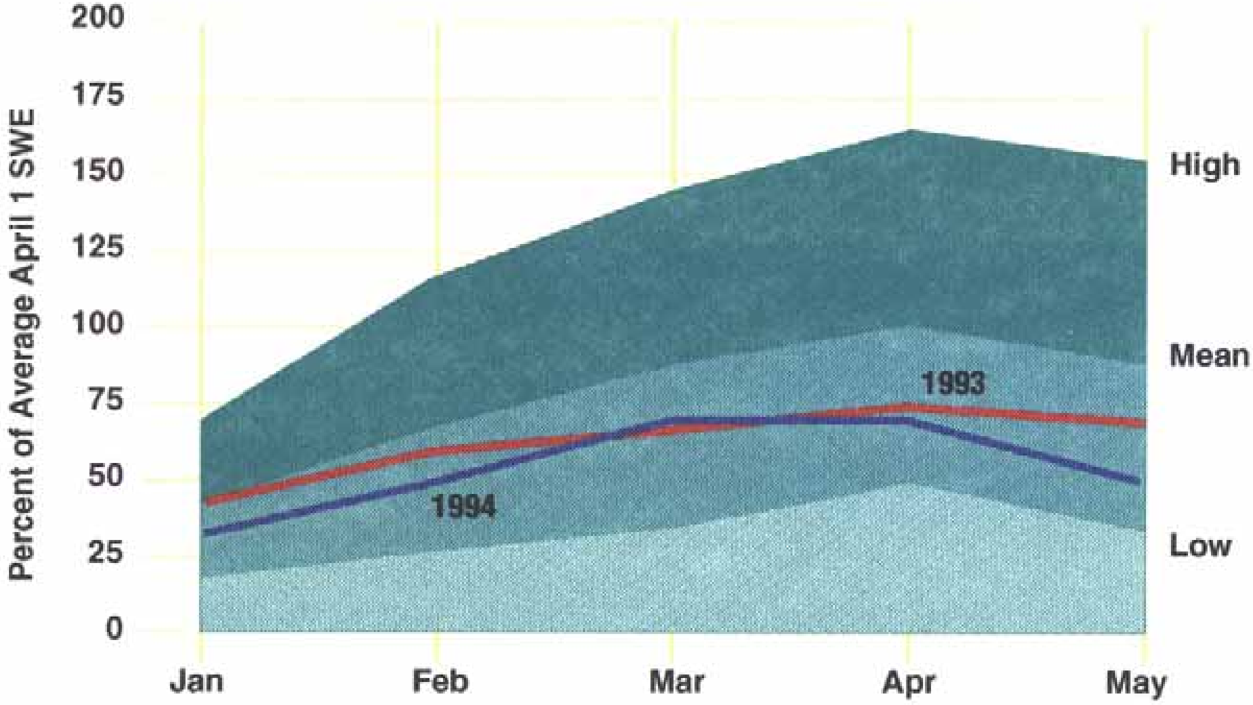
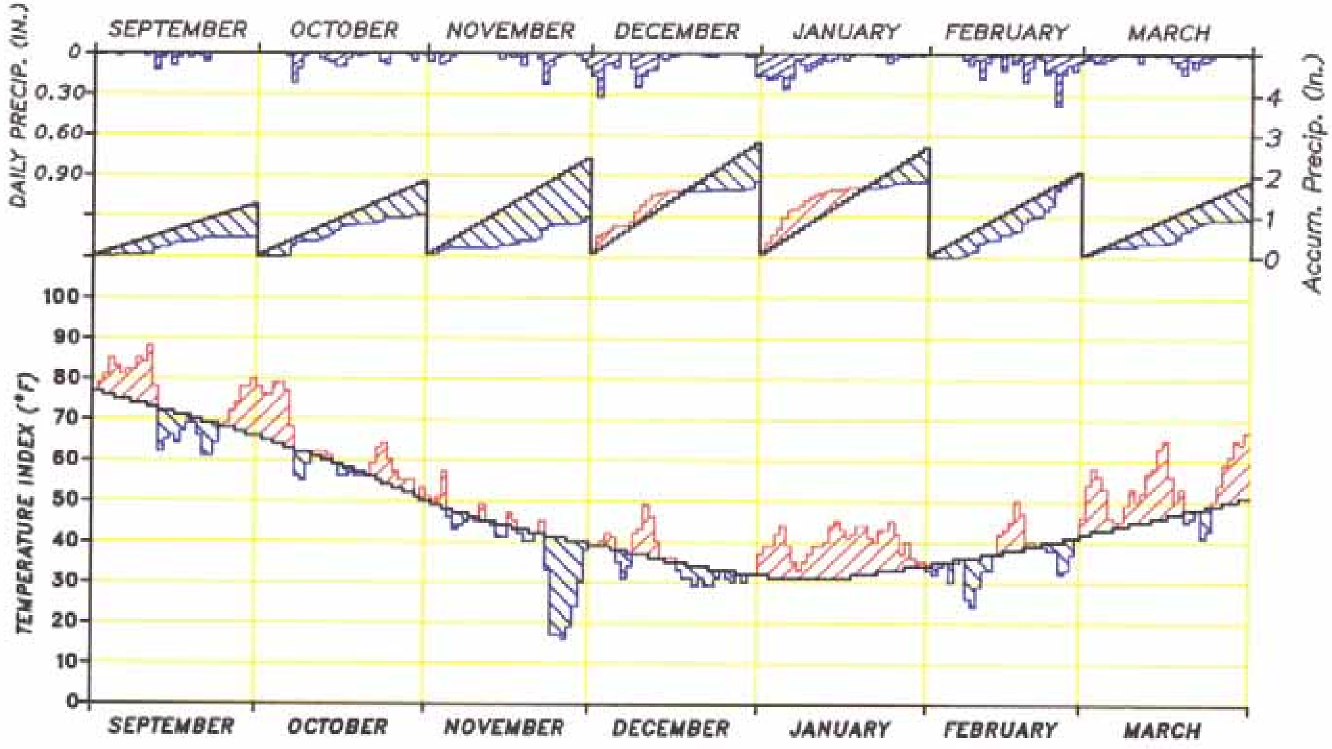
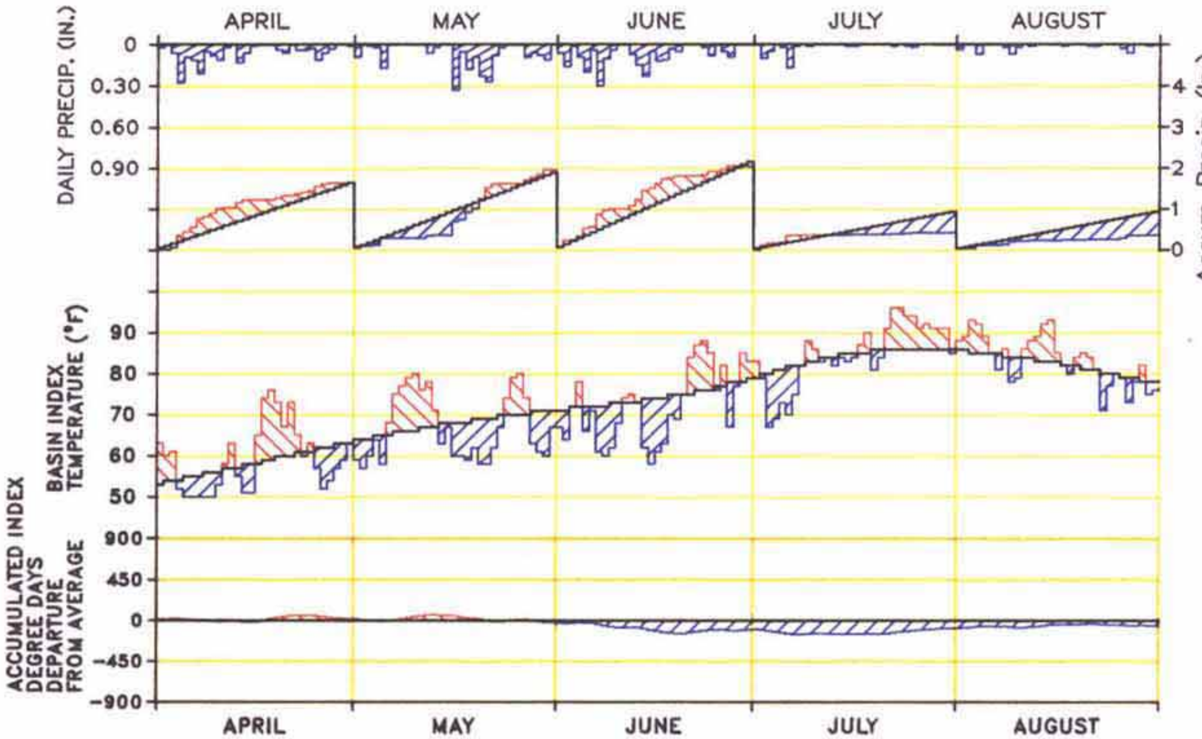


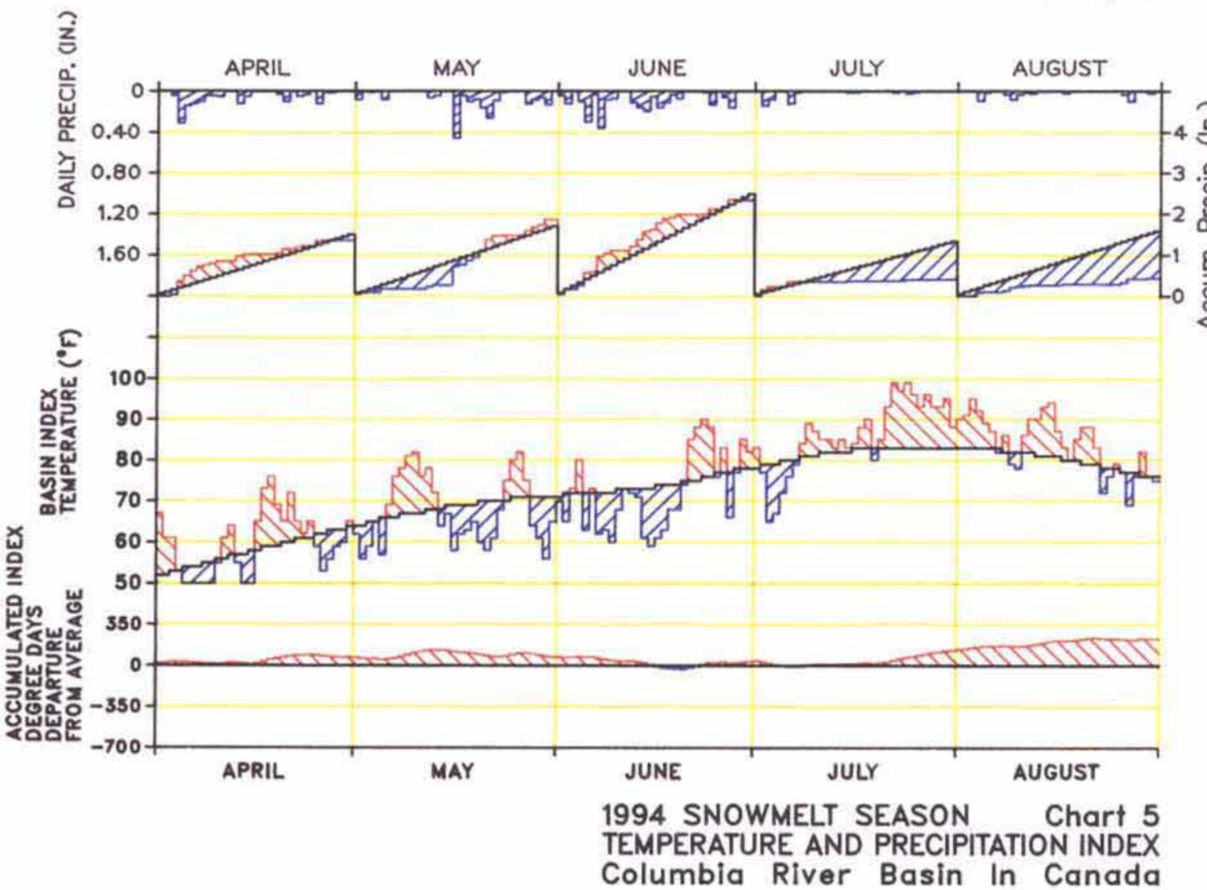
Chart 2
Columbia Basin Snowpack



WINTER SEASON CHART 3
TEMPERATURE AND PRECIPITION INDEX 1993–1994
Columbia River Basin Above The Dalles, OR

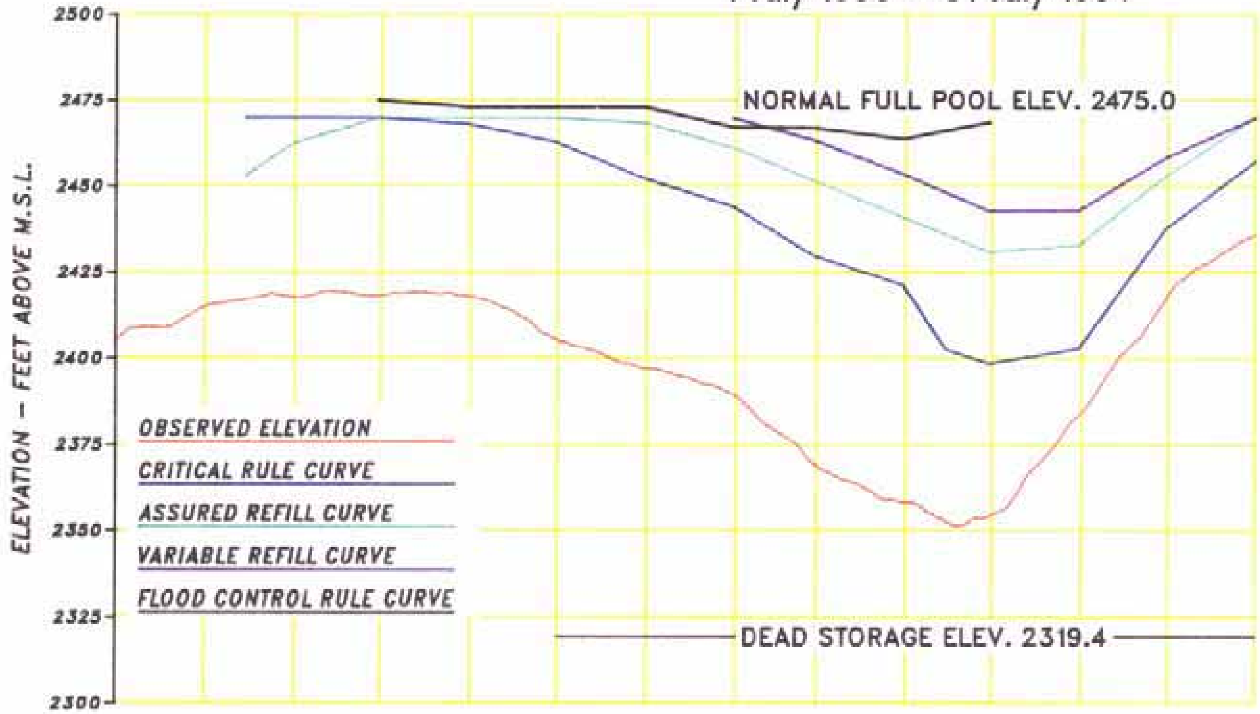


1994 SNOWMELT SEASON CHART 4
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin Above The Dalles, OR



1994 SNOWMELT SEASON Chart 5
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin In Canada

Chart 6
Regulation of Mica
1 July 1993 – 31 July 1994



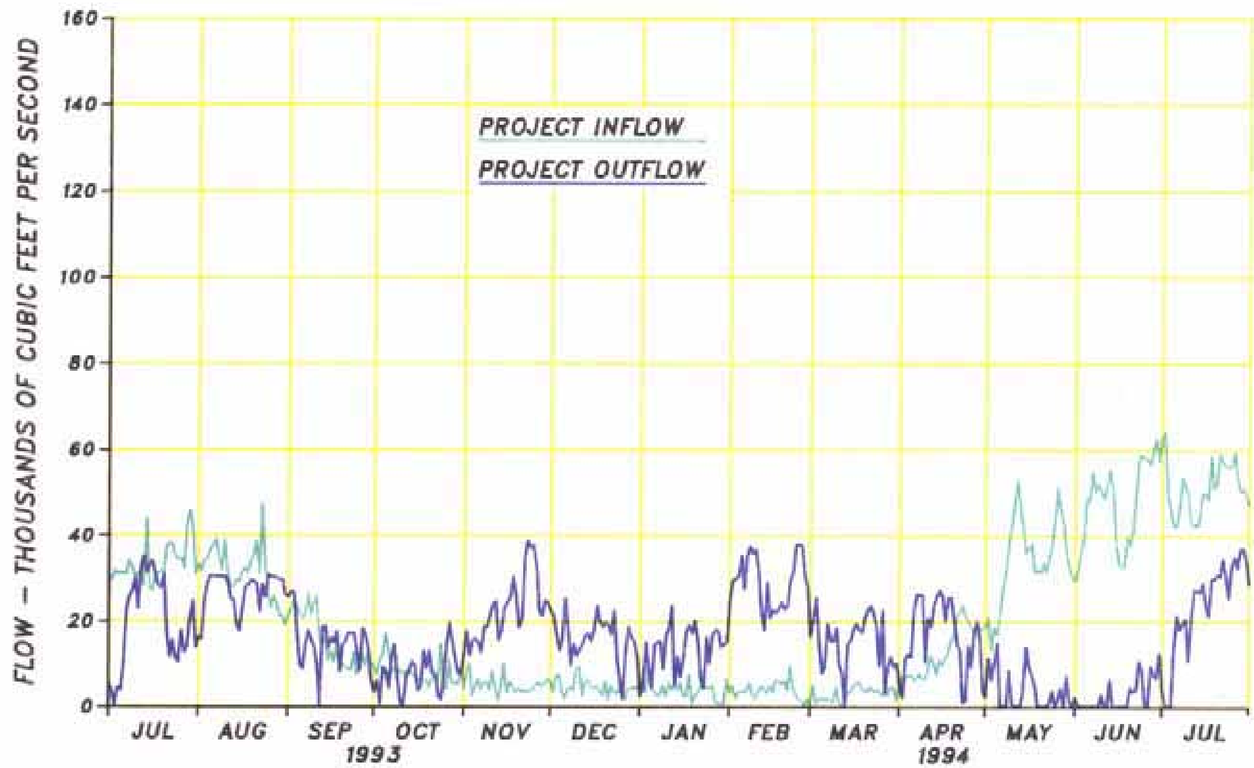


Chart 7
Regulation of Arrow
1 July 1993 – 31 July 1994

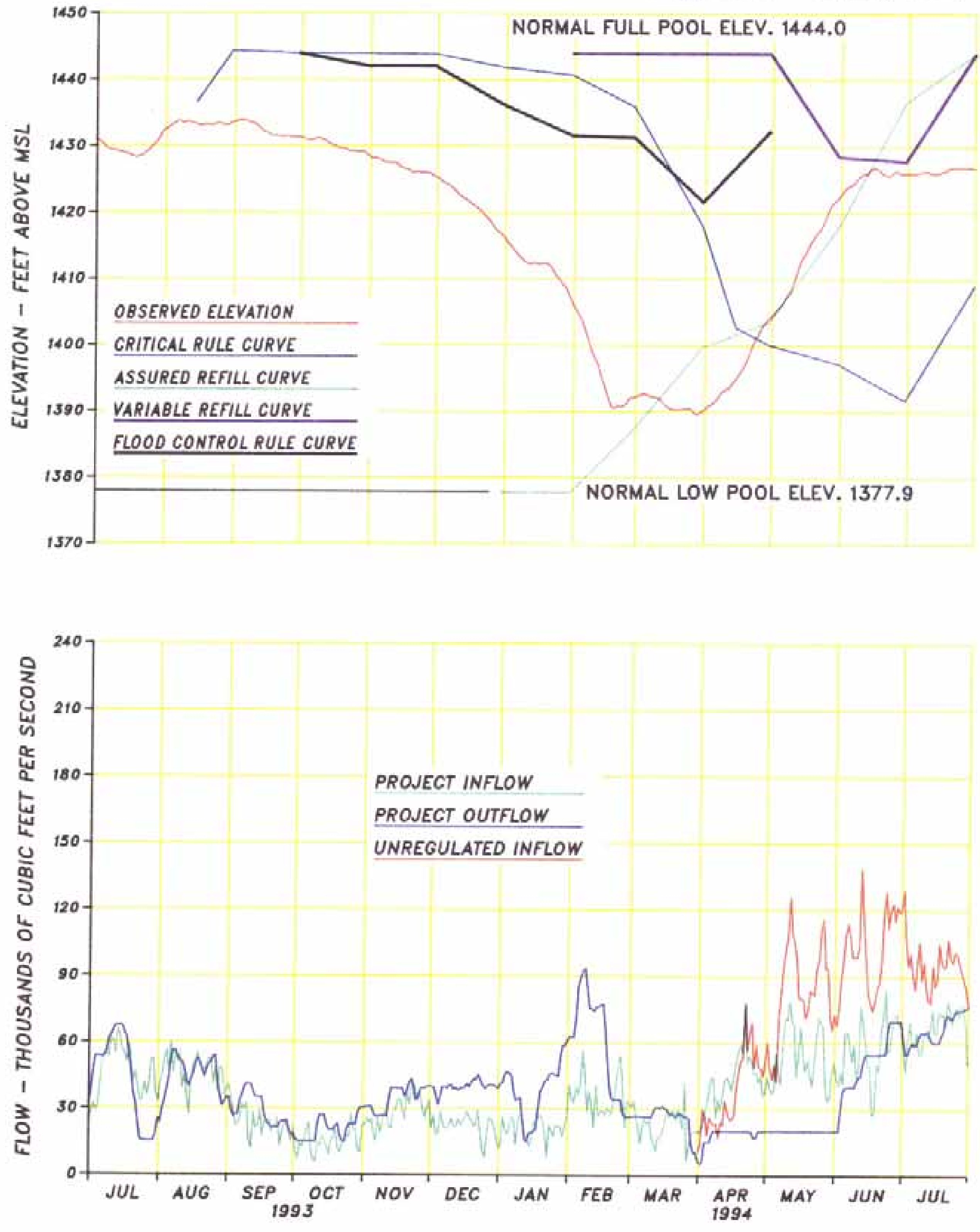
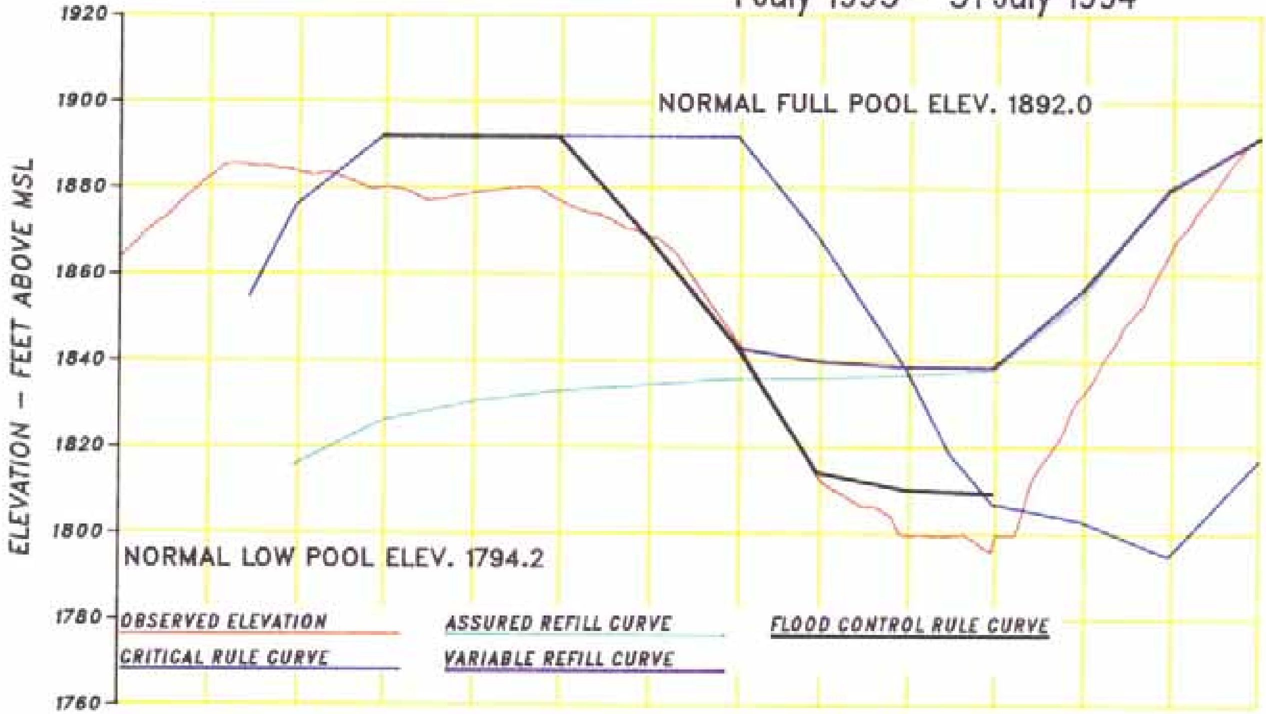


Chart 8
Regulation of Duncan
1 July 1993 – 31 July 1994



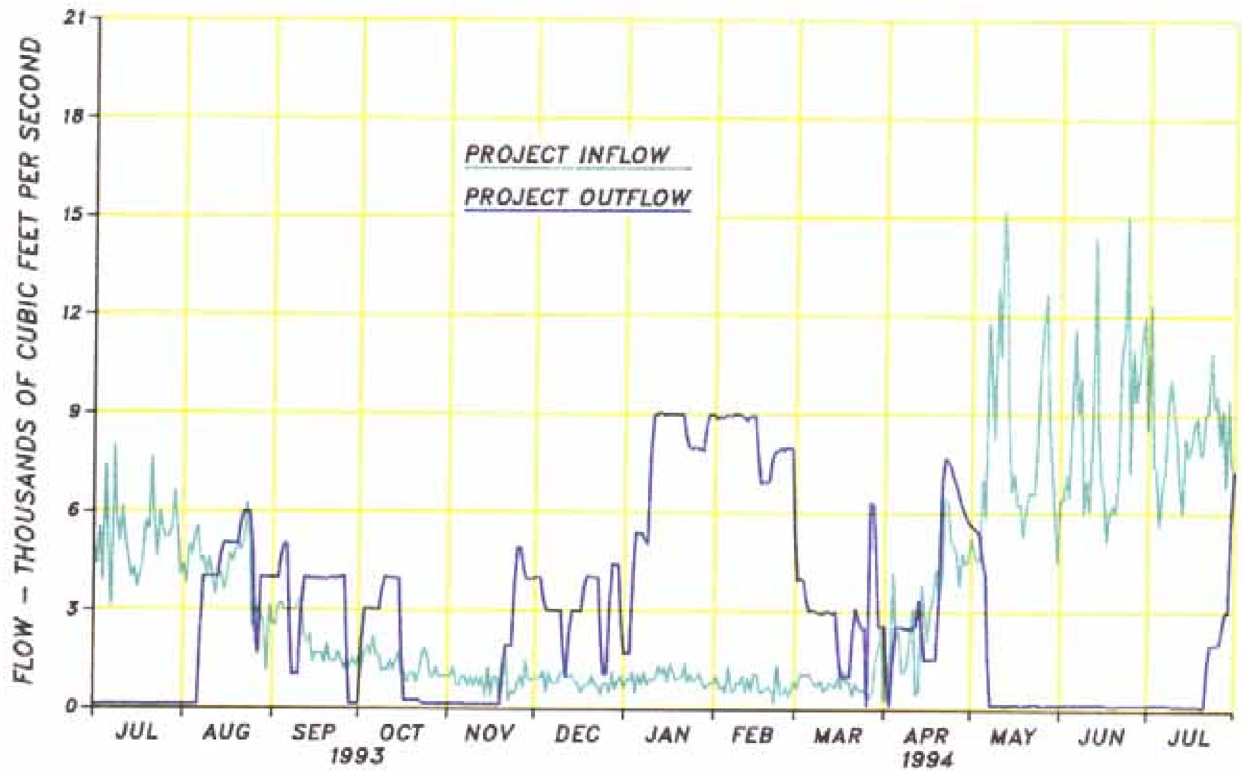


Chart 9
Regulation of Libby
1 July 1993 – 31 July 1994

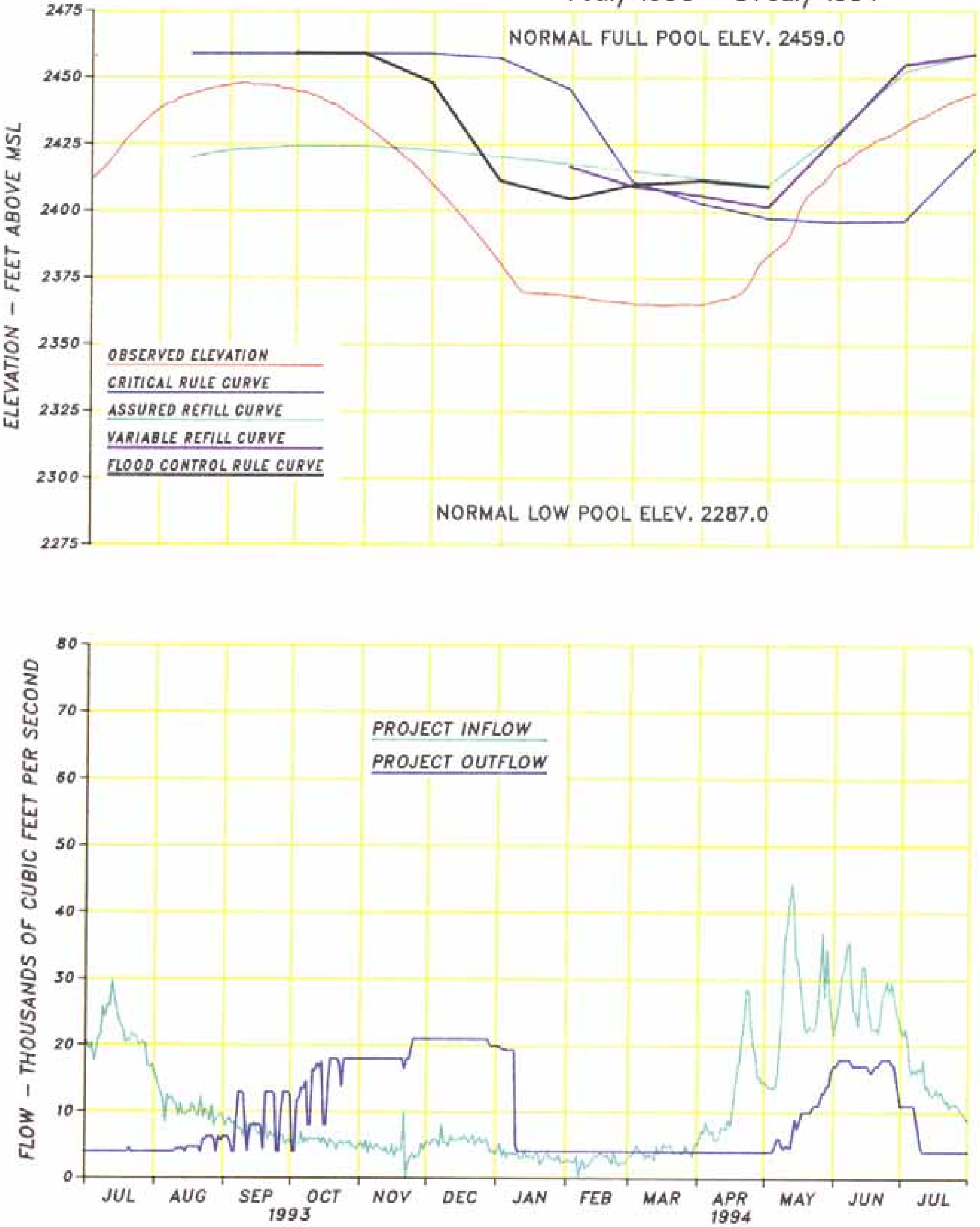


Chart 10
Regulation of Kootenay Lake
1 July 1993 – 31 July 1994

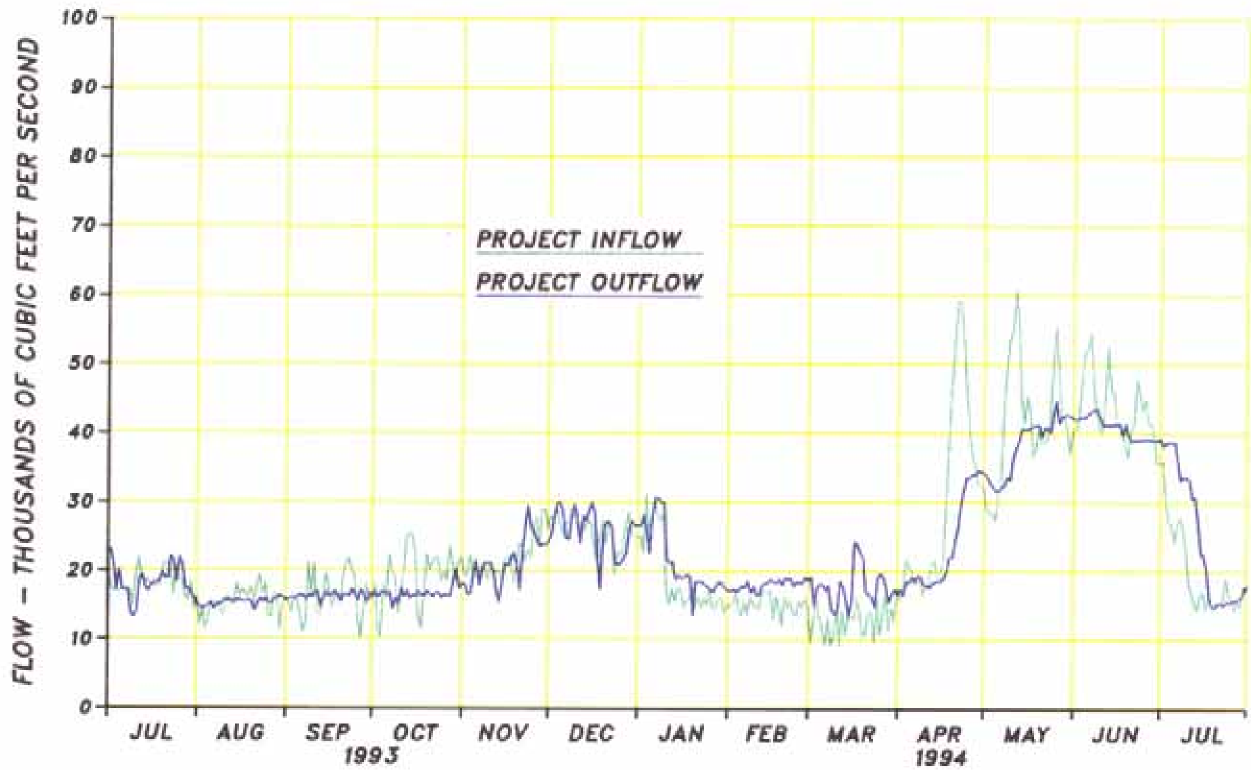


Chart 11
Columbia River at Birchbank
1 July 1993 – 31 July 1994

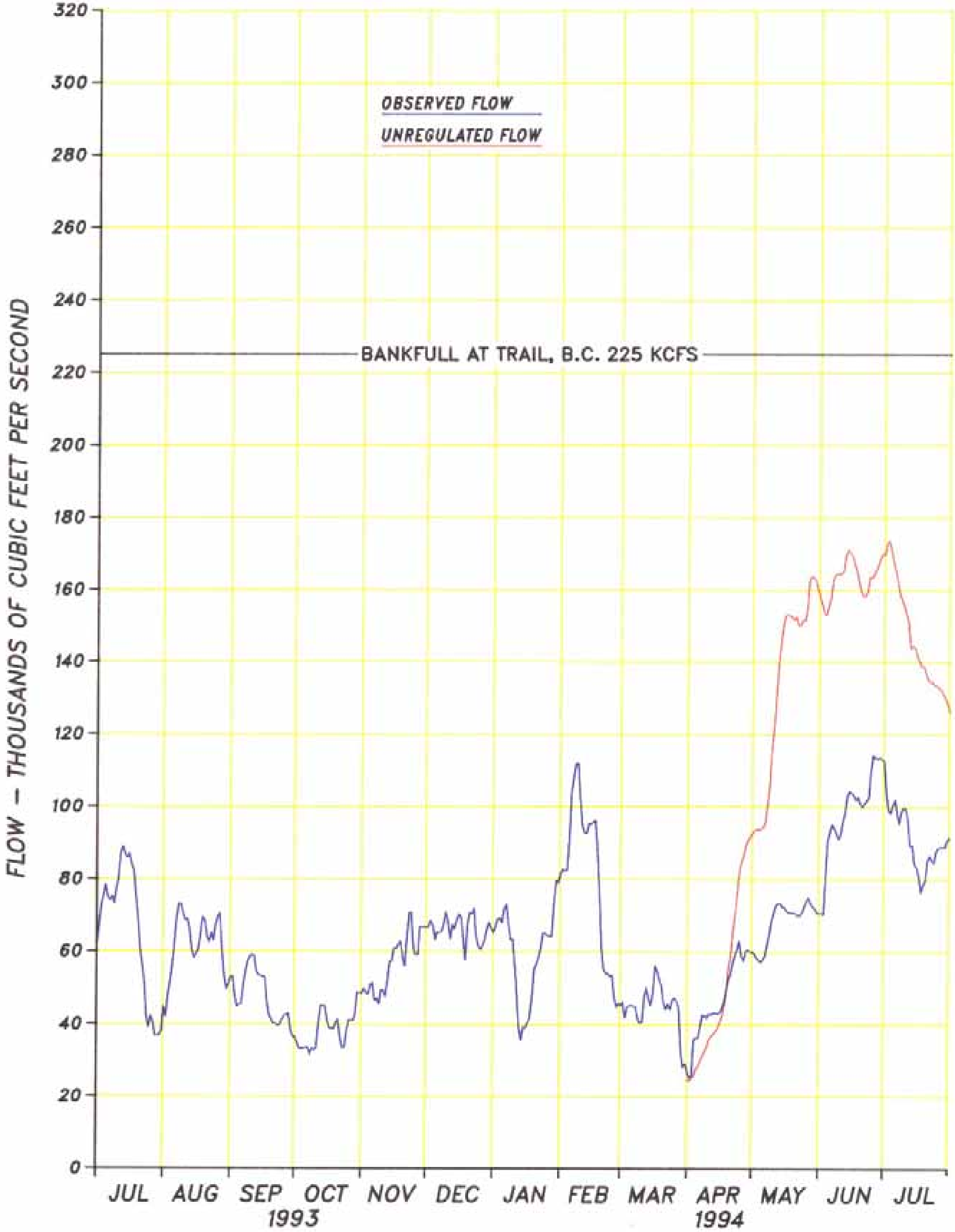


Chart 12
Regulation of Grand Coulee
1 July 1993 – 31 July 1994

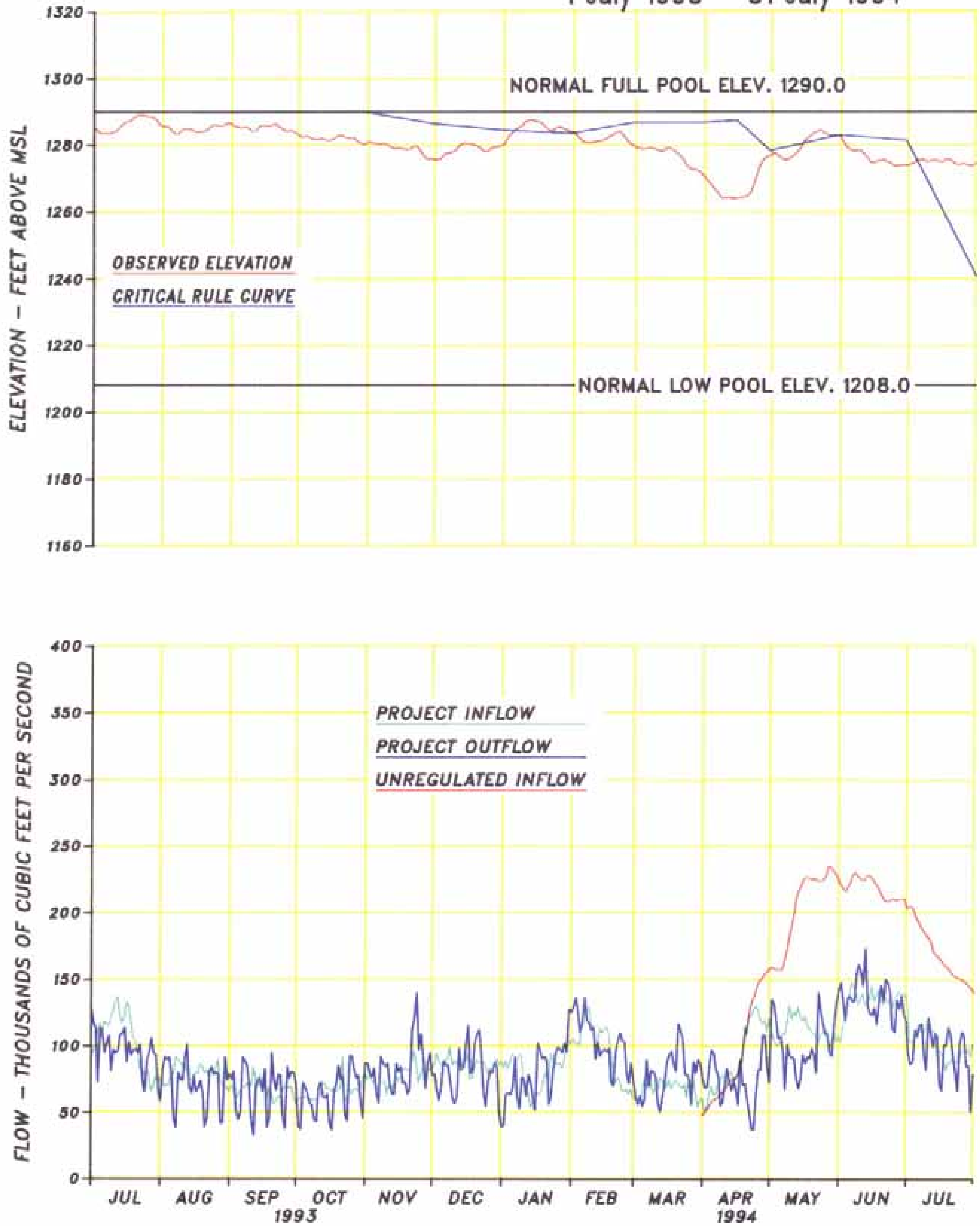


Chart 13
Columbia River at The Dalles
1 July 1993- 31 July 1994

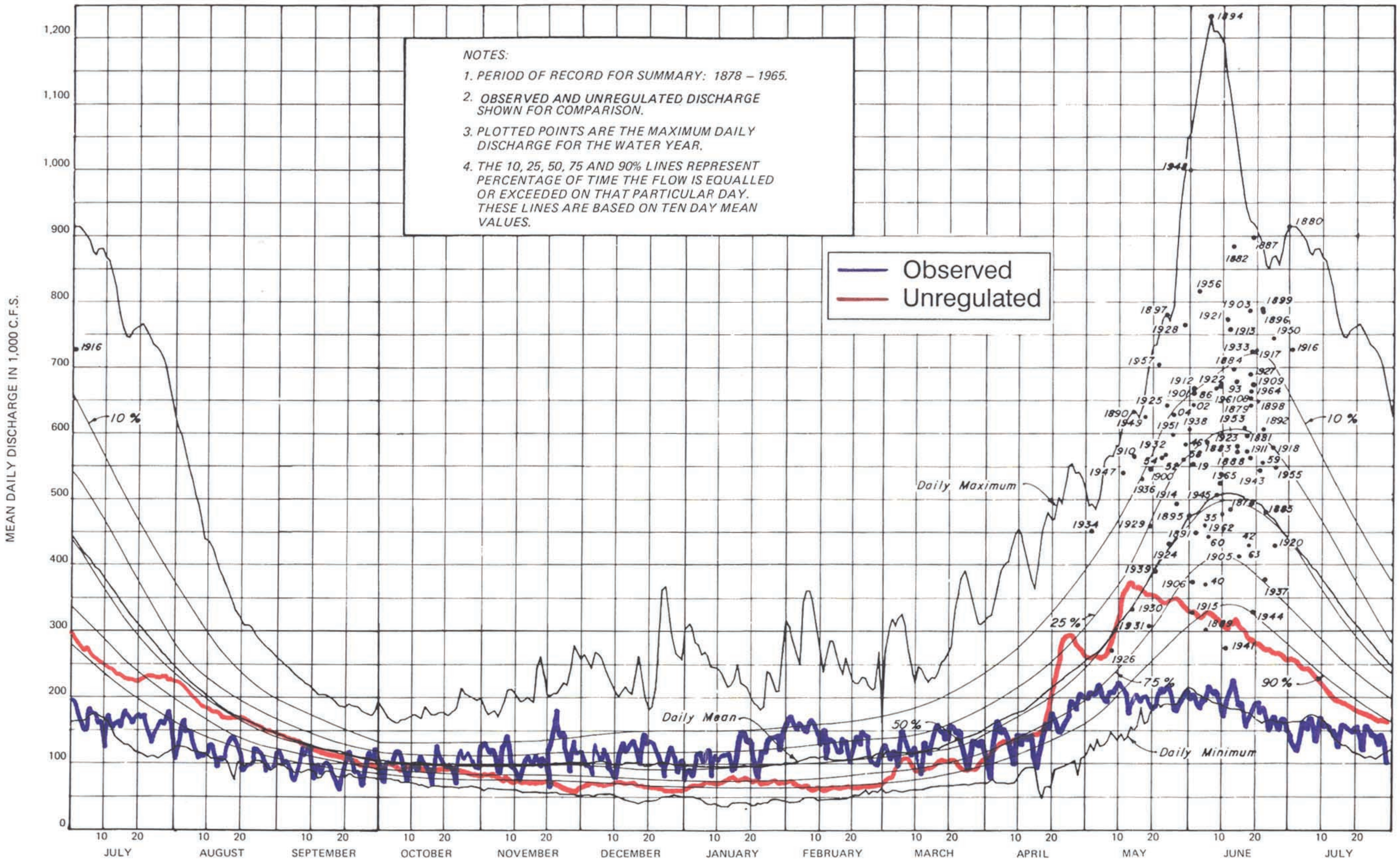
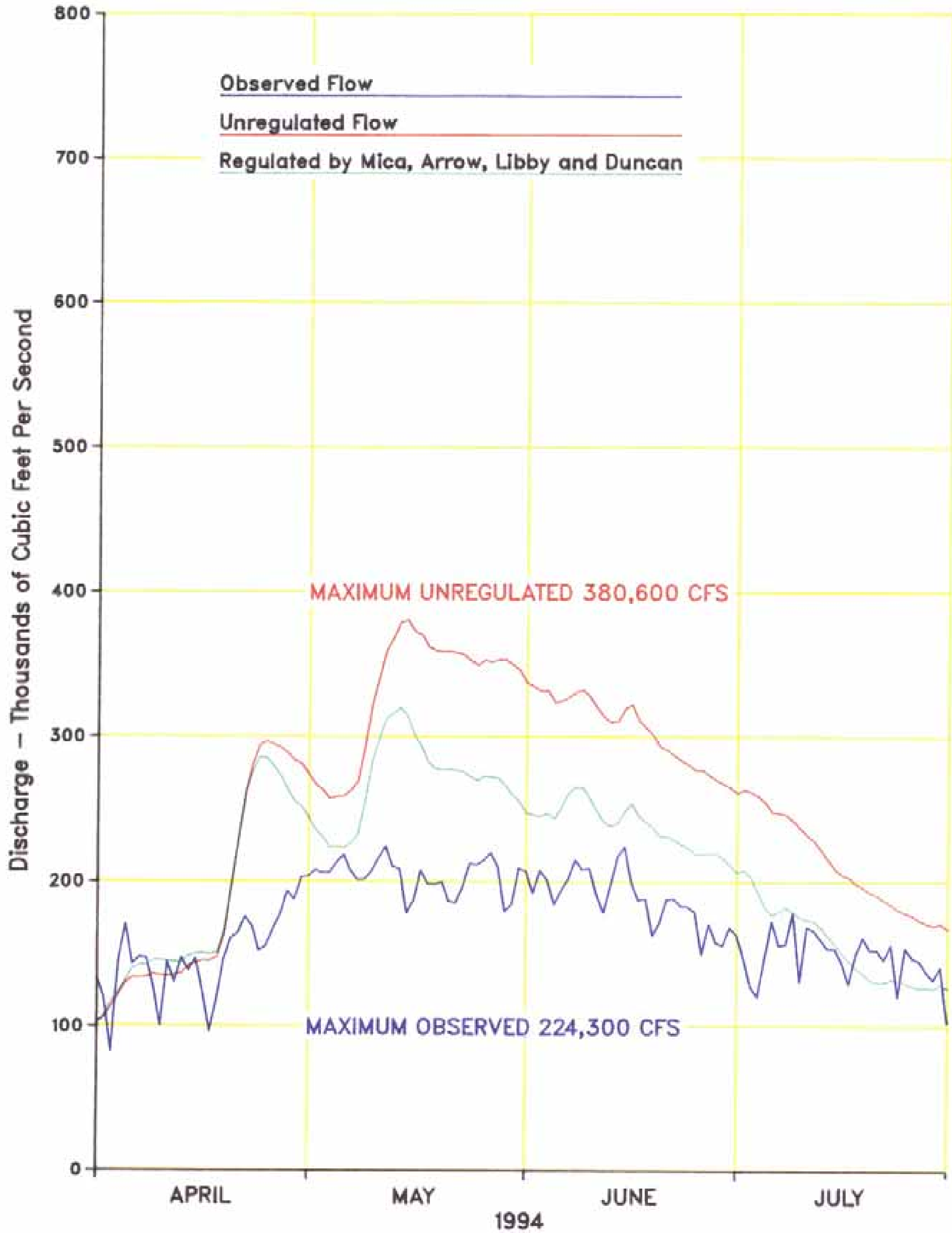


Chart 14
Columbia River at The Dalles
1 April 1994 – 31 July 1994



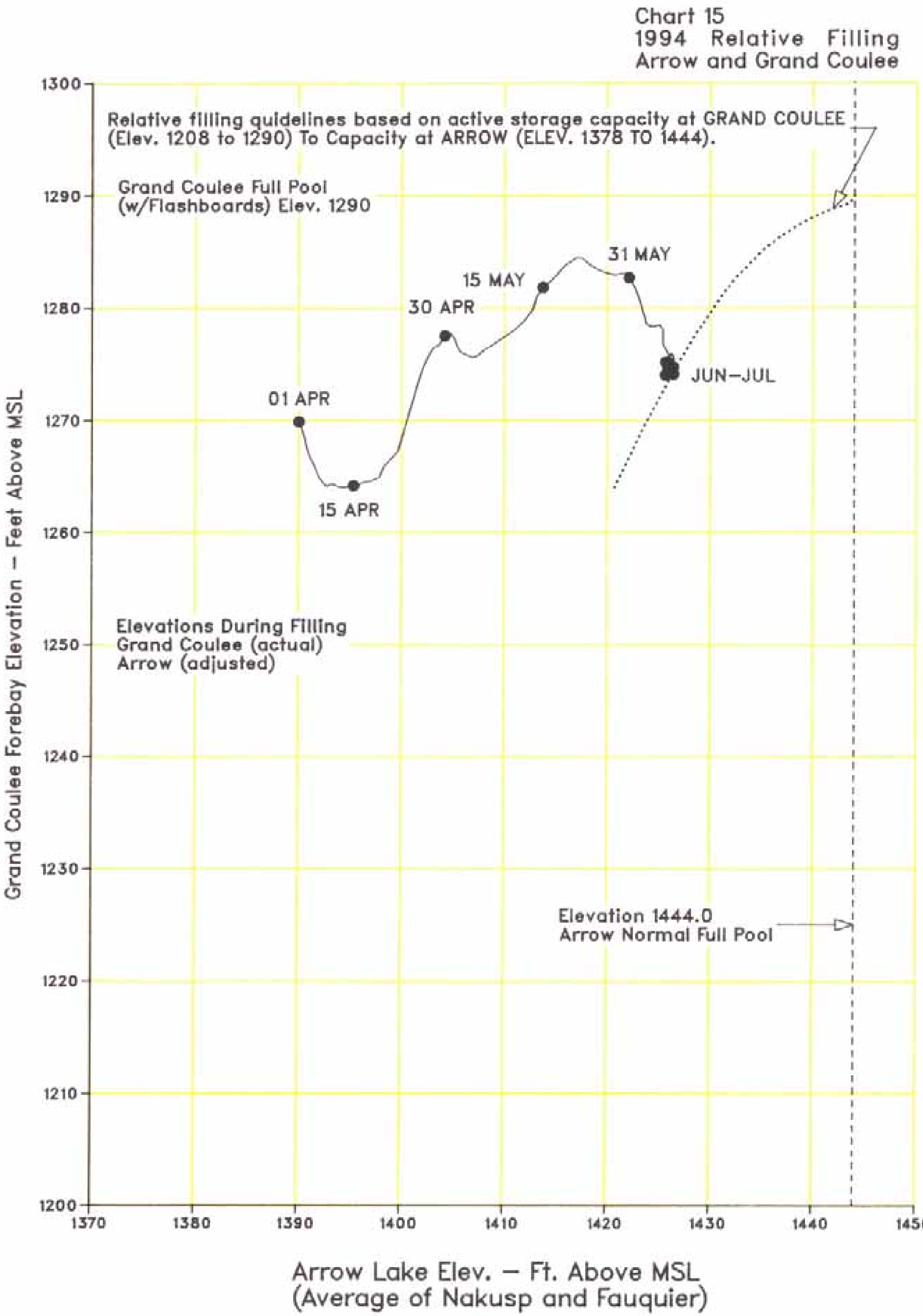


Chart 15
1994 Relative Filling
Arrow and Grand Coulee
Relative filling guidelines based on active storage capacity at GRAND COULEE
(Elev. 1208 to 1290) To Capacity at ARROW (ELEV. 1378 TO 1444).
Grand Coulee Full Pool
(w/Flashboards) Elev. 1290
31 MAY
15 MAY
30 APR
JUN-JUL
01 APR
15 APR
Elevations During Filling
Grand Coulee (actual)
Arrow (adjusted)
Elevation 1444.0
Arrow Normal Full Pool
Grand Coulee Forebay Elevation - Feet Above MSL
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1370
1380
1390
1400
1410
1420
1430
1440
1450
Arrow Lake Elev. - Ft. Above MSL
(Average of Nakusp and Fauquier)