ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 SEPTEMBER 1984

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA · UNITED STATES

CANADIAN SECTION
G.M. MacNABB, Chairman
B.E. Marr, Member

UNITED STATES SECTION
L.A. DUSCHA, Chairman
J.E. Harper, Member

31 December 1984

The Honorable George P. Shultz
The Secretary of State
Washington, D.C.

The Honourable Pat Carney
Minister of Energy, Mines and
Resources
Ottawa, Ontario

Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, D.C., on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the twentieth Annual Report, dated 30 September 1984, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1983 to 30 September 1984.

Respectfully submitted:

For the United States

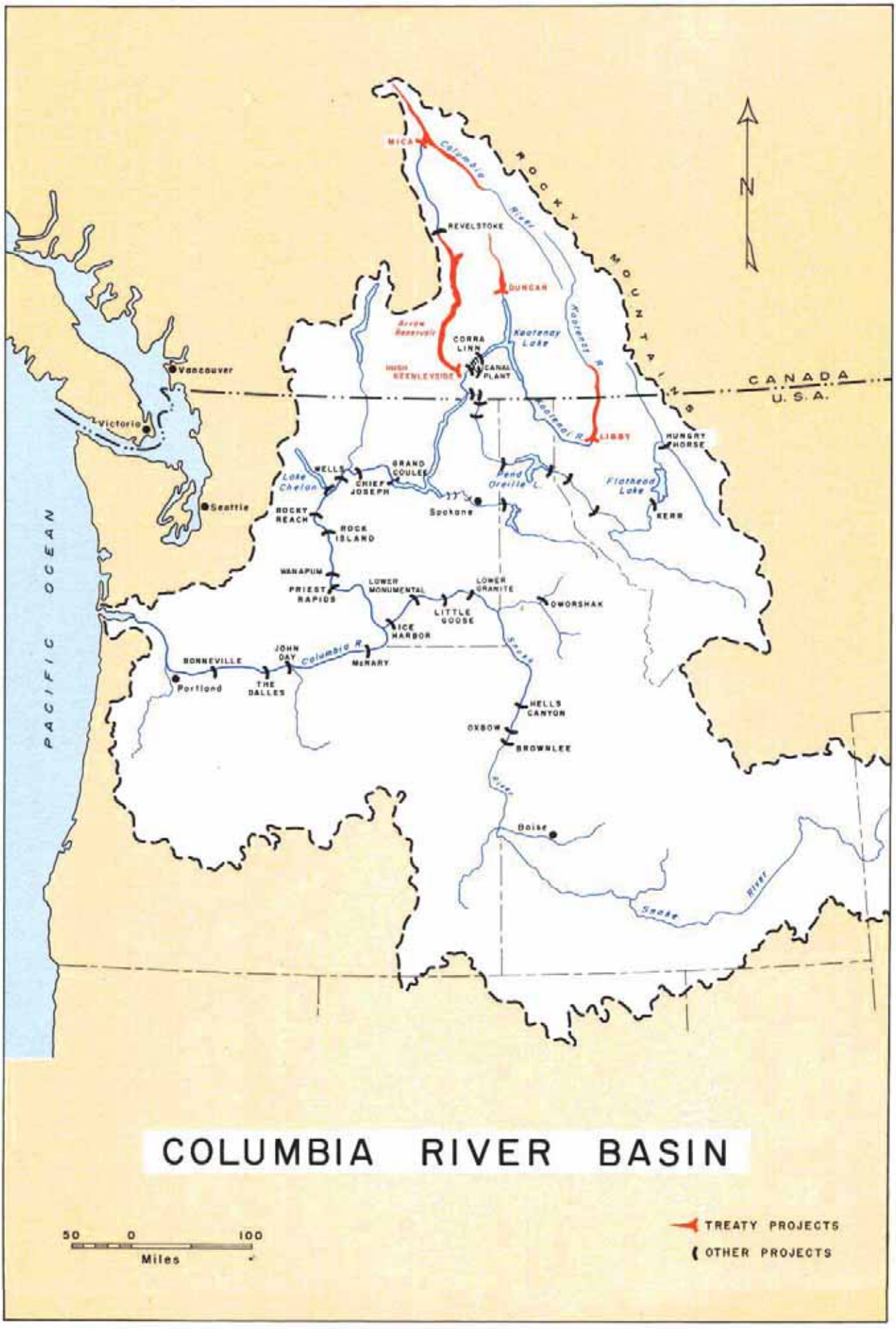
Lloyd A. Duscha, Chairman

J. Emerson Harper

For Canada

G.M. MacNabb, Chairman

B.E. Marr



COLUMBIA RIVER BASIN

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to the
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COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

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Photographs supplied by the British Columbia Hydro and Power Authority, the Government of British Columbia, and the U.S. Army Corps of Engineers.

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SUMMARY

The twentieth Annual Report of the Permanent Engineering Board is submitted to the Governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of 17 January 1961. The status of projects, progress of Entity studies, operation of Duncan, Arrow, Mica and Libby reservoirs, and the resulting benefits are described.

The Duncan, Arrow, Mica and Libby storage projects were operated throughout the year in accordance with the objectives of the Treaty and the terms of operating plans developed by the Entities. Special agreements for using additional storage in the reservoirs at Arrow and Mica and for initial filling of non-Treaty projects did not conflict with Treaty operations. Although reservoir operations reduced peak freshet flows, the unregulated peaks would not have caused major flood damages in either country. (Pages 27-34)

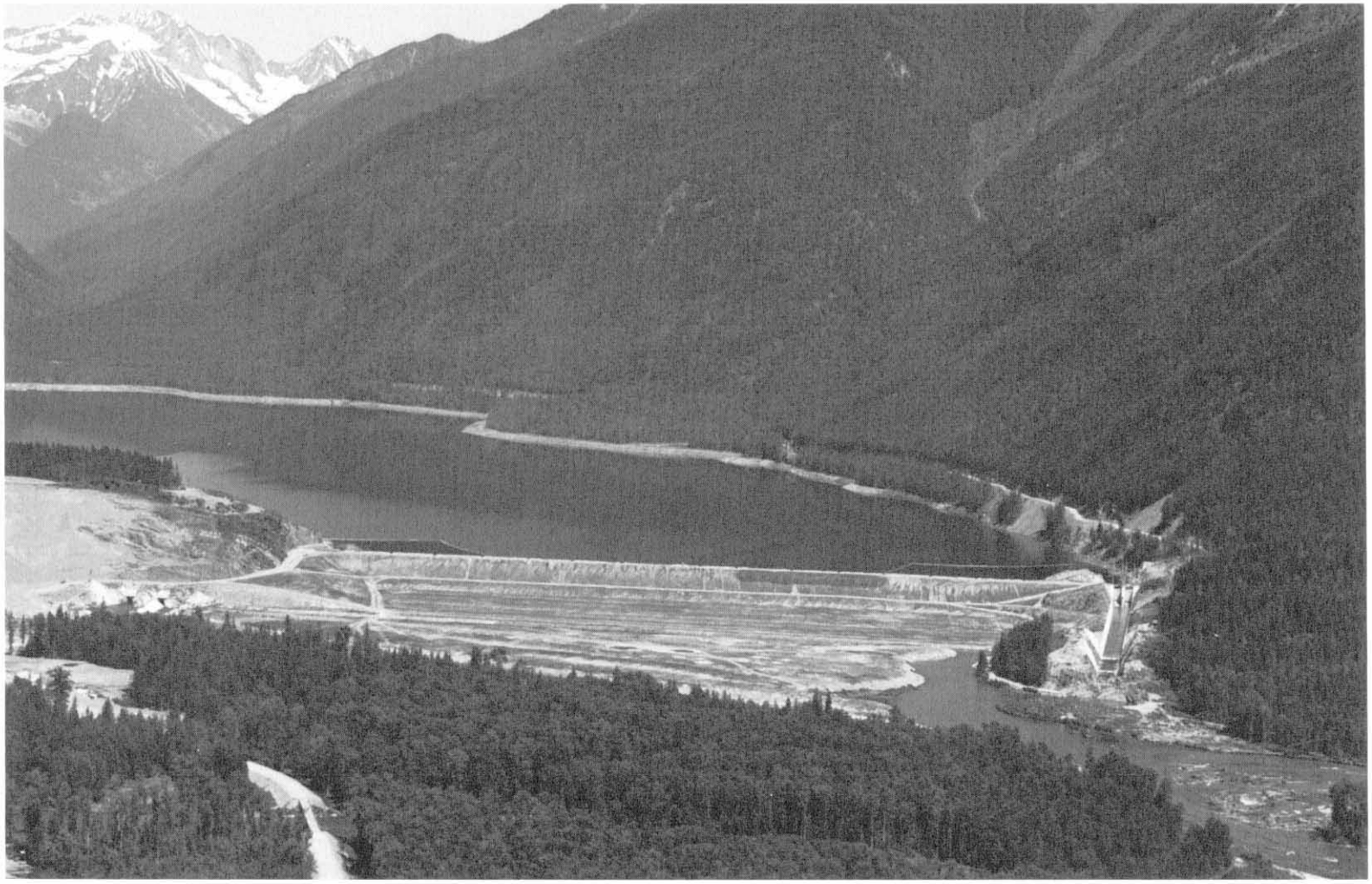
Studies pertaining to development of the hydrometeorological network and power operating plans are being continued by the Entities to ensure operation of the projects in accordance with the terms of the Treaty. Annual calculations of downstream power benefits are proceeding satisfactorily and the Board has advised the Entities of its position on the use of updated streamflow records. (Pages 22-25)

The Board concludes that the objectives of the Treaty are being met.

INTRODUCTION

The Columbia River Treaty, which provides for co-operative development of the water resources of the Columbia River basin, was signed in Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty . . ."

This Annual Report, which covers the period 1 October 1983 to 30 September 1984, describes activities of the Board, progress being achieved by both countries under the terms of the Treaty, operation of the Treaty projects, and the resulting benefits. The report states that, in the opinion of the Board, the objectives of the Treaty are being met. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included.



DUNCAN DAM
The earth dam with discharge tunnels to the left and spillway to the right.

Duncan River, British Columbia

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. The sum of $253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date at a ceremony at the Peace Arch Park on the International Boundary the Treaty and its Protocol were proclaimed by President Johnson, Prime Minister Pearson, and Premier Bennett of British Columbia.

The essential undertakings of the Treaty are as follows:

(a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes and Duncan Lake, in British Columbia.

(b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved stream flow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

(c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.

UNDERGROUND POWERHOUSE at Mica project.

(d) On commencement of the respective storage operations the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

(e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

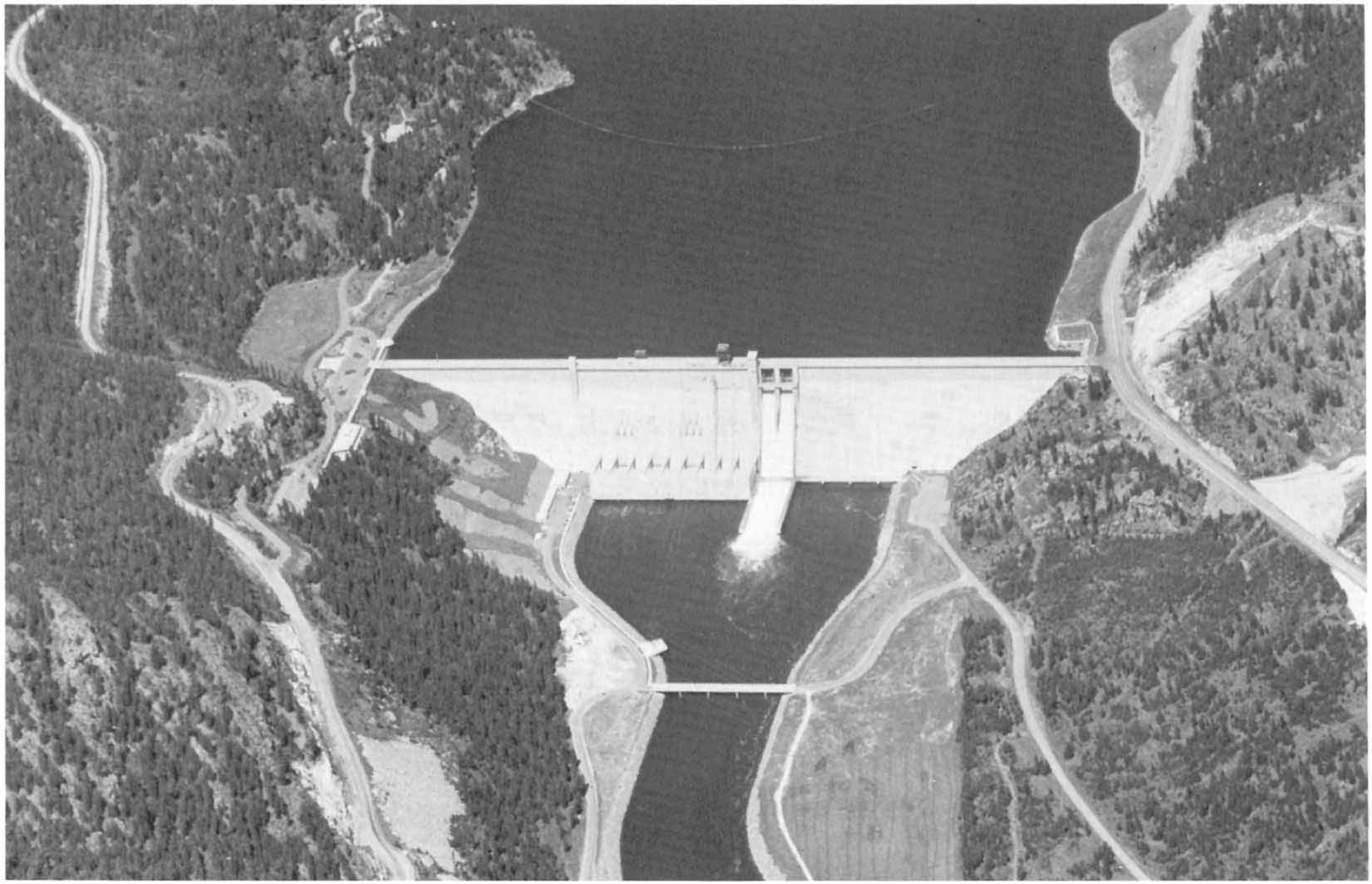
(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

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

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

The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Canadian Entitlement Purchase Agreement of 13 August 1964 provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	1 April 1968
Arrow storage	1 April 1969
Mica storage	1 April 1973



LIBBY DAM
The dam and reservoir, Lake Koocanuse. The powerhouse is at the left of the spillway.

Kootenai River, Montana

PERMANENT ENGINEERING BOARD

General

Article XV of the Columbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.

Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964 the Secretary of the Army and the Secretary of the Interior on 7 December 1964 appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977 the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964 the two governments announced the compostition of the Board.

The names of Board members, alternate members and secretaries are shown in Appendix A.

Duties and Responsibilities of the Board

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

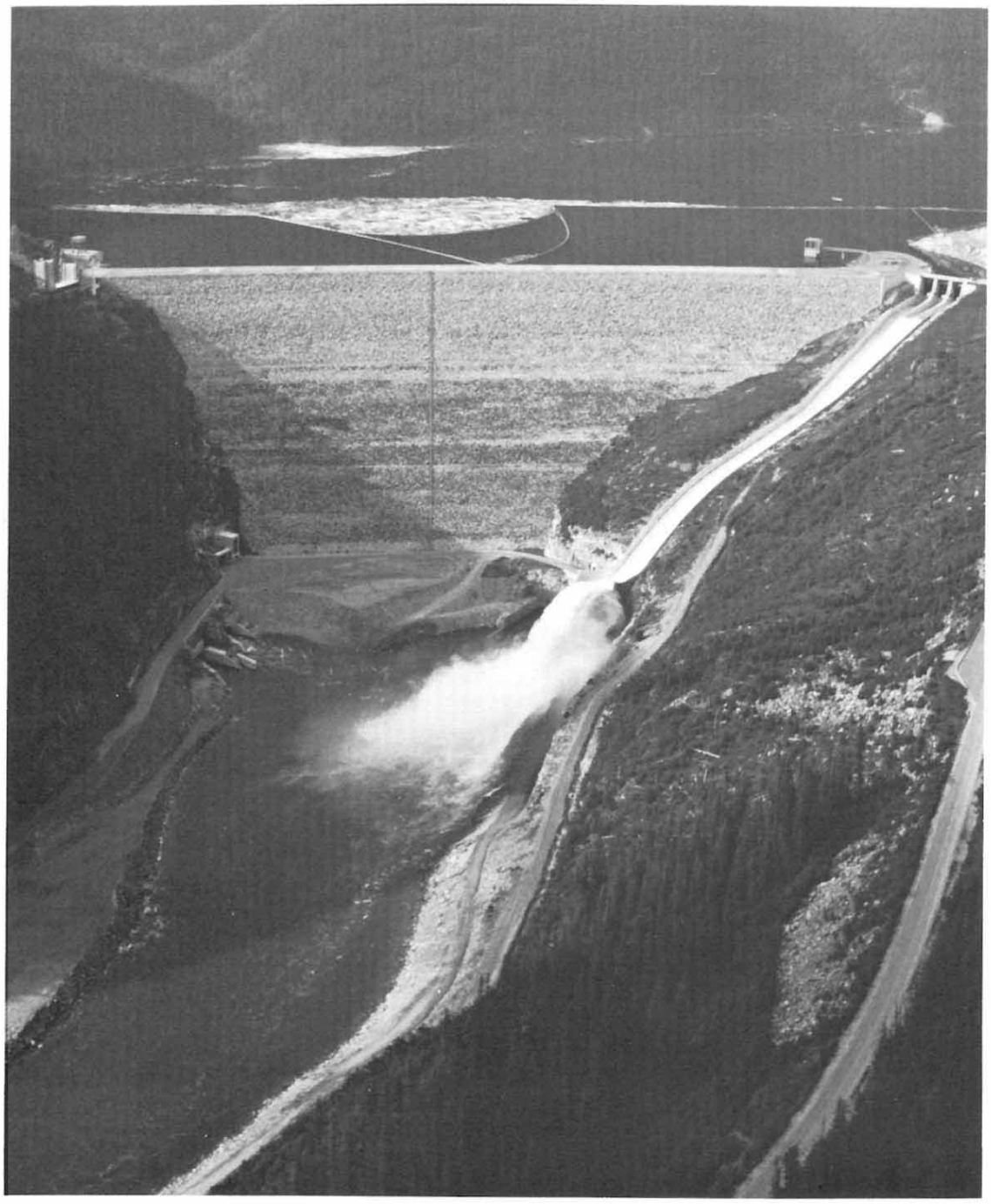
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the entities in the establishment and operation of a hydro-meteorological system as required by Annex A of the Treaty.



MICA DAM Columbia River, British Columbia
The earth dam with spillway in operation. The underground powerhouse is at the left.

ENTITIES

General

Article XIV(1) of the Treaty provides for the designation by Canada and the United States of entities which are empowered and charged with the duty of formulating and executing the operating arrangements necessary to implement the Treaty. Provision is made for either government to designate one or more entities. The powers and duties of the entities are specified in the Treaty and related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Pursuant to the Department of Energy Organization Act of 4 August 1977 these appointments are now made by the Secretary of the Army and the Secretary of Energy. Order in Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity for the purposes of the Treaty.

The names of the members of the two entities are shown in Appendix B. It is noted that on 5 September 1984 Brigadier General George R. Robertson succeeded Colonel James H. Higman who had succeeded Brigadier General James W. van Loben Sels on 22 June 1984.

Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents the Treaty requires that the entities be responsible for:

(a) co-ordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty,

(b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control,

(c) calculation of the amounts payable to the United States of America for standby transmission services,

(d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6),

(e) the establishment and operation of a hydrometeorological system as required by Annex A,

(f) assisting and co-operating with the Permanent Engineering Board in the discharge of its functions,

(g) periodic calculation of accounts,

(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,

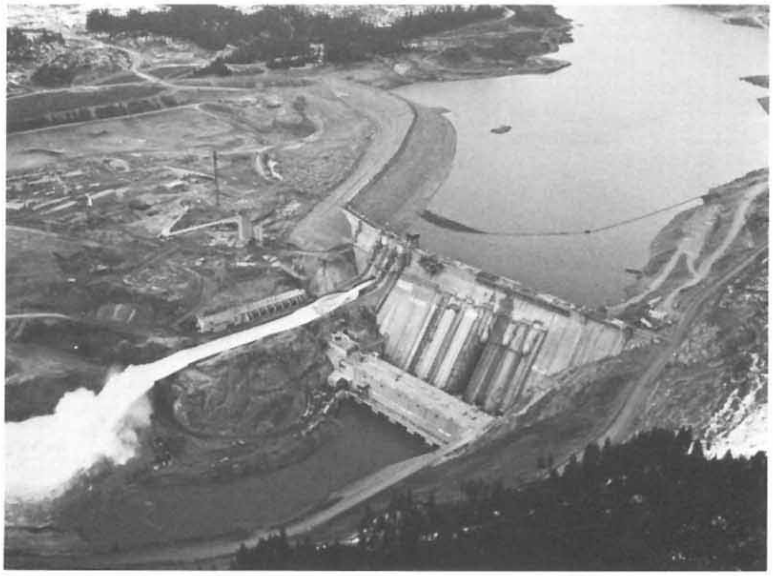
(i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein,

(j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss,

(k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of 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.

REVELSTOKE DAM
downstream from Mica Dam
completed in 1984.



ACTIVITIES OF THE BOARD

Meetings

The Board met in Seattle, Washington on 30 November 1983 to review progress under the Treaty and to discuss preparation of the Board's Annual Report. The Board met with the Entities on the same day to discuss Entity studies and general progress.

Reports Received

Throughout the report year the Canadian Entity provided the Board with weekly reports on operation of the Canadian storage reservoirs and with daily flow forecasts during the freshet season for the northern part of the Columbia River basin. The United States Entity provided monthly reports on the operation of the Libby storage reservoir. The Entities also provided copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculations, and the following documents and reports:

— Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1982 to 30 September 1983

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1988-89, plus a copy of the Entities' agreement on this document

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1983 through 31 July 1984, plus a copy of the Entities' agreement on this document

— Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1988-89, plus a copy of the Entities' agreement on this document

- Columbia River Treaty, Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans, May 1983, plus a copy of the Entities' agreement on this document

- An agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration on interim operating procedures to facilitate initial filling of the reservoir at the Revelstoke project, dated 9 September 1983

- Hydrometeorological Committee Documents (undated) by the Columbia River Treaty Hydrometeorological Committee

- An agreement between the Entities dated 9 April 1984, relating to:

  - Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration Relating to: (1) Initial Filling of Non-Treaty Reservoirs, (2) The Use of Columbia River Non-Treaty Storage and (3) Mica and Arrow Reservoir Refill Enhancement

  - Contract between Bonneville Power Administration and Mid-Columbia Purchasers Relating to Federal and Canadian Columbia River Storage.

Subsequent to the end of this report year the Board received the following documents and reports from the Entities:

- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1984 through 31 July 1985, plus a copy of the Entities' agreement on this document

- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1989-90, plus a copy of the Entities' agreement on this document

— Report of Columbia River Treaty Canadian and United States Entities 1 October 1983 through 30 September 1984

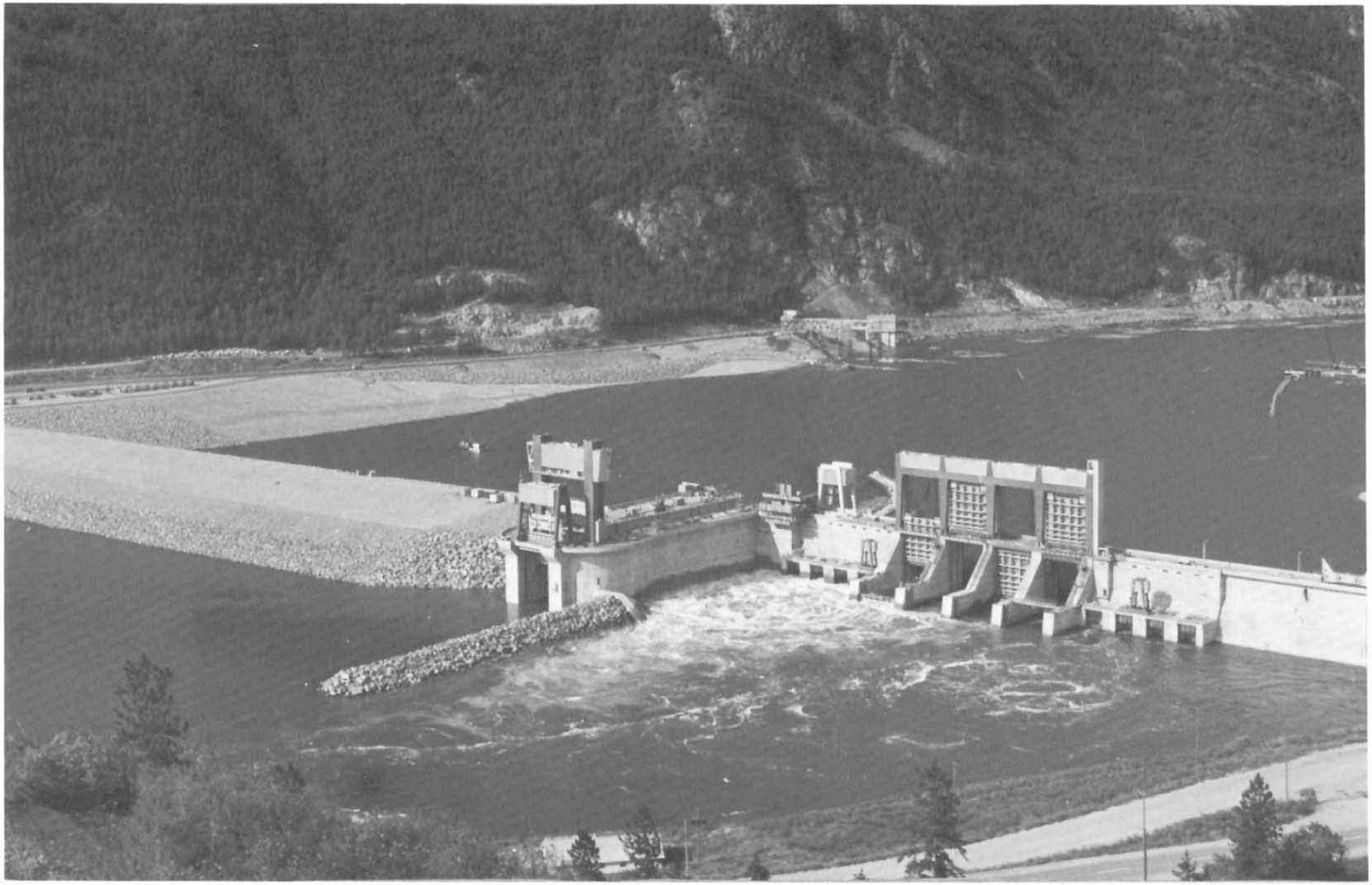
— Hydrometeorological Committee Documents, 1 November 1984, by the Columbia River Treaty Hydrometeorological Committee

— Report on Impact of Water Budget Flows on Assured Operating Plans and Determination of Downstream Power Benefits, 4 October 1984, by the Columbia River Treaty Operating Committee

— Report on Impact of Use of Updated Streamflow Records in Determination of Downstream Power Benefits, 4 October 1984, by the Columbia River Treaty Operating Committee.

Report to Governments

The nineteenth Annual Report of the Board was submitted to the two governments on 31 December 1983.



HUGH KEENLEYSIDE DAM
Concrete spillway and discharge works with navigation lock and earth dam.

Columbia River, British Columbia

PROGRESS

General

The results achieved under the terms of the Treaty include construction of the Treaty projects, development of the hydrometeorological network, annual preparation of power and flood control operating plans, and the annual calculation of downstream power benefits. The three Treaty storage projects in British Columbia, the Duncan, Arrow and Mica projects, produce power and flood control benefits in both Canada and the United States. The Libby storage project in Montana is in operation and provides power and flood control benefits in both countries. In the United States increased flow regulation provided by Treaty projects has facilitated the installation of additional generating capacity at existing plants on the Columbia River. In Canada completion of the Canal Plant on the Kootenay River in 1976, installation of generators at Mica Dam in 1976-77 and the completion of the Revelstoke project in 1984 have caused power benefits to increase substantially. This amounts to some 4,000 megawatts of generation in Canada that may not have been installed without the Treaty. In addition, the installation of generating capacity at Hugh Keenleyside Dam and at the Murphy Creek Site near Trail, British Columbia is being considered.

The Treaty provides Canada with the option of diverting the Kootenay River at Canal Flats into the headwaters of the Columbia River commencing in 1984. British Columbia Hydro and Power Authority has completed engineering feasibility and detailed environmental studies of the potential diversion.

The locations of the above projects are shown on Plate 1 in Appendix D.

Status of the Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled by the Sales Agreement for operation by 1 April 1968 and was the first of the Treaty projects to be completed. It became fully operational on 31 July 1967, well in advance of Treaty requirements.

The earthfill dam, about 130 feet high, is located on the Duncan River a few miles north of Kootenay Lake. The reservoir behind the dam extends for about 27 miles and provides 1,400,000 acre-feet of usable storage which is all committed under the Treaty. There are no power facilities included in this project which is shown in the picture on page 2.

Characteristics of the project are shown in Table 1 of Appendix D.

MONUMENT AND PLAQUE
located on Duncan Dam.

Arrow Project

The Hugh Keenleyside Dam, at the outlet of the Arrow Lakes, was the second Treaty project to be completed. It became operational on 10 October 1968 well ahead of the date of 1 April 1969 scheduled by the Sales Agreement. The project at present has no associated power facilities, however, installation of generators is being considered.

The dam consists of two main components: a concrete gravity structure which includes the spillway, low-level outlets and navigation lock and an earthfill section which rises 170 feet above the riverbed. The reservoir, about 145 miles long, includes both the Upper and Lower Arrow Lakes, and provides 7,100,000 acre-feet of Treaty storage.

The project is shown in the picture on page 16 and project data are shown in Table 2 of Appendix D.

Mica Project

Mica Dam, the largest of the Treaty projects, was scheduled by the Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973.

Mica Dam is located on the Columbia River about 85 miles north of Revelstoke, British Columbia. The earthfill dam rises more than 800 feet above its foundation and creates a reservoir 135 miles long, Kinbasket Lake, with a storage capacity of 20,000,000 acre-feet. The project utilizes 12,000,000 acre-feet of live storage of which 7,000,000 acre-feet are committed under the Treaty.

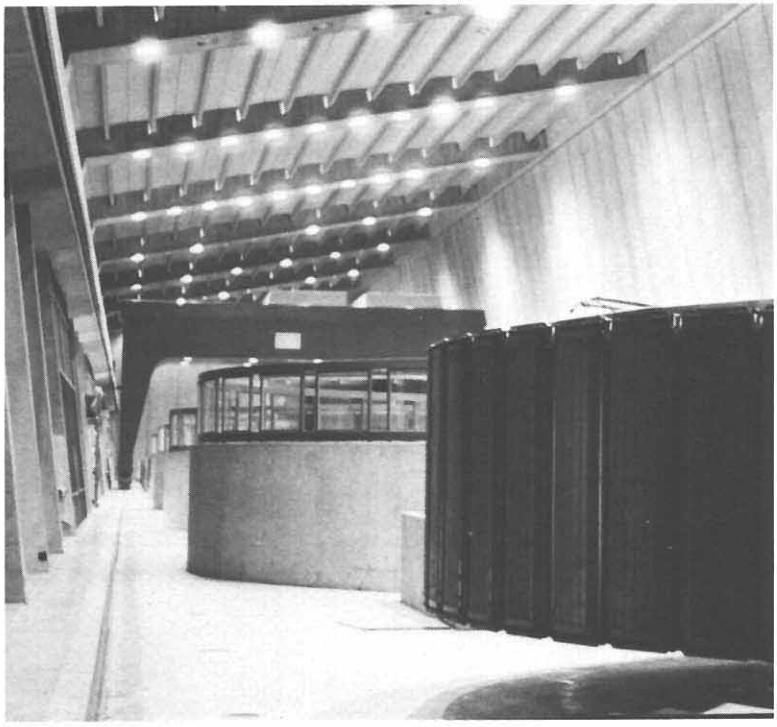
The underground powerhouse has space for a total of six 434 megawatt units with a total capacity of 2,604 megawatts. The first two generators were placed in service late in 1976 and the last of the initial four units commenced operation in October 1977.

The project is shown in the picture on page 9 and project data are shown in Table 3 of Appendix D.

Libby Project in the United States

Libby Dam is located on the Kootenai River 17 miles northeast of the town of Libby, Montana. Construction began in the spring of 1966, storage has been fully operational since 17 April 1973, and commercial generation of power began on 24 August 1975, coincident with formal dedication of the project. The concrete gravity dam rises 370 feet above the riverbed and creates Lake Koocanusa which is 90 miles long and extends 42 miles into Canada. Lake Koocanusa has a gross storage of 5,869,000 acre-feet, of which 4,980,000 acre-feet are usable for flood control and power purposes. The Libby powerhouse now has four units with a total installed capacity of 420 megawatts. Construction of additional units was initiated during fiscal year 1978 and the turbines have been installed. However, Congressional restrictions imposed in the 1982 Appropriations Act provide for completion of only one of the four additional units. That generator has been installed.

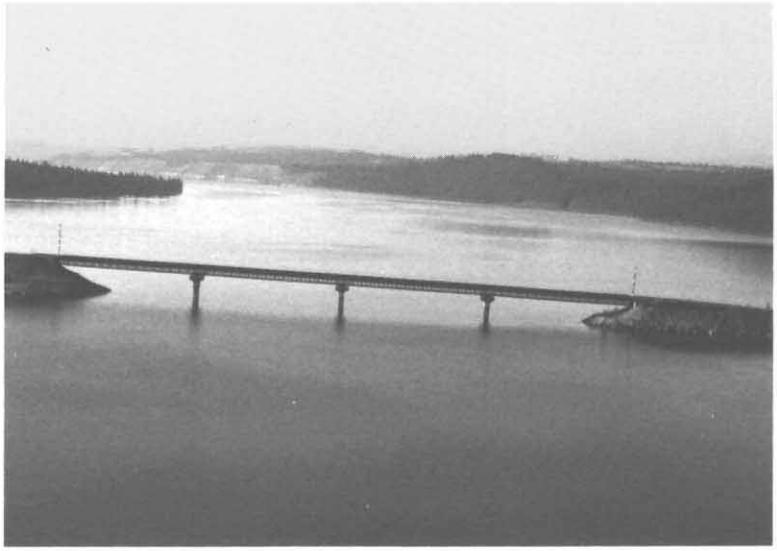
GENERATOR ROTOR
under repair
in Libby Powerhouse.



Work on the Libby Project during the report period included completion of flood protection works for the powerhouse. There has been no construction activity on the Reregulating Dam since that project was halted by court order in September 1978.

The Libby project is shown in the picture on page 6 and project data are shown in Table 4 of Appendix D.

KIKOMUN HIGHWAY BRIDGE
across Lake Koocanusa in British Columbia.



Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. Responsibility for ongoing maintenance and clean-up of the reservoir has been turned over to British Columbia Hydro and Power Authority.

Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system includes snow courses, meteorological stations and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on further development of the Treaty Hydrometeorological System.

In developing the hydrometeorological network the Entities, with the concurrence of the Board, adopted a document in 1976 which defines the Columbia River Treaty Hydrometeorological System Network and sets forth a method of classifying facilities into those required as part of the Treaty System and those of value as Supporting Facilities. During the 1976-77 report year, the Entities, with the concurrence of the Board, adopted a plan for exchange of operational hydrometeorological data. That plan is still in force.

Early in this report year, the Entities provided the Board with a draft of the Hydrometeorological Committee Documents which was reviewed with Board representatives. After the end of the report year, the Entities provided the Board with a new document containing a combined listing of Treaty and Support Facilities and information on exchange of data.

Work proceeded on incorporating Data Collection Platforms to improve communication within the Canadian Hydrometeorological Network. Data are being transmitted by satellite and transferred from the British Columbia Hydro and Power Authority system control centre by the microwave channel to the Columbia River Operational Hydromet Management System (CROHMS) computer in Portland. This system is operated by the U.S. Army Corps of Engineers. Automated hourly transmissions of Canadian hydrometeorological data into CROHMS were started on 15 August 1984.

Power Operating Plans

The Treaty and related documents provide that the Entities are to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation. These operating plans, prepared five years in advance, are called Assured Operating Plans. They represent the basic operating commitment of the Canadian Entity, and provide the Entities with a basis for system planning. At the beginning of each operating year, a Detailed Operating Plan is prepared on the basis of current resources and loads to obtain results that may be more advantageous to both countries than those which would be obtained by operating in accordance with the Assured Operating Plan.

The Entities have agreed with the Board's view, as noted in the Board's annual report to 30 September 1981, that Canada's commitment to operate under an Assured Operating Plan is tied directly to the benefits produced by that plan.

Paragraph 8 of the Protocol to the Treaty stipulates that a specific 30-year record of streamflows be used for calculating downstream power benefits. The Board notes that the Entities are using this record for part of the downstream benefit calculations but have updated and extended the record for general use and are using this updated record for the specified 30-year period to develop Assured Operating Plans. The Board's position is that the updated 30-year record should be used both to develop the Assured Operating Plans and the Downstream Benefits. The Board has advised the Entities accordingly.

The document Columbia River Treaty, Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans has been revised to recognize use of the updated record for the 30-year period. The Board's position on streamflow, as noted above, should be reflected in this document.

The Assured Operating Plan for operating year 1988-89, received by the Board early in the report year, includes generation at the Mica and Revelstoke projects in Canada and is based on the operation of the system for optimum generation in both countries.

Early in this report year the Entities provided the Board with a Detailed Operating Plan for Canadian storage for the operating year ending 31 July 1984. A Detailed Operating Plan for the operating year ending 31 July 1985 was forwarded to the Board after the end of the report year. These plans contain criteria for operating the Arrow, Duncan, Mica and Libby reservoirs.

In April 1984, the Entities reached an agreement relating to the initial filling of non-Treaty reservoirs, the use of non-Treaty storage, and Mica and Arrow reservoir refill enhancement. Copies of the agreement and of the associated contracts between Bonneville Power Administration and British Columbia Hydro and Power Authority, and between Bonneville Power Administration and the Mid-Columbia Purchasers were transmitted to the Board in September and are currently under review.

The Northwest Power Planning Council was established by Act of Congress in 1980 to prepare a program for improvement of fish and wildlife in the Columbia River Basin and to develop a conservation and electric power plan for the Pacific Northwest. The Council, on 15 November 1982, adopted the Columbia River Basin Fish and Wildlife Program which establishes a water budget. This budget reserves 3.45 million acre-feet of storage upstream from Priest Rapids Dam on the Columbia River and 1.19 million acre-feet upstream from Lower Granite Dam on the Snake River. This storage is used by United States' project operators when it is required to improve low flows in the main rivers during the downstream migration of anadromous fish. Fisheries and native Indian interests control use of the storage for this purpose. The use of Canadian Treaty storage is advocated by the United States Northwest Power Planning Council in its Fish and Wildlife Program.

The Board does not agree that use of Canadian storage could be considered for fishery purposes in developing the Assured Operating Plans as it contradicts Treaty requirements for optimum operation for power and flood control benefits. The Board notes however that the Entities could, by agreement, provide water for fish migration under detailed operating arrangements providing this does not conflict with Treaty requirements. Such arrangements must not result in any decrease to Canadian downstream power or flood control benefits. The Board has advised the Entities of this position.

Annual Calculation of Downstream Benefits

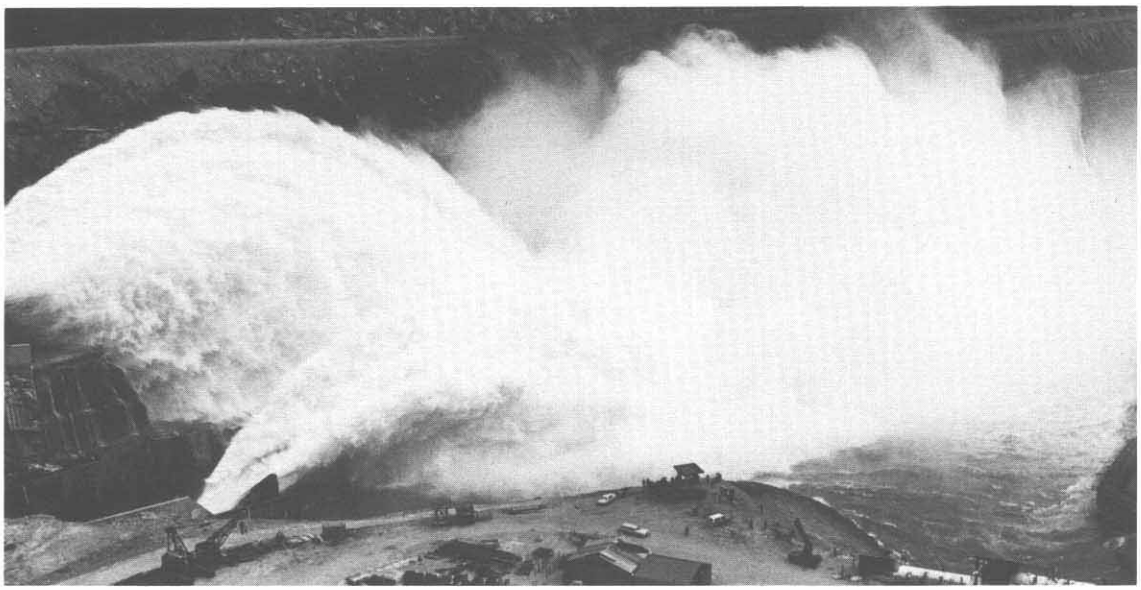
The general requirements for determination of assured operating plans and downstream power benefits are summarized in the first paragraph of the preceding section.

In this report year the Entities provided the Board with a copy of their agreed document outlining downstream power benefits resulting from Canadian storage for the operating year 1988-89. The Board has completed its review of this document and concludes that it meets the requirements of the Treaty. Copies of the three computer studies used in the final calculations for the determination of downstream benefits, and which also provide the basis of the hydroelectric operating plan, were forwarded to the Board by the Entities. A report on determination of downstream power benefits for the operating year 1989-90 was received from the Entities after the end of the report year.

Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

The Columbia River Treaty Flood Control Operating Plan defines flood control operation of the Duncan, Arrow, Mica and Libby Reservoirs. This plan was received from the Entities and reviewed by the Board in the 1972-73 report year.



MICA DAM
Spillway and outlet works in operation.

Flow Records

Article XV (2)(a) of the Treaty specified that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada-United States of America boundary. Flows for this report year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia.

OPERATION

General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storages and to direct operation of these storages in accordance with the terms of the Entity agreements.

During the report year the Treaty storage in Canada was operated by the Canadian Entity in accordance with:

— Columbia River Treaty Flood Control Operating Plan

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1983 through 31 July 1984

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1984 through 31 July 1985

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1983-84

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1984-85.

In addition, other agreements were in effect during this period:

— An agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration, dated 9 June 1983, providing extra storage in Arrow Lakes reservoir and in Kinbasket Lake.

— An agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration on interim operating procedures to facilitate initial filling of the reservoir at the Revelstoke project, dated 9 September 1983

— An agreement between the Entities dated 9 April 1984 relating to:

  — Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration Relating to: (1) Initial Filling of Non-Treaty Reservoirs, (2) The Use of Columbia River Non-Treaty Storage and (3) Mica and Arrow Reservoir Refill Enhancement

  — Contract between Bonneville Power Administration and Mid-Columbia Purchasers Relating to Federal and Canadian Columbia River Storage.

Power Operation

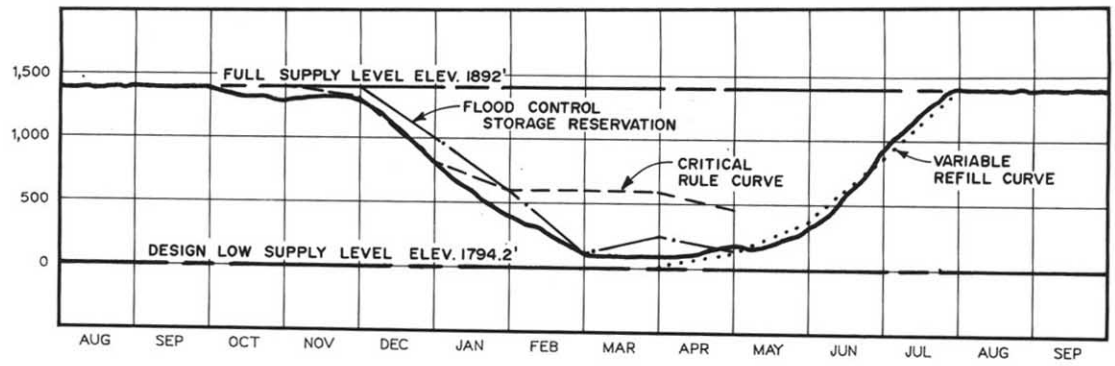
The three Canadian Treaty reservoirs, Duncan, Arrow and Mica, and the Libby reservoir in the United States were in full operation throughout this report year.

All power reservoirs in the Columbia River System were essentially full after the 1983 freshet. At the beginning of the report year, all Canadian Treaty storages were almost full and drafting had begun at Libby reservoir. The normal drawdown for power purposes was interrupted in November when inflows increased markedly due to much above normal precipitation. A relatively rapid drawdown of reservoirs was necessary in December and throughout the winter to meet operating rule curves.

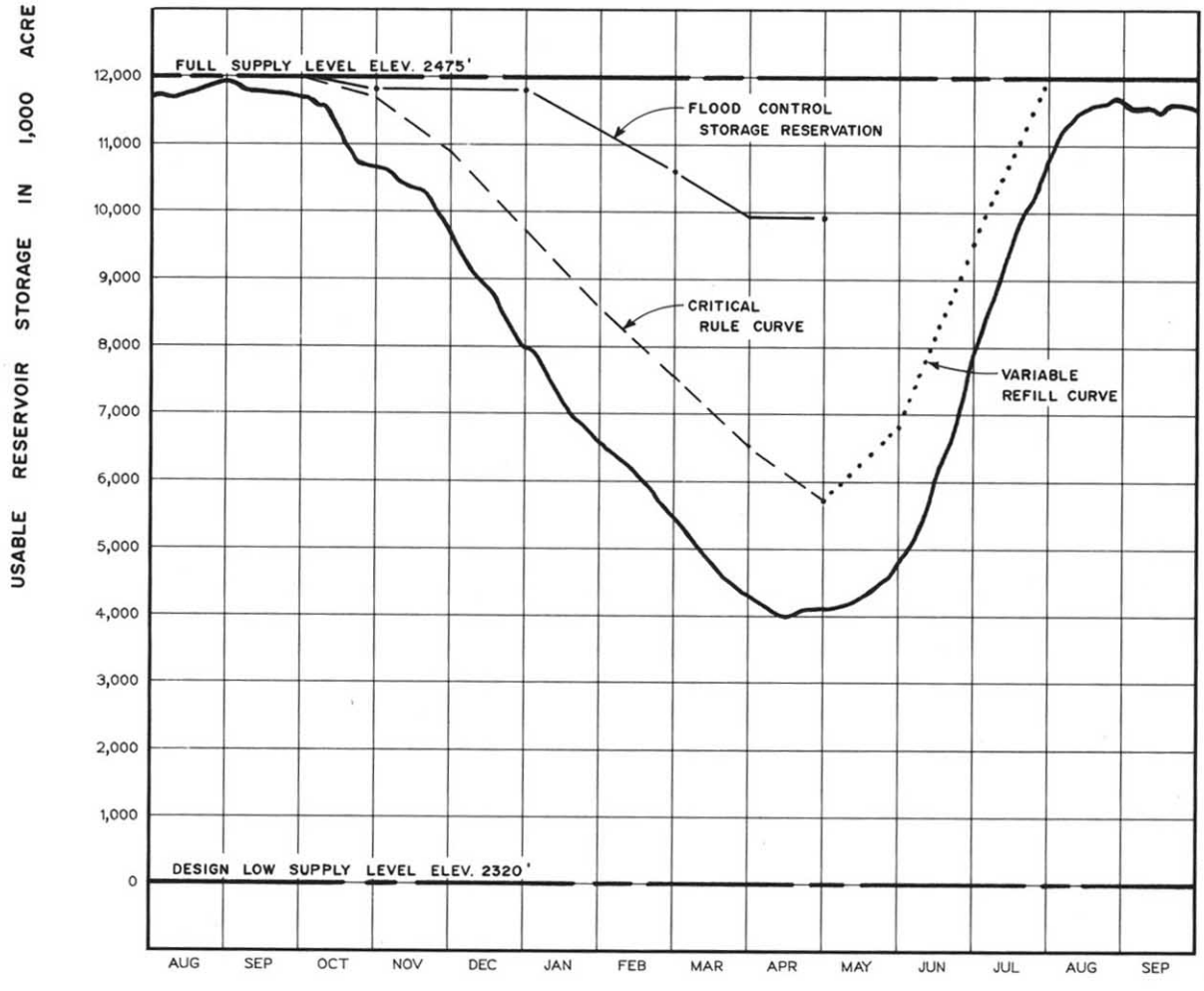
The 1984 freshet volume was slightly below average at Treaty projects, and was somewhat late because temperatures in May and early June were below normal. Flood control was provided by normal refill operations.

All Treaty reservoirs except Arrow filled during the freshet. Drafting at Mica, Arrow and Libby began before the end of September. Duncan remained full.

The reservoir for the new Revelstoke project downstream of Mica Dam was filled to elevation 1874.7 feet during the year. This was about five feet below full pool. Storage was transferred between Mica and Arrow reservoirs and into the Revelstoke reservoir under special agreements. These transfers and the filling of Revelstoke reservoir were accomplished without disrupting Treaty operations.

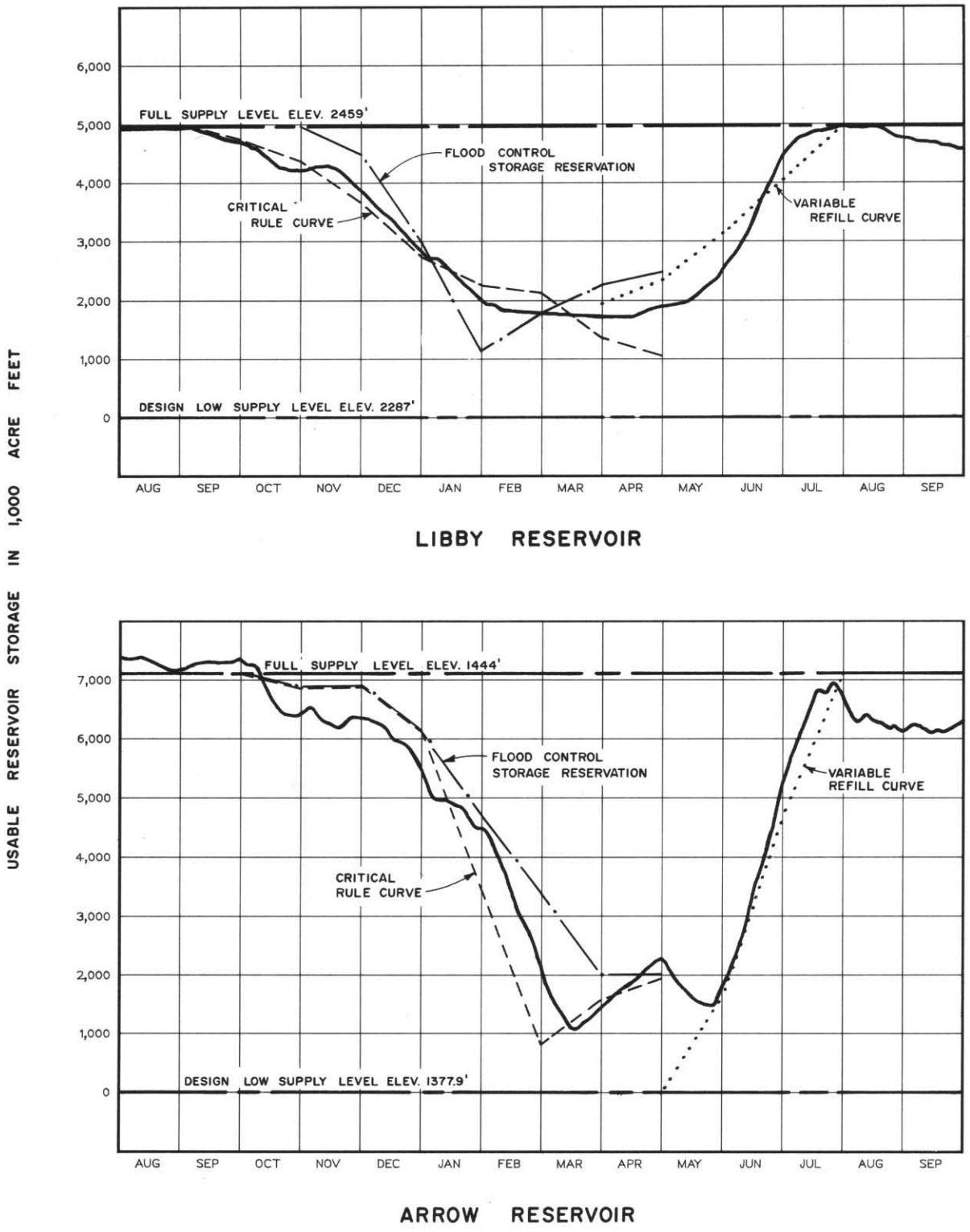


DUNCAN RESERVOIR



MICA RESERVOIR

HYDROGRAPHS — Duncan and Mica reservoir levels for the 14-month period ending 30 September 1984.



HYDROGRAPHS — Libby and Arrow reservoir levels for the 14-month period ending 30 September 1984.

In 1984, operation in the United States incorporated requirements of the Northwest Power Planning Council's Fish and Wildlife Program. This program specifies a water budget for use during the period 15 April to 15 June to meet minimum flow requirements for the downstream migration of anadromous fish. The water budget of 3.45 million acre-feet for Priest Rapids on the Columbia River was fully utilized between 28 April and 4 June. Above average flows on the Snake River enabled fishery goals to be met without any call on water budget storage.

Operation of the reservoirs is illustrated on pages 29 and 30 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storages. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control the forecasted freshet. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves which apply to operation of the combined Canadian Treaty storages have also been provided to the Board.

Duncan reservoir was nearly full at elevation 1891.5 feet at the beginning of the report year. Storage was drafted through October but the reservoir partially refilled when heavy precipitation occurred in November. Outflows were increased in December to deliver Treaty storage and drafting continued until the minimum elevation of 1804 feet was reached on 10 March 1984. Refill began in April and the reservoir refilled relatively slowly. Normal full pool elevation of 1892 feet was reached at the end of July and the reservoir remained full until the end of September.

At the beginning of the report year, Arrow reservoir was two feet above its normal full pool elevation of 1444 feet, in accordance with special agreements related to the filling of Revelstoke reservoir. Drafting of Treaty storage began 2 October 1983 and releases of 30,000 to 65,000 cfs were made throughout the period October to January. Discharges

were as high as 90,000 cfs in February and March and the reservoir reached its lowest level of the year at elevation 1390.9 feet by 18 March 1984. Outflows were reduced to 5,000 cfs in late March because of unusually high runoff in the lower Columbia River tributaries. The reservoir continued to fill until 2 May when discharges were increased to help fill Grand Coulee reservoir downstream. As a result, Arrow reservoir was drawn down approximately eight feet by 26 May before outflows were again reduced and filling resumed.

Arrow reservoir filled quickly during June and July reaching its peak level, elevation 1442.8 feet, on 27 July 1984. Although the reservoir was not quite up to full pool elevation of 1444 feet, the Treaty storage was considered full after accounting for storage transferred to Revelstoke. Arrow outflows were then increased for downstream power purposes and at the end of the report year the reservoir level was six and one half feet below normal full pool elevation.

Treaty storage in the Mica reservoir was full at the beginning of the report year. The reservoir elevation was 2472 feet, three feet below normal full pool elevation. Generation at Mica was curtailed on 9 and 10 October 1983 to facilitate closure of the diversion tunnel at the Revelstoke project. Following closure at Revelstoke, discharges at Mica exceeded the Detailed Operating Plan targets until mid-January. This facilitated transfer of storage from Mica for the initial filling of the Revelstoke reservoir, under agreements between British Columbia Hydro and Power Authority and Bonneville Power Administration. Mica reservoir continued to be drafted until 16 April 1984 when it reached its lowest elevation of the year at 2387.8 feet.

Refilling began when inflows increased in late April. Discharges were reduced below Detailed Operating Plan targets to replace water previously released to fill the Revelstoke reservoir. The reservoir filled slowly through May and the beginning of June because inflows were much lower than normal. Treaty storage was full by 2 August and the reservoir reached its peak elevation of 2472.3 feet on 28 August. Storage was drafted in September and at the end of the report year the elevation of the reservoir was 2470.6 feet.

RECREATIONAL AREA
at Libby Dam.

Libby reservoir was about six feet below its normal full pool elevation of 2459 feet at the beginning of the report year. Drafting to meet power and flood control requirements continued throughout the winter. After 10 February outflows were held to about 4,000 cfs until the lowest level of the year, elevation 2370.3 feet, was reached 15 April 1984. Releases were maintained at a low level through June and increased in July to reduce the rate of filling. Libby reservoir was full at elevation 2459 feet on 31 July 1984. Drafting began in August and on 30 September the reservoir was at elevation 2450.2 feet.

Flood Control Operation

Flood control during the 1984 spring runoff was provided by the normal refill operation of the Treaty projects and other storage reservoirs in the Columbia River basin. Operation was scheduled on a daily basis from 19 April through 8 July under normal procedures for the flood control period. Operation during the freshet was in accordance with the Entities' document Columbia River Treaty Flood Control Operating Plan and the freshet was controlled to well below damaging levels.

BENEFITS

Flood Control Provided

Without regulation by upstream reservoirs the 1984 freshet would have produced a below average peak discharge at Trail, British Columbia and an above average peak discharge at The Dalles, Oregon, but would not have caused major flood damage in either country.

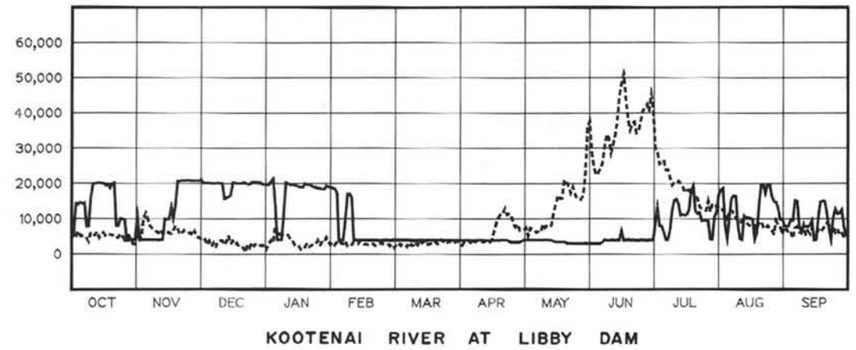
It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about five and one half feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about thirteen feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 35 by hydrographs which show both the actual discharges and the flows that would have occurred if the dams had not been built. It is noted that the hydrograph showing pre-project conditions for Birchbank has been computed on the assumption that the effects of Duncan, Arrow, Mica and Libby regulation and of the regulation provided by the Corra Linn development on Kootenay Lake have been removed.

The operation of Columbia Basin reservoirs for the system as a whole reduced the natural annual peak discharge of the Columbia River near The Dalles, Oregon from about 628,000 cfs to 375,000 cfs. Regulation by the Treaty storage projects during the 1984 freshet period contributed minor flood control benefits in Canada and the United States.

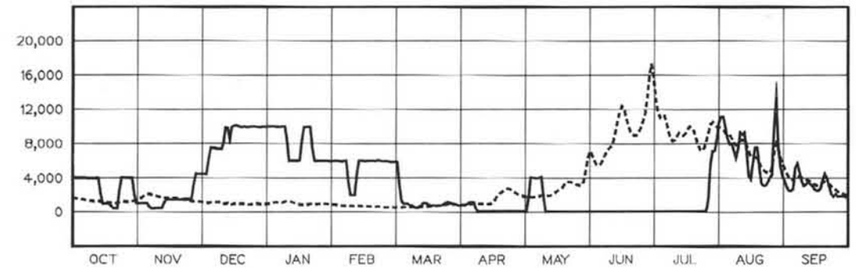
All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage projects have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.

Power Benefits

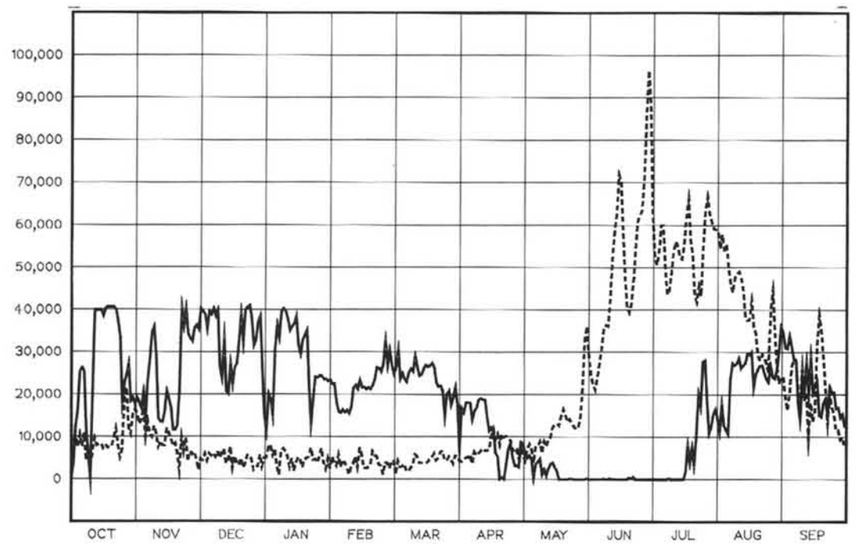
Downstream power benefits in the United States which arise from operation of the Canadian Treaty Storage were pre-determined and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement.



KOOTENAI RIVER AT LIBBY DAM

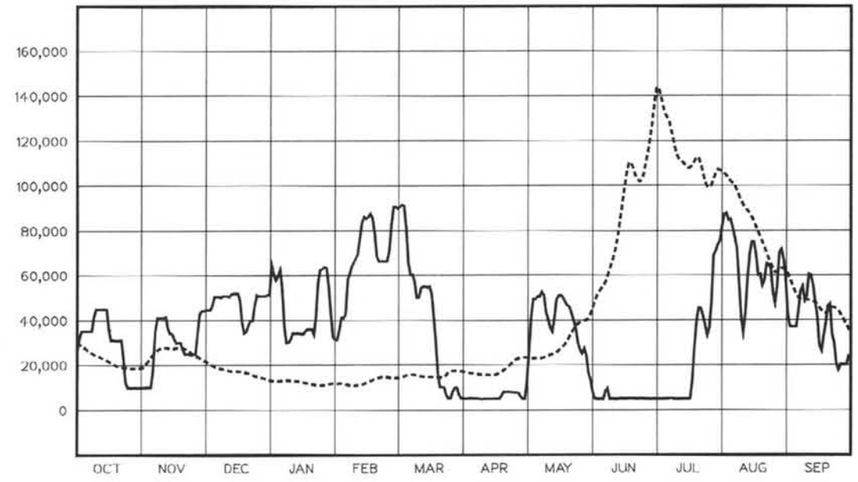


DUNCAN RIVER AT DUNCAN DAM

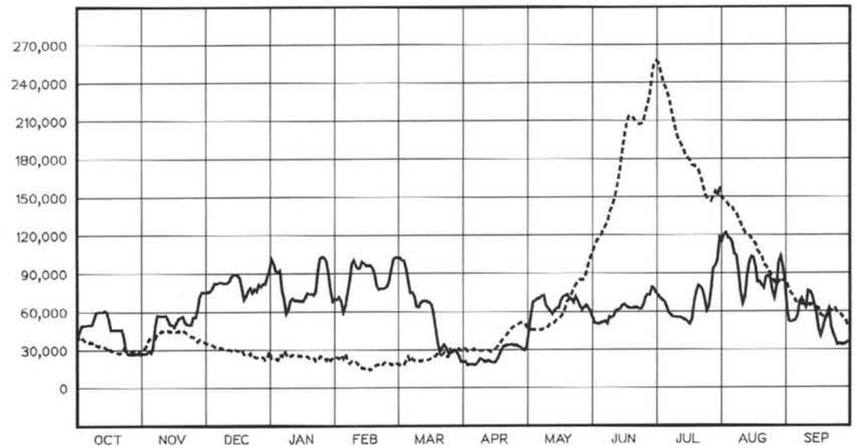


COLUMBIA RIVER AT MICA DAM

DISCHARGE IN CUBIC FEET PER SECOND



COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM



COLUMBIA RIVER AT BIRCHBANK

LEGEND

Observed Flows

Pre-Project Flows

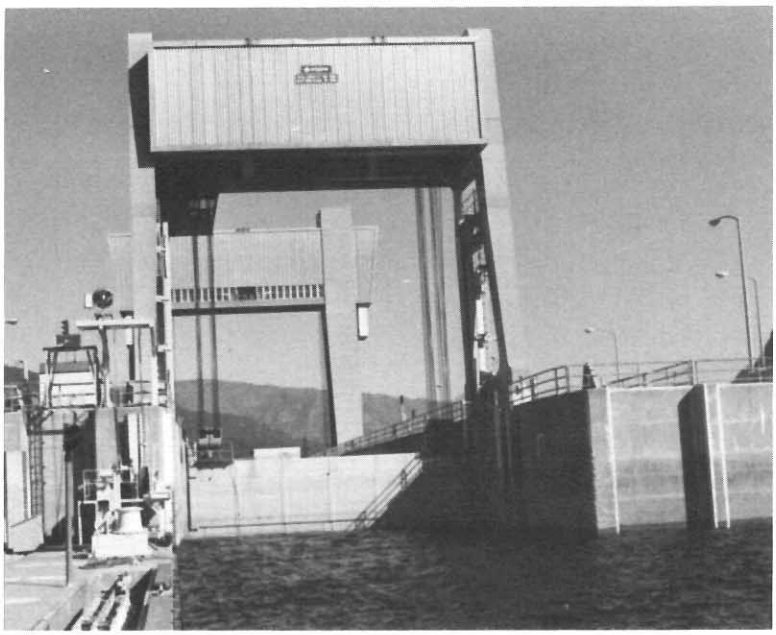
HYDROGRAPHS — Observed and pre-project flows for year ending 30 September 1984.

The United States Entity delivered capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. No additional downstream power benefits were realized during the year from the operation of Treaty storage other than the added generation made possible on the Kootenay River in Canada and additional generation in the United States system resulting from regulation provided by Libby. The Kootenay River benefits in Canada, under Article XII of the Treaty, and generation at the Mica project are retained wholly within Canada while the benefits from Libby in the United States are not shareable under the Treaty.

Other Benefits

In previous report years, by agreement between the Entities, streamflows have been regulated for non-power purposes such as accommodating construction in river channels and providing water to assist the downstream migration of juvenile fish in the United States. These arrangements were supplemental to Treaty operating plans. In this report year similar arrangements were made.

NAVIGATION LOCK entrance at Hugh Keenleyside Dam.



CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty. Operation also reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and special agreements primarily to assist in filling the Revelstoke reservoir. Operation under these latter agreements did not conflict with normal Treaty operations.

2. Entity evaluations pertaining to development of the hydrometeorological network, power operating plans, and the annual calculation of downstream power benefits are proceeding satisfactorily.

3. Following a review of the practice of updating historic streamflow records for factors such as irrigation depletions, the Board has advised the Entities that such updated data should be used for the calculation of the Assured Operating Plans and Downstream Power Benefits.

4. Treaty storage projects were regulated to avoid what otherwise would have been minor flood damages in the United States from the above average freshet.

5. The objectives of the Treaty are being met.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. Lloyd A. Duscha, Chairman Deputy Director, Engineering & Construction Directorate, Headquarters, U.S. Army Corps of Engineers, Washington, D.C.	Mr. G.M. MacNabb, Chairman President, Natural Sciences & Engineering Research Council Canada, Ottawa, Ontario
Mr. J. Emerson Harper Acting Director, Office of Power Marketing Coordination, Department of Energy, Washington, D.C.	Mr. B.E. Marr Deputy Minister, Ministry of Environment, Victoria, B.C.
Alternates	
Mr. Alex Shwaiko Chief, Office of Policy, Civil Works Directorate, Headquarters, U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark Regional Director, Pacific and Yukon Region, Inland Waters Directorate, Department of the Environment, Vancouver, B.C.
Mr. Thomas L. Weaver Assistant Administrator for Engineering, Western Area Power Administration, Department of Energy, Golden, Colorado	Mr. H.M. Hunt Head, Power and Special Projects Section, Ministry of Environment, Victoria, B.C.
Secretaries	
Mr. S.A. Zanganeh Hydraulics & Hydrology Division, Civil Works Directorate, Headquarters, U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark Regional Director, Pacific and Yukon Region, Inland Waters Directorate, Department of the Environment, Vancouver, B.C.

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Record of Membership

United States

Members

Mr. Wendell E. Johnson 1)	1964-1970
Mr. Morgan E. Dubrow	1964-1970
Mr. John W. Neuberger	1970-1973
Mr. Joseph B. Caldwell 1)	1971-1973
Mr. Homer B. Willis 1)	1973-1979
Mr. C. King Mallory	1973-1975
Mr. Raymond A. Peck, Jr.	1976-1977
Mr. J. Emerson Harper	1978-
Mr. Lloyd A. Duscha 1)	1979-

Alternates

Mr. Fred L. Thrall	1964-1974
Mr. J. Emerson Harper	1964-1978
Mr. Alex Shwaiko	1974-
Mr. Thomas L. Weaver	1979-

Secretaries

Mr. John W. Roche	1965-1969
Mr. Verle Farrow	1969-1972
Mr. Walter W. Duncan	1972-1978
Mr. S.A. Zanganeh	1978-

Canada

Members

Mr. G.M. MacNabb 1)	1964-
Mr. A.F. Paget	1964-1973
Mr. V. Raudsepp	1973-1974
Mr. B.E. Marr	1974-

Alternates

Mr. E.M. Clark	1964-
Mr. J.T. Rothwell	1964-1965
Mr. H.M. Hunt	1966-

Secretaries

Mr. E. M. Clark	1964-

1) Chairman

COLUMBIA RIVER TREATY ENTITIES

United States

Mr. Peter T. Johnson, Chairman

Administrator, Bonneville
Power Administration,
Department of Energy,
Portland, Oregon

Brigadier General George R. Robertson[1]

Division Engineer,
U.S. Army Engineer Division, North Pacific,
Portland, Oregon

Canada

Mr. R.W. Bonner, Chairman

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

[1] Vice Colonel James H. Higman as of 5 September 1984.
Colonel Higman succeeded Brigadier General James W. Van Loben Sels on 22 June 1984.

APPENDIX C

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
1	11,300	5,950	22,300	22,000	22,500	5,940	6,870	9,540	20,500	11,100	12,300	9,950
2	7,100	11,000	22,200	22,100	22,200	6,060	6,710	10,000	17,400	10,700	16,700	8,440
3	6,920	8,050	22,400	22,300	22,100	6,040	6,580	10,600	15,900	14,700	19,000	8,310
4	13,500	11,400	22,700	22,300	17,900	6,080	6,580	10,400	15,400	16,600	16,600	8,410
5	14,300	10,500	22,800	23,400	8,330	5,970	6,680	10,000	15,700	13,200	9,620	9,390
6	14,600	8,960	22,800	14,400	6,930	5,890	7,050	9,780	16,100	11,800	6,100	10,700
7	14,500	9,390	22,800	9,410	6,750	5,920	7,200	9,890	15,800	10,600	11,000	14,000
8	14,600	8,530	22,900	8,670	14,500	5,920	7,240	9,720	16,700	8,600	15,600	13,200
9	8,900	7,860	23,000	8,200	19,700	5,880	7,430	10,300	18,200	8,260	16,500	8,280
10	8,540	7,460	23,200	18,600	20,400	6,040	7,340	10,500	18,000	10,700	16,200	7,070
11	17,200	7,890	23,200	23,200	16,800	6,120	7,360	10,500	16,900	14,500	9,490	8,260
12	19,400	8,560	22,500	23,300	7,340	6,140	7,210	10,800	16,900	17,100	5,960	8,310
13	19,900	8,190	18,900	23,300	6,760	6,340	7,190	12,900	16,600	18,200	5,640	8,180
14	20,100	8,040	18,400	23,200	6,600	6,580	7,070	13,200	16,900	14,800	10,600	9,250
15	20,000	12,200	18,300	22,500	6,380	6,680	7,190	15,000	18,000	13,200	10,700	9,060
16	20,100	12,800	19,200	22,700	6,540	6,690	7,880	15,200	18,900	13,000	10,700	5,430
17	19,600	13,500	21,800	22,500	6,320	6,710	9,610	14,400	20,000	12,800	10,500	5,080
18	20,000	16,100	21,900	22,500	6,180	6,740	11,400	13,800	17,700	12,700	10,300	11,100
19	19,500	13,700	22,000	22,400	6,210	6,690	12,400	14,700	15,500	15,000	5,990	14,100
20	19,200	19,900	21,900	22,200	6,260	6,760	14,300	18,500	14,500	19,200	7,240	14,600
21	20,000	22,700	22,100	22,200	6,020	6,870	16,500	20,500	15,800	18,000	14,600	14,900
22	17,300	22,900	22,400	22,500	6,120	7,300	16,600	18,500	19,300	13,900	18,900	11,200
23	10,200	22,900	22,400	22,700	6,110	7,390	16,000	18,100	17,000	12,000	18,900	7,900
24	9,520	23,000	22,500	22,600	6,100	7,550	15,000	18,700	15,300	12,400	17,900	5,500
25	10,600	23,000	22,300	23,200	6,020	7,550	13,700	17,100	14,600	10,800	19,400	10,500
26	10,600	22,900	22,200	23,700	5,990	7,440	12,400	15,900	14,600	10,600	19,600	12,100
27	9,290	22,900	22,300	23,500	5,980	7,400	11,300	15,600	13,700	10,500	15,800	11,800
28	5,540	22,900	22,300	23,300	5,890	7,140	10,700	15,900	13,000	10,100	14,800	11,900
29	5,390	22,700	22,300	23,000	5,980	7,120	10,100	16,900	12,200	6,060	14,700	12,200
30	5,300	22,500	22,200	23,000		7,050	9,690	20,500	11,800	5,740	12,300	8,550
31	5,510		21,900	22,600		6,900		23,200		12,500	10,400	
Mean	13,500	14,600	21,900	21,000	10,000	6,610	9,780	14,200	16,300	12,600	13,000	9,920

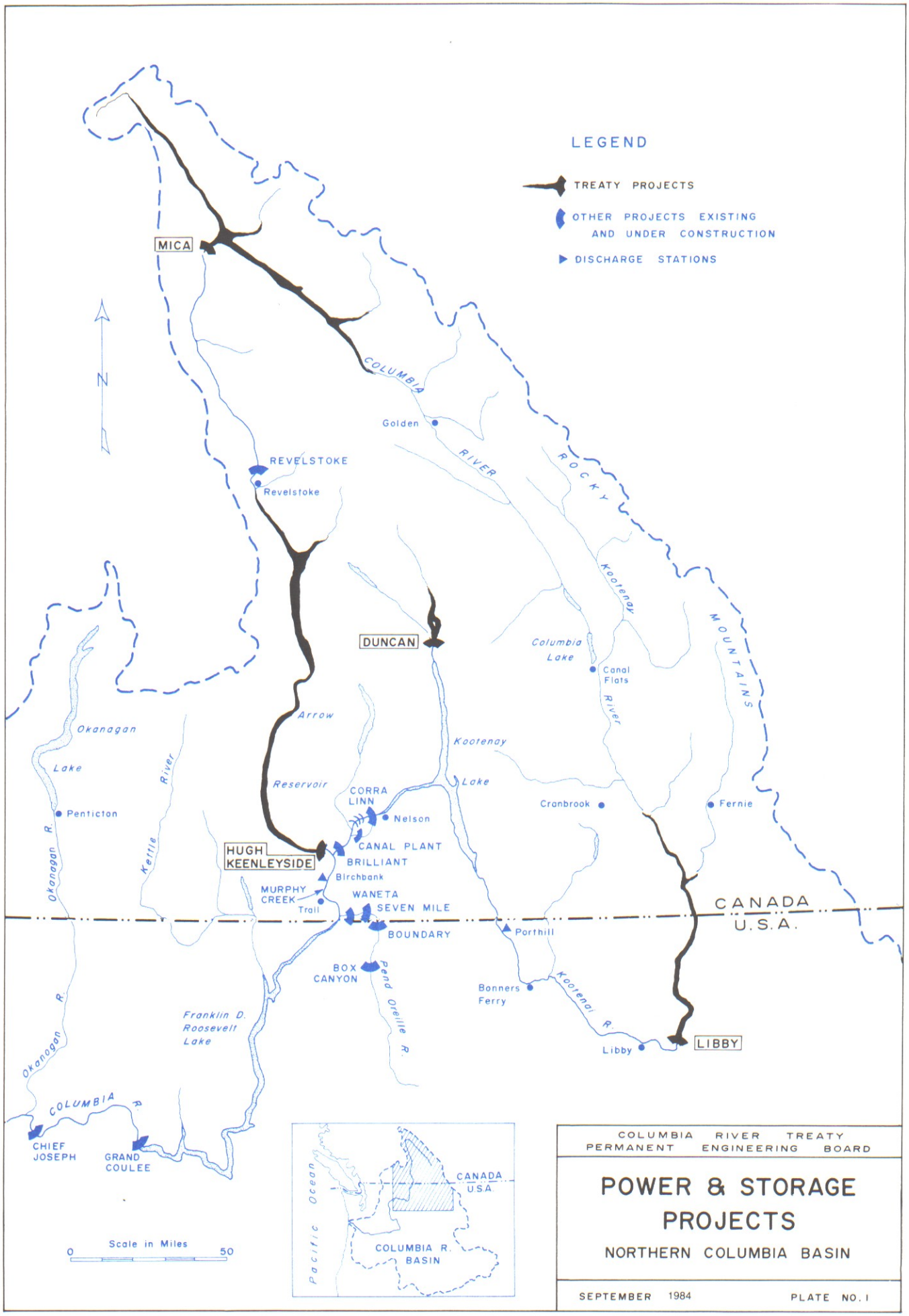
KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1984 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
1	39,600	27,300	75,200	101,000	69,600	103,000	20,500	32,600	55,400	74,400	115,000	61,700
2	43,800	27,300	75,600	98,200	71,500	103,000	20,800	45,000	51,100	72,800	120,000	51,800
3	48,700	27,600	76,300	92,000	68,600	101,000	18,500	58,900	50,400	70,500	122,000	51,700
4	49,400	28,900	78,800	91,500	59,500	100,000	18,600	68,200	50,300	69,400	117,000	52,300
5	49,400	27,700	82,300	92,400	64,600	94,100	18,800	68,700	51,200	67,600	117,000	53,100
6	49,800	32,900	82,300	77,200	74,800	84,900	18,400	70,300	52,000	64,000	114,000	56,800
7	49,800	48,700	83,000	69,400	84,100	75,300	18,600	70,800	52,600	58,900	105,000	67,700
8	49,800	57,200	83,300	58,600	98,000	75,300	20,300	72,300	50,600	57,600	104,000	70,400
9	54,700	56,900	82,600	61,900	101,000	72,200	23,200	72,900	56,300	55,900	91,000	65,200
10	59,700	56,900	82,600	68,900	96,600	64,400	22,500	64,900	55,600	55,600	75,300	63,700
11	60,000	56,900	82,600	70,800	94,300	63,500	21,000	62,700	56,900	55,400	65,900	76,100
12	60,000	57,200	84,000	68,800	94,300	67,300	20,800	60,600	60,200	55,400	71,500	75,700
13	60,000	53,700	87,600	68,700	99,300	68,300	21,900	58,100	61,900	54,900	87,200	72,400
14	60,700	49,800	89,300	68,500	98,300	68,900	20,500	60,800	62,000	54,100	98,000	65,100
15	60,000	49,800	89,000	68,600	96,400	68,000	20,100	62,800	65,000	53,400	103,000	57,800
16	53,700	48,000	88,600	68,600	96,600	67,400	20,100	63,000	65,500	52,100	102,000	46,200
17	45,900	51,600	86,500	70,900	96,400	65,600	22,400	68,400	64,200	50,000	95,700	40,500
18	45,900	54,400	78,400	74,500	94,800	58,300	26,200	71,500	63,100	54,000	82,900	46,800
19	45,900	55,400	69,600	73,800	90,300	47,300	29,500	72,600	62,600	67,300	83,400	53,200
20	45,900	56,500	72,400	74,100	80,800	35,500	32,800	73,300	62,800	75,500	80,600	57,600
21	45,900	51,900	76,600	73,100	77,700	28,400	33,200	70,700	63,200	80,500	78,500	62,100
22	46,300	50,100	78,800	76,400	78,300	31,700	33,900	69,900	63,300	79,600	86,800	47,500
23	41,000	49,800	75,200	91,800	78,300	34,100	33,900	67,600	62,000	76,700	87,900	42,200
24	30,700	49,800	77,700	102,000	78,800	31,400	34,500	71,800	62,200	69,500	86,700	38,300
25	27,100	55,800	76,300	103,000	80,200	27,700	33,400	68,400	65,800	60,900	76,200	33,600
26	26,700	55,400	81,200	103,000	84,500	27,800	34,000	64,500	71,500	64,200	70,500	34,800
27	26,700	61,800	79,800	99,600	93,700	28,400	32,700	61,600	73,400	77,100	79,100	33,800
28	26,900	72,000	81,900	89,500	101,000	29,700	32,200	63,600	73,200	93,800	98,900	34,000
29	27,000	75,200	81,900	76,600	103,000	28,100	30,300	65,300	79,100	96,000	103,000	34,700
30	27,000	75,200	87,600	68,200		25,300	30,000	62,800	78,100	101,000	95,100	36,100
31	27,100		92,500	70,200		20,500		60,200		118,000	84,800	
Mean	44,700	50,700	81,300	79,700	86,400	57,900	25,500	64,700	61,400	68,900	93,500	52,800

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1984 in cubic feet per second.

APPENDIX D

PROJECT INFORMATION



COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

POWER & STORAGE PROJECTS

NORTHERN COLUMBIA BASIN

SEPTEMBER 1984

PLATE NO. 1

TABLE 1

DUNCAN PROJECT

Duncan Dam and Duncan Lake

Storage Project	
Construction began	17 September 1964
Storage became fully operational	31 July 1967
Reservoir	
Normal Full Pool Elevation	1,892 feet
Normal Minimum Pool Elevation	1,794.2 feet
Surface Area at Full Pool	18,000 acres
Total Storage Capacity	1,432,500 ac-ft
Usable Storage Capacity	1,400,000 ac-ft
Treaty Storage Commitment	1,400,000 ac-ft
Dam, Earthfill	
Crest Elevation	1,907 feet
Length	2,600 feet
Approximate height above riverbed	130 feet
Spillway — Maximum Capacity	47,700 cfs
Discharge Tunnels — Maximum Capacity	20,000 cfs
Power Facilities	
None	

TABLE 2

ARROW PROJECT

Hugh Keenleyside Dam and Arrow Lakes

Storage Project	
Construction began	March 1965
Storage became fully operational	10 October 1968
Reservoir	
Normal Full Pool Elevation	1,444 feet
Normal Minimum Pool Elevation	1,377.9 feet
Surface Area at Full Pool	130,000 acres
Total Storage Capacity	8,337,000 ac-ft
Usable Storage Capacity	7,100,000 ac-ft
Treaty Storage Commitment	7,100,000 ac-ft
Dam, Concrete Gravity and Earthfill	
Crest Elevation	1,459 feet
Length	2,850 feet
Approximate height above riverbed	170 feet
Spillway — Maximum Capacity	240,000 cfs
Low Level Outlets — Maximum Capacity	132,000 cfs
Power Facilities	
None	

TABLE 3

MICA PROJECT

Mica Dam and Kinbasket Lake

Storage	
Construction began	September 1965
Storage became fully operational	29 March 1973
Reservoir	
Normal Full Pool Elevation	2,475 feet
Normal Minimum Pool Elevation	2,320 feet
Surface Area at Full Pool	106,000 acres
Total Storage Capacity	20,000,000 ac-ft
Usable Storage Capacity	
Total	12,000,000 ac-ft
Commitment to Treaty	7,000,000 ac-ft
Dam, Earthfill	
Crest Elevation	2,500 feet
Length	2,600 feet
Approximate height above foundation	800 feet
Spillway — Maximum Capacity	150,000 cfs
Outlet Works — Maximum Capacity	37,400 cfs
Power Facilities	
Designed ultimate installation	
6 units at 434 mw	2,604 mw
Power commercially available	December 1976
Presently installed	
4 units at 434 mw	1,736 mw
Head at full pool	600 feet
Maximum Turbine Discharge	
of 4 units at full pool	38,140 cfs

TABLE 4

LIBBY PROJECT

Libby Dam and Lake Koocanusa

Storage Project	
Construction began	June 1966
Storage became fully operational	17 April 1973
Reservoir	
Normal Full Pool Elevation	2,459 feet
Normal Minimum Pool Elevation	2,287 feet
Surface Area at Full Pool	46,500 acres
Total Storage Capacity	5,869,000 ac-ft
Usable Storage Capacity	4,980,000 ac-ft
Dam, Concrete Gravity	
Deck Elevation	2,472 feet
Length	3,055 feet
Approximate height above riverbed	370 feet
Spillway — Maximum Capacity	145,000 cfs
Low Level Outlets — Maximum Capacity	61,000 cfs
Power Facilities	
Designed ultimate installation	
8 units at 105 mw	840 mw
Power commercially available	24 August 1975
Presently installed	
4 units at 105 mw	420 mw
Head at full pool	352 feet
Maximum Turbine Discharge	
of 4 units at full pool	19,625 cfs