

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C.

Ottawa, Ontario

30 SEPTEMBER 1978



COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A • U N I T E D S T A T E S

CANADIAN SECTION

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

UNITED STATES SECTION

H.B. WILLIS, Chairman
J.E. Harper, Member

31 December 1978

The Honorable Cyrus Vance
The Secretary of State
Washington, D.C.

The Honourable A. Gillespie
Minister of Energy, Mines and
Resources
Ottawa, Ontario

Gentlemen:

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 fourteenth Annual Report, dated 30 September 1978, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1977 to 30 September 1978.

Respectfully submitted:

For the United States

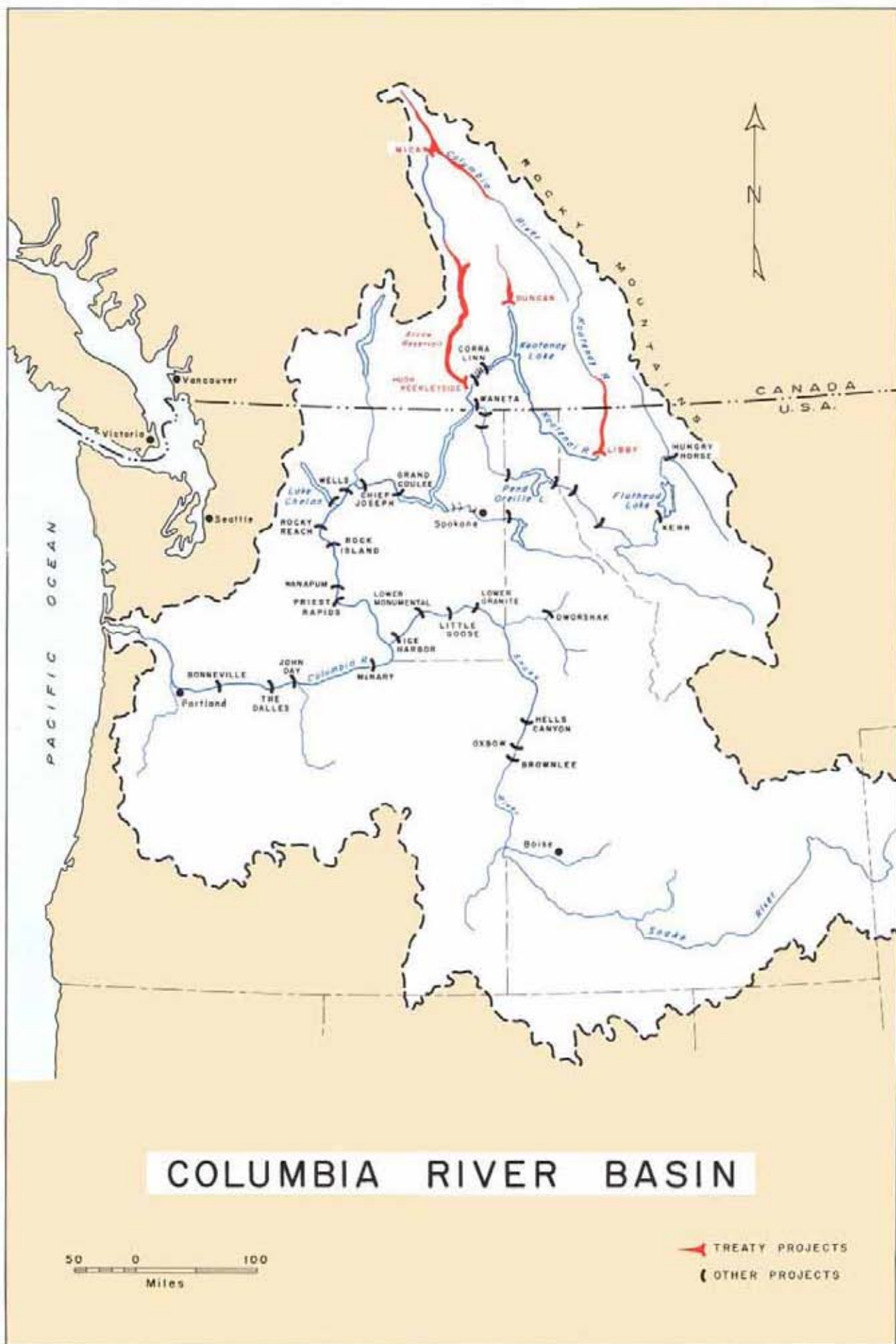
For Canada

Homer B. Willis, Chairman

G.M. MacNabb, Chairman

J. Emerson Harper

B.E. Marr



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

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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 1977 to 30 September 1978, 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 also 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.



MICA DAM
The earth dam with the spillway in use.

Columbia 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.

Features of the Treaty and Related Documents

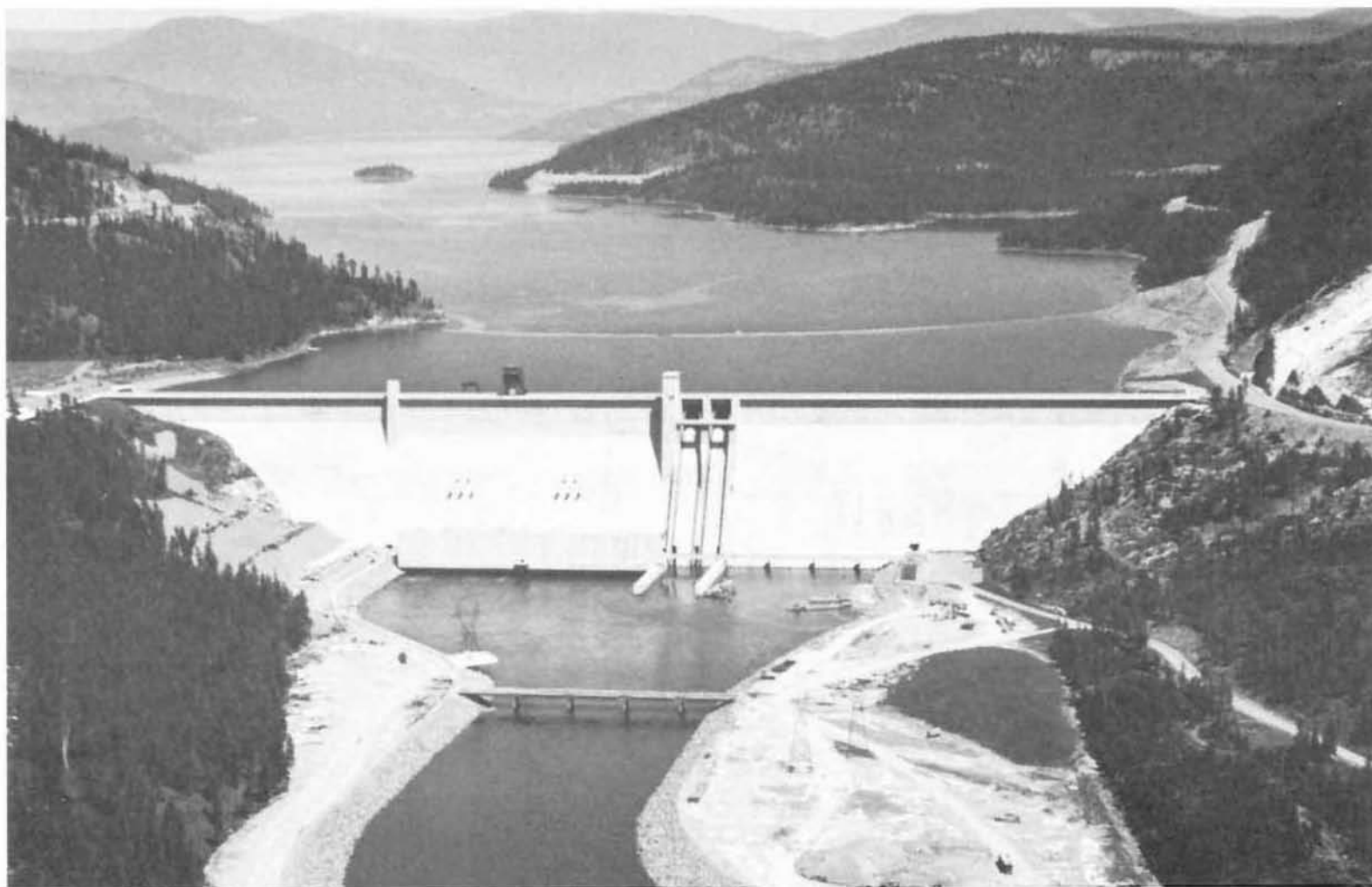
The essential undertakings of the Treaty are as follows:

- (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.
- (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
Overview of dam and Lake Kootenai. 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 composition of the Board.

The names of the current Board members, alternate members and secretaries are shown in Appendix A. It is noted that Mr. J. Emerson Harper was appointed a member of the Board effective August 1978. On 2 August 1978 Mr. Shapur A. Zanganeh replaced Mr. Walter W. Duncan as secretary of the United States Section of the Board.

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 hydrometeorological system as required by Annex A of the Treaty.

Rec'd 2-7-83



COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A · U N I T E D S T A T E S

CANADIAN SECTION

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

UNITED STATES SECTION

L.A. DUSCHA, Chairman
J.E. Harper, Member

Office of the Chief of Engineers
Department of the Army
ATTN: DAEN-CWE-HY
Casimir Pulaski Bldg., Room 6115
Washington, D.C. 20314

28 January 1983

Mr. Peter T. Johnson
Chairman, United States Entity
Columbia River Treaty
Bonneville Power Administration
U.S. Department of Energy
P.O. Box 3621
Portland, Oregon 97208

*Noted
Peter 2/9/83*

Dear Mr. Johnson:

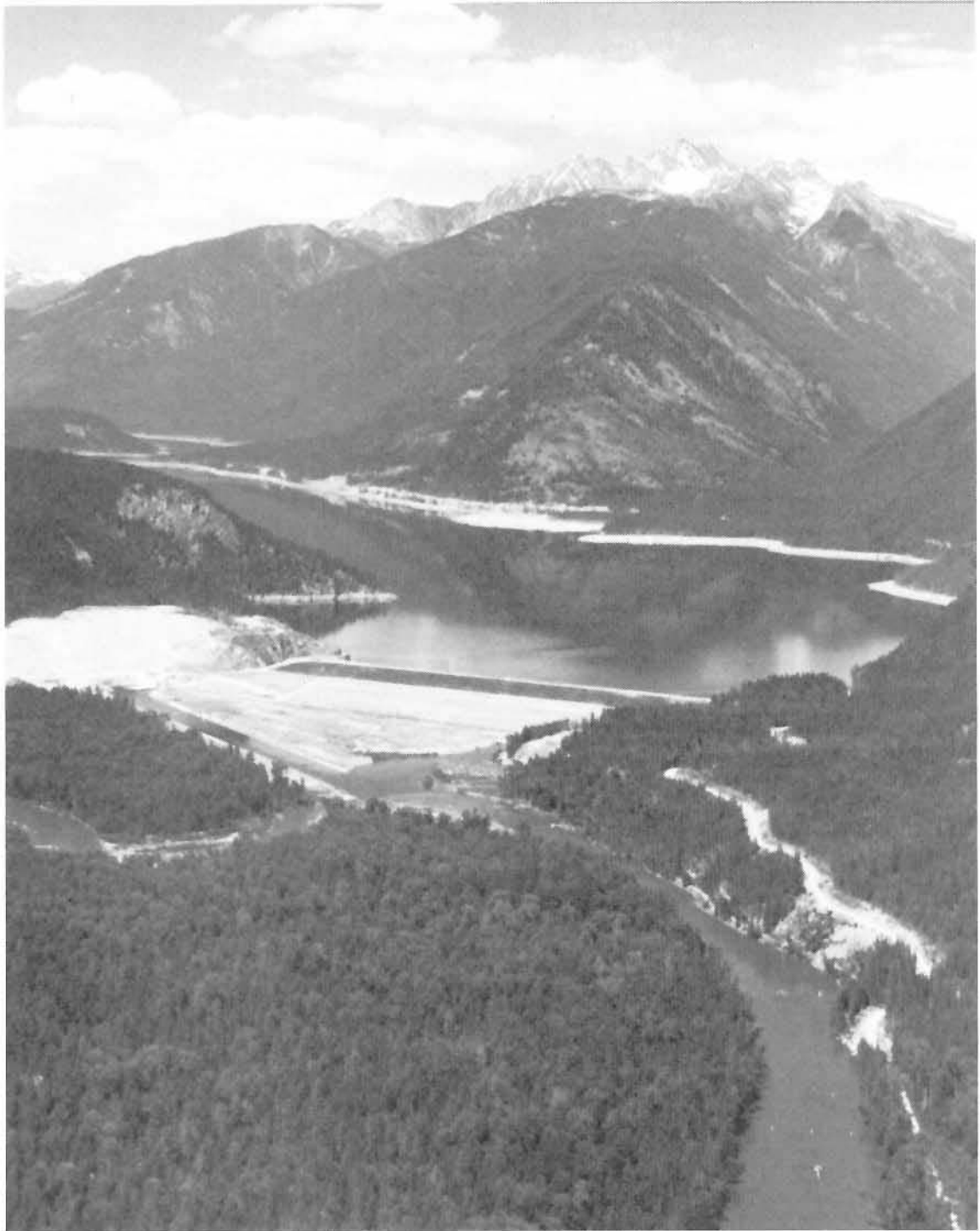
Inclosed are three copies of the Annual Report to the Governments of the United States and Canada, prepared by the Columbia River Treaty Permanent Engineering Board for your information and retention. This is the eighteenth annual report of the Board prepared in compliance with Article XV of the Columbia River Treaty of 17 January 1961. This Annual Report, which covers the period 1 October 1981 to 30 September 1982, describes the 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.

Sincerely yours,

S.A. Zanganeh

S. A. ZANGANEH
Secretary, U.S. Section

1 Incl (trip)
As stated



DUNCAN DAM

Duncan River, British Columbia

The earth dam and Duncan Lake. Discharge tunnels are to the left of the dam.

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 Mr. S. Sterling Munro has succeeded Mr. Donald P. Hodel as Chairman of the United States Entity and that Brigadier General Richard M. Wells has succeeded Major General Wesley E. Peel as Member of the United States Entity.

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.

LAKE KOOCANUSA,
one of several locations
where sloughing
is occurring



ACTIVITIES OF THE BOARD

Meetings

The first meeting of the Board during the report year was held in Toronto, Ontario on 14 November 1977 to review progress under the Treaty and to discuss preparation of the Board's Annual Report. The second meeting of the Board was held in Vicksburg, Mississippi on 21 March 1978. The Board met with the Entities on the same day to discuss Entity studies and general progress. The Board also toured some of the hydraulic models at the U.S. Corps of Engineers Waterways Experimental Station in Vicksburg on 22 March.

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 1976 to 30 September 1977
- Columbia River Treaty Hydroelectric Operating Plan — Assured Operating Plan for Operating Year 1982-83, plus a copy of the Entities' agreement on this document
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1977 through 31 July 1978, plus a copy of the Entities' agreement on this document

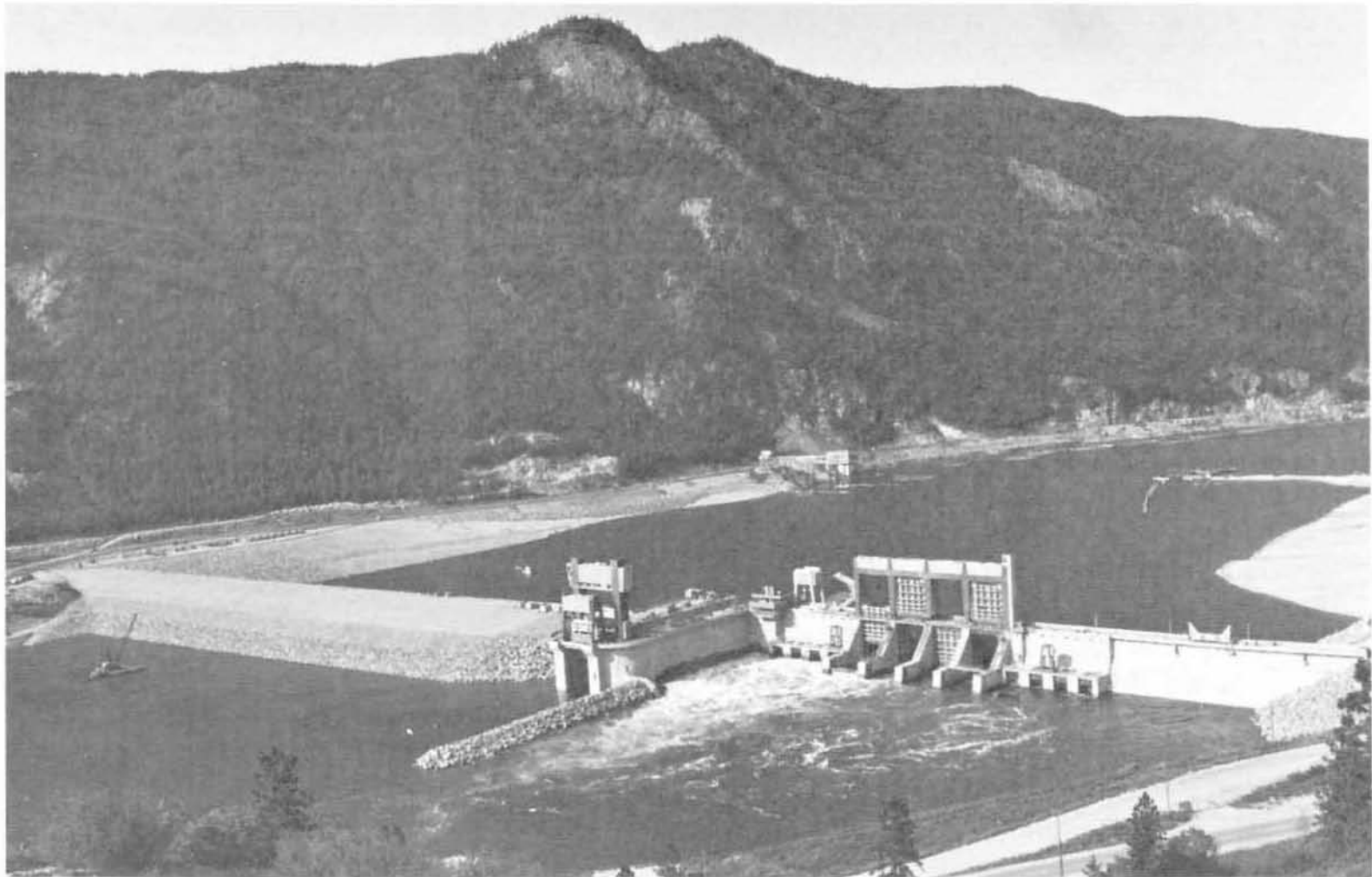
- Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1982-83, plus a copy of the Entities' agreement on this document
- The Canadian and United States Entities' Agreement to Enhance Filling of Mica Reservoir dated 2 May 1978, together with an associated agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration on the Mica Storage Arrangement.

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 1978 through 31 July 1979, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Hydroelectric Operating Plan — Assured Operating Plan for Operating Year 1983-84, plus a copy of the Entities' agreement on this document
- Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1983-84, plus a copy of the Entities' agreement on this document
- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1977 to 30 September 1978.

Report to Governments

The thirteenth Annual Report of the Board was submitted to the two governments on 31 December 1977.



HUGH KEENLEYSIDE DAM
Earth dam at the outlet of Arrow Lakes with navigation lock and discharge works.

Columbia River, British Columbia

PROGRESS

General

The results achieved under the terms of the Treaty include construction of the Treaty projects, progress in developing the hydrometeorological network, 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, are now in operation and supply power benefits 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. Completion of the Canal Plant on the Kootenay River in 1976 and installation of generators at Mica Dam during 1976 and 1977 have caused the power benefits in Canada to increase substantially. Completion of the Revelstoke project, now under construction, will result in a further substantial increase in power benefits in Canada. By 1985 some 4,000 megawatts of generation in Canada that would otherwise not have been installed will be benefiting from the operation of Treaty storage. This capacity will be installed at Mica and Revelstoke on the Columbia River and at the Canal Plant on the Kootenay River.

The Treaty provides Canada with the option of diverting the Kootenay River into the headwaters of the Columbia River commencing in 1984. British Columbia Hydro and Power Authority is currently studying both the engineering and environmental aspects of the potential diversion at Canal Flats.

The locations of the above projects are shown in 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 9.

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

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 has no associated power facilities.

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 15 and project data are shown in Table 2 of Appendix D.

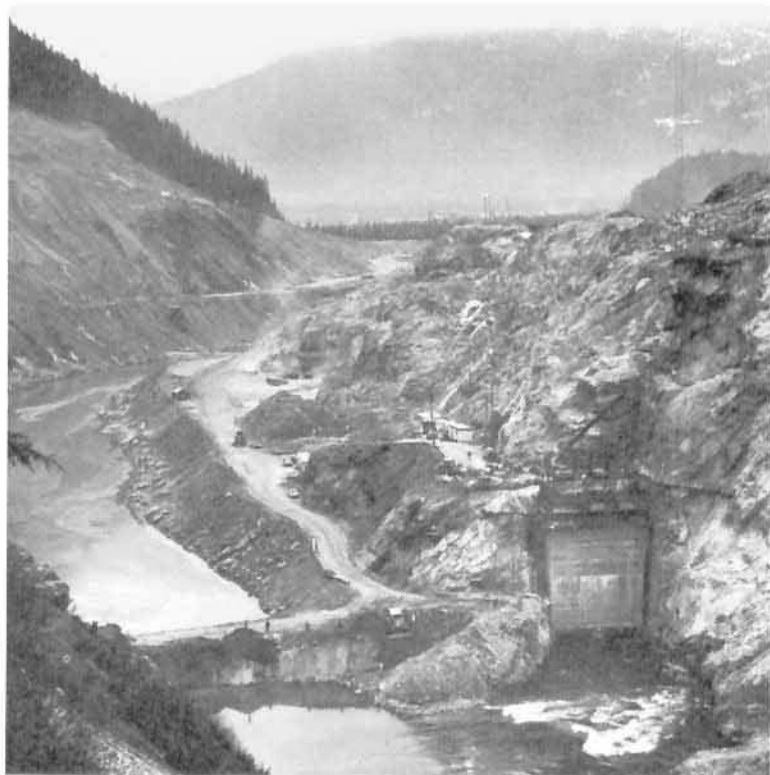
Mica Project

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, McNaughton 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 reservoir filled for the first time during the summer of 1976.

The underground powerhouse has space for a total of six 434 megawatt units with a total

DIVERSION ENTRANCE
and upstream cofferdam
at Revelstoke site.



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 dam is shown in the picture on page 2 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 river bed and creates Lake Koocanusa which is 90 miles long and extends 42 miles into Canada. Lake Koocanusa has a gross storage of 5,809,000 acre-feet, of which 4,934,000 acre-feet are usable for flood control and power purposes. The present installed capacity at the Libby powerhouse is 420 megawatts.

Construction work on the Libby project during the report year included repair on the stilling basin, construction of a fish hatchery, and modification of the David Thompson bridge near the Libby Dam. The stilling basin repair contract, underway since mid-1977, was completed in September 1978. The construction of the fish hatchery facility, located near Eureka, Montana, was begun in May 1978, and by the end of September was about 26% completed. Replacement of the wood deck with a concrete deck and sidewalks on the David Thompson bridge downstream of the dam was initiated in December 1977 and is scheduled for completion in December 1978.

Construction of the Libby Additional Units and Re-regulating Dam project was initiated during the report year. A contract for the manufacture and installation of the turbines for the

four additional units in the main dam was begun in January 1978, and by September was about 16% completed. Work on the haul bridge for the re-regulation dam progressed during the year, and by September was about 73% completed.

Further construction activity on the re-regulating dam is uncertain at this time pending resolution of a preliminary injunction issued on 8 September 1978 by the United States District Court in Butte, Montana. The injunction was in response to complaint by three plaintiffs seeking to halt construction of the project. The basic issues centred on alleged lack of congressional authorization for the project, inadequacies in the project environmental impact statement, violation of coordination requirements of the Endangered Species Act, and other laws relating to project justification, environment and cultural resources. The injunction ordered a halt to further construction of the project, except those items necessary for complying with legal requirements and enhancement of the environment. At a hearing before the Ninth Circuit Court of Appeals on 2 November 1978 the United States Corps of Engineers was allowed to continue work on the main Libby Dam project including additional power units, but the preliminary injunction on the re-regulating dam was left in effect. Further construction activity, at this time, on the re-regulating dam is pending legal resolution of this matter.

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

Libby Project in Canada

While Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada, certain activities are being conducted by Provincial Government agencies in the environs of the pondage. Coordinated by the Ministry of the Environment, parks facilities are being enhanced and potential sites studied for future develop-

ments; fishery and wildlife studies are also being continued. Kikomun Creek bridge across the reservoir is currently being upgraded by installation of permanent steel decking. Observations are continuing on slope stability of the reservoir perimeter in certain areas. Sloughing in silts and sands typical of the area is demonstrated by the photograph on page 12.

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.

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. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on establishing the Treaty Hydrometeorological System.

During the previous report year the Entities, with the concurrence of the Board, adopted a revised plan for exchange of operational hydrometeorological data. This plan is still in force. Progress is being made in automating the collection and processing of hydrometeorological data in the Columbia River system.

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 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 assured operating plan for operating year 1982-83, received by the Board early in the report year, includes generation at the Mica project and is based on the operation of the system for optimum generation in both countries. The Board has reviewed this plan and concludes that it is consistent with the terms of the Treaty and does not depart substantially from previous plans. The assured operating plan for 1983-84 was provided to the Board after the end of the report year.

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 1978. A detailed operating plan for the operating year ending 31 July 1979 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.

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 1982-83. 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 1983-84 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.

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. Actual recorded flows for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia, Plate 1, are tabulated in Appendix C for this report year.

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 1977 through 31 July 1978
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1978 through 31 July 1979
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1977-78
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1978-79.

In addition, three special agreements were in effect in this period. The 1977 Emergency Draft Arrangement for Canadian Storage and the 1977 agreement for improvement of low water levels in Arrow reservoir both terminated when return of energy and restoration of storage under these agreements were completed early in 1978. A new Agreement to Enhance Filling of

Mica Reservoir was signed by the Entities in May and will be in effect until the end of the 1978-79 operating year.

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. After the drought year in 1977 only the Duncan reservoir was full. The other three did not fill after the freshet nor did most other reservoirs in the Columbia River basin. The total storage deficiency in the system of 12.7 million acre-feet carried through November but storage conditions returned to normal when heavy rains occurred in late November and December. The 1978 freshet was about average and operation during the flood control period was uneventful. All reservoirs filled after the 1978 freshet.

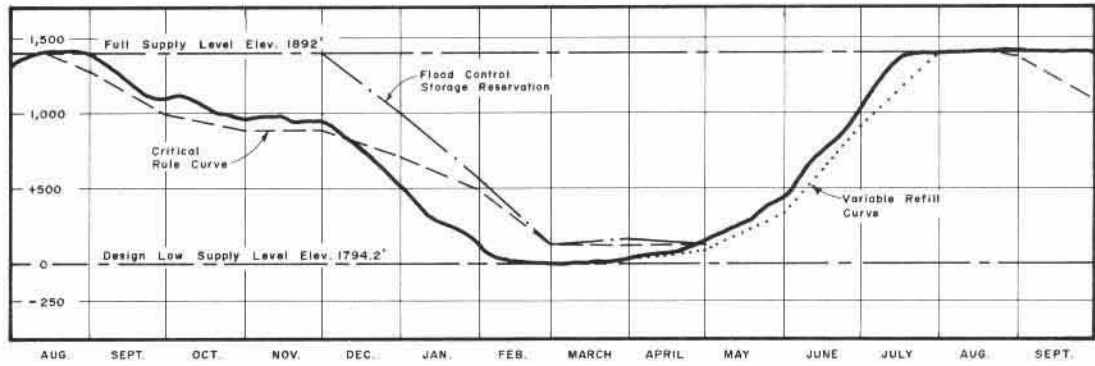
With a storage deficit carried over from the previous year, discharge requirements as specified in the 1977-78 Detailed Operating Plan, and a slightly below average inflow forecast for the 1978 freshet, the probability of refilling the Mica reservoir was substantially less than the probability of refilling other reservoirs in the system. In May 1978 the Entities, recognizing potential mutual benefits, concluded an Agreement to Enhance Filling of Mica Reservoir. This agreement provides that either Bonneville Power Administration or British Columbia Hydro and Power Authority may store extra water in the Mica reservoir by delivering energy to the other party in lieu of the equivalent Mica release. Implementation of this agreement ensured that the Mica reservoir was virtually full by mid-August. The remainder of the season was such that the extra water was released and equivalent energy was returned before the end of the report year. The present agreement remains valid for the 1978-79 operating year.

Operation of the reservoirs is illustrated on pages 27 and 28 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.

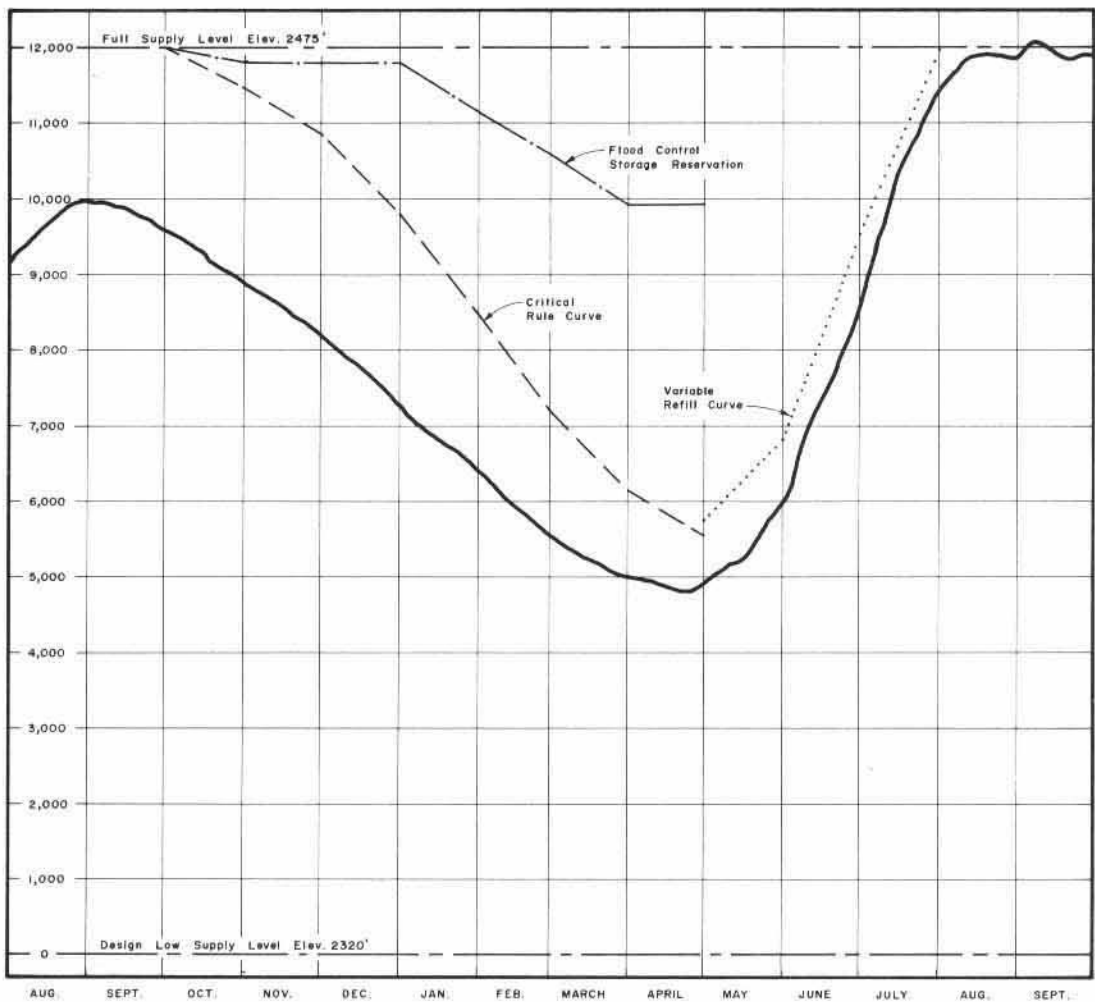
At the beginning of the report year the Duncan reservoir was at elevation 1875.3 feet. Drafting of storage had begun on 2 September 1977 and continued throughout the season at rates up to 10,000 cfs. Storage releases from the Duncan reservoir were coordinated with releases from the Libby project and from Kootenay Lake to comply with the International Joint Commission's Control Order for Kootenay Lake levels and to make best use of generating capacity at the Brilliant power plant near the mouth of the Kootenay River. On the basis of a favourable inflow forecast all Treaty storage in the Duncan reservoir was drafted and minimum pool elevation 1794.2 feet occurred on 20 February 1978. Between 13 March and 27 April the outflow was maintained at 200 cfs for fish trapping by the British Columbia Fish and Wildlife Branch and was subsequently reduced to 100 cfs until the reservoir filled. Full pool elevation 1892.0 feet was reached on 23 July.

The Arrow reservoir was at elevation 1397.3 feet, essentially empty, at the beginning of the report year. Winter rains caused a small rise to about 1405 feet and this storage was later drafted. The minimum level for the year was 1392.7 feet on 26 March 1978. Discharges during the refill period were adjusted to meet needs at the Grand Coulee reservoir and all Treaty

USABLE RESERVOIR STORAGE IN 1000 ACRE FEET

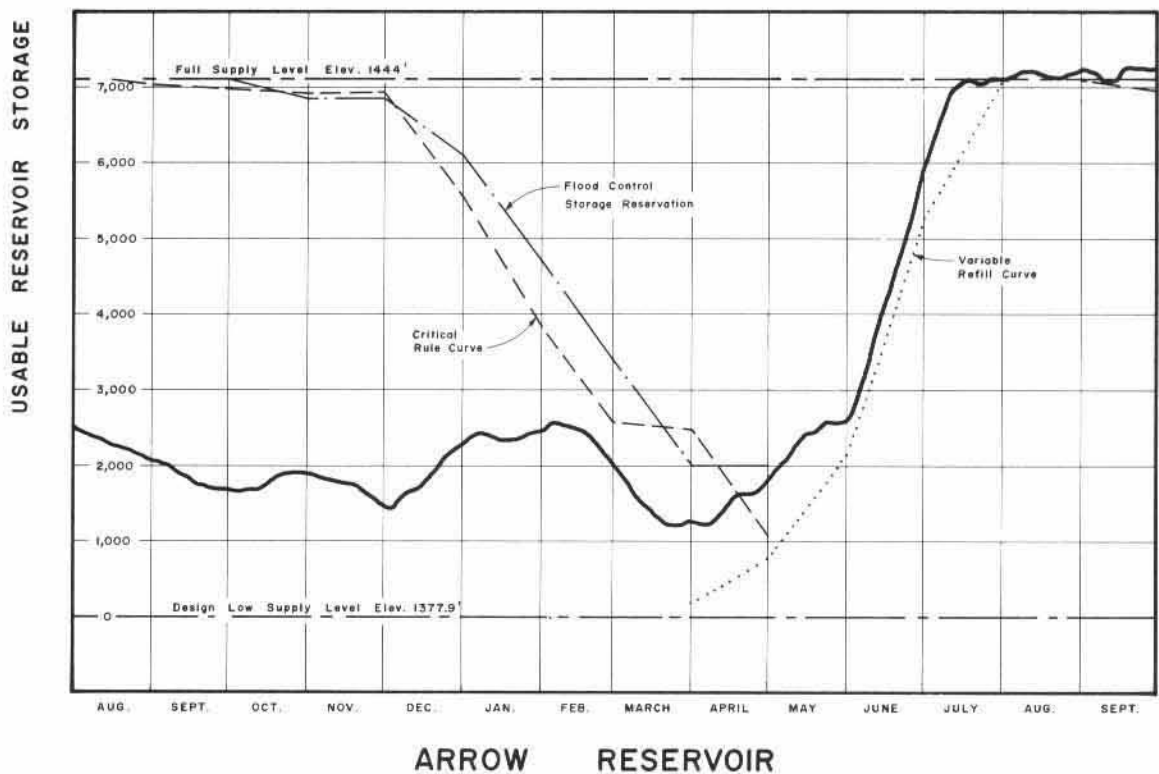
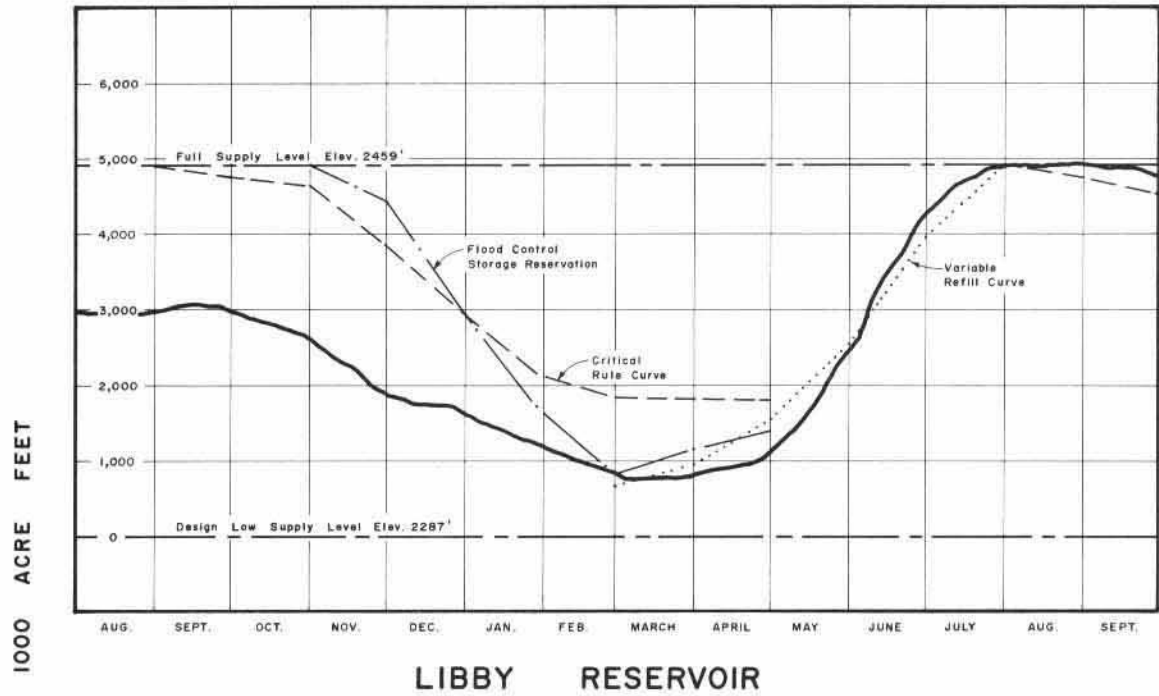


DUNCAN RESERVOIR



MICA RESERVOIR

HYDROGRAPHS—Duncan and Mica reservoir levels for the 14-month period ending 30 September 1978.



HYDROGRAPHS—Libby and Arrow reservoir levels for the 14-month period ending 30 September 1978.

storage space in this reservoir was filled by 14 July. Heavy rain in early September brought surplus water to the system and on 30 September 1978 the Arrow reservoir was at elevation 1445.3 feet, 1.3 feet above the required level for Treaty storage.

In accordance with the 1977 agreement for improvement of low water levels in the Arrow reservoir, energy delivered to the United States during the summer of 1977 in lieu of requested storage drafts was returned during November and December. By 6 January 1978 this special agreement was terminated.

The storage deficit of about 900,000 acre-feet in the Mica reservoir resulting from the Emergency Draft Arrangement of 1977 was transferred to the Arrow reservoir between 1 January and 18 February 1978. This storage deficit was deemed fully restored and the arrangement terminated when the Arrow reservoir reached its specified flood control evacuation elevation on 15 April 1978.

McNaughton Lake was at elevation 2451.6 feet at the beginning of this report year, about 23 feet below full pool elevation. The transfer of the storage deficit noted above to Arrow reservoir early in 1978 ended the head loss for which the United States had been providing compensatory energy. Minimum reservoir level was 2398.0 feet on 26 April 1978. Under the Agreement to Enhance Filling of Mica Reservoir discharges were reduced from scheduled levels during the period 27 April to 14 July and the Canadian system was compensated by energy deliveries from the United States. This operation increased the rate of filling the reservoir. Operation was modified during the period 9 to 23 June when Mica discharges were manipulated to expedite moving log bundles down the river to Arrow Lakes. By 19 August the reservoir was essentially full although full pool elevation 2475.0 feet was not reached until 4 September. Heavy rains early in September caused a temporary surcharge on the reservoir which peaked on 8 September at elevation 2475.7 feet. At the end of the report year McNaughton Lake was at elevation 2473.9 feet.

Water supply conditions toward the end of the year were favourable and the extra energy which had been delivered under the Agreement to Enhance Filling of Mica Reservoir was returned to the United States before the end of the report year.

On 30 September 1977 Lake Koocanusa, at elevation 2411.0 feet, was 48 feet below full pool elevation. During the fall discharges were regulated to accommodate preliminary work for the stilling basin repairs which were carried out in the period December through May. Storage was drafted for power in accordance with rule curves and the lowest lake level was 2329.6 feet on 20 March 1978. Outflows were held near minimum during the freshet to improve the probability of refill and by 30 July the reservoir was virtually full. Drafting commenced late in September and at the end of the report year the level was at elevation 2455.4 feet.

POWERHOUSE
at Libby Dam.
Construction has begun
on units 5 and 6.



Flood Control Operation

Operation for flood control during the 1978 freshet was in accordance with the Entities' document "Columbia River Treaty Flood Control Operating Plan" and required storage space was provided in all reservoirs prior to the freshet. The freshet was controlled to well below damaging levels by regulating discharges for the best probability of refilling reservoirs.

BENEFITS

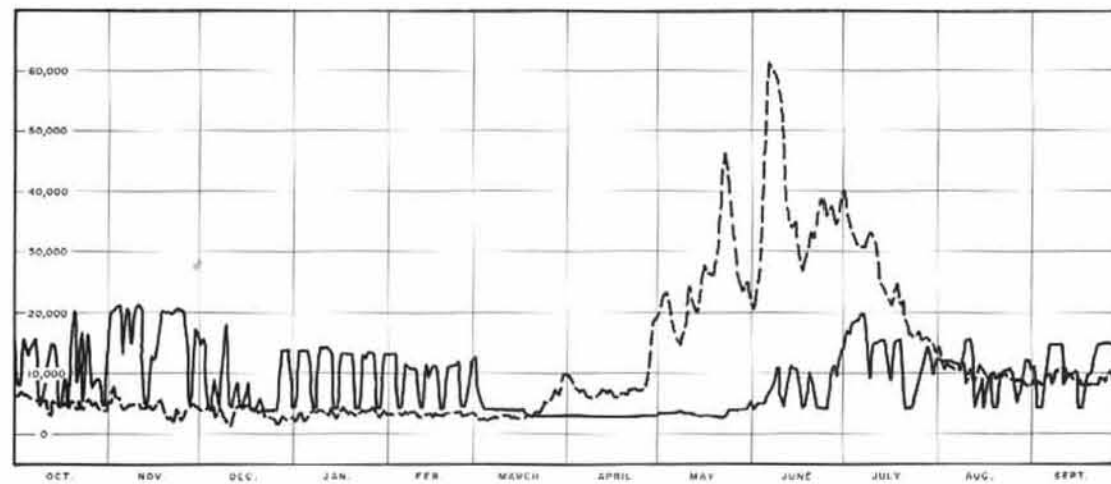
Flood Control Provided

Without regulation by upstream reservoirs the 1978 freshet would have produced a normal peak discharge at The Dalles, Oregon, and would have caused little flood damage. In Canada, even without the four storage projects constructed as a result of the Treaty, the peak discharge of the Columbia River at Trail would not have reached damaging levels.

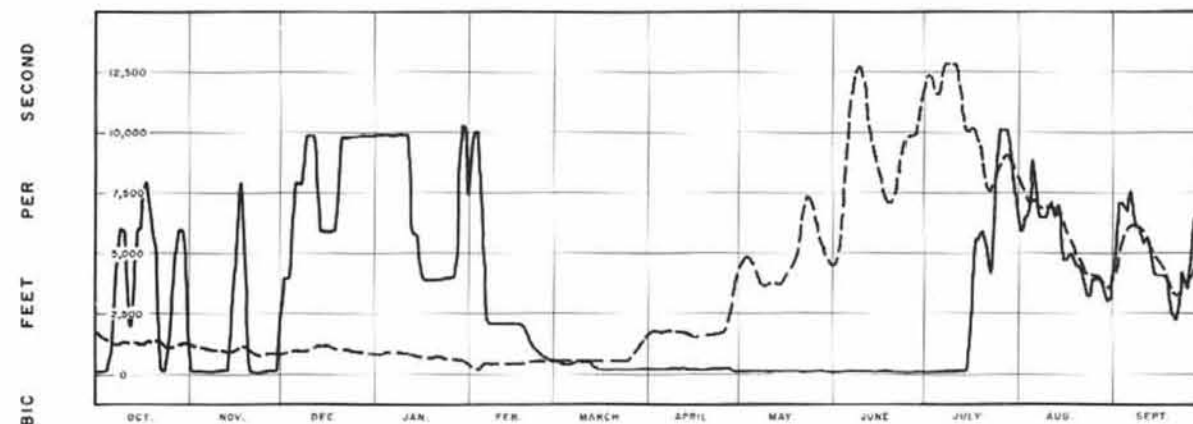
It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by almost six feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about eleven feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 33 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 573,000 cfs to 314,000 cfs. Regulation by the Treaty storage projects during the 1978 freshet period contributed only minor flood control benefits in Canada and the United States.

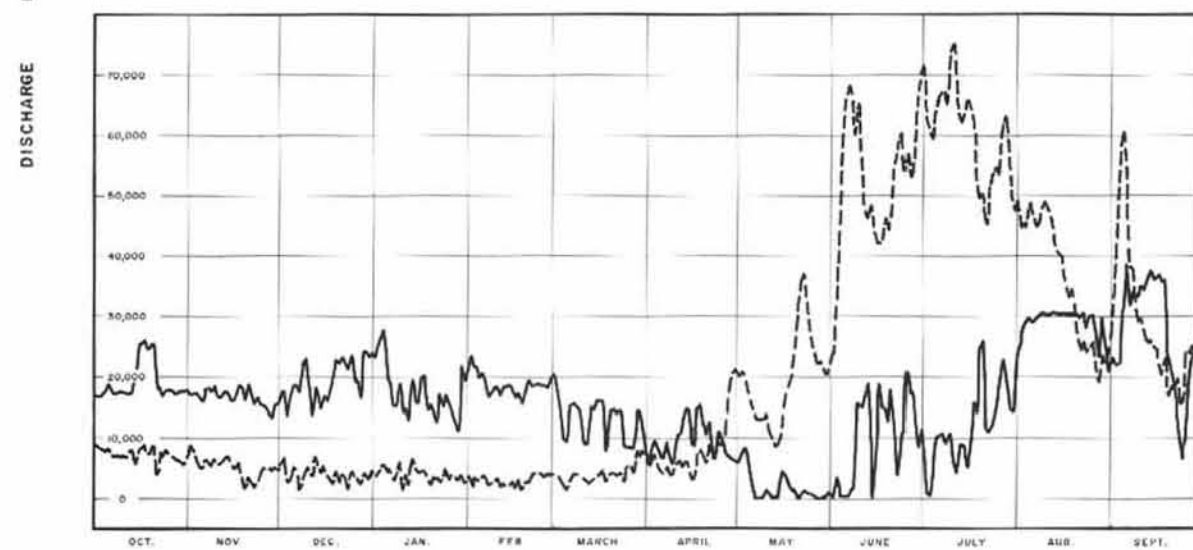
All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage projects have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.



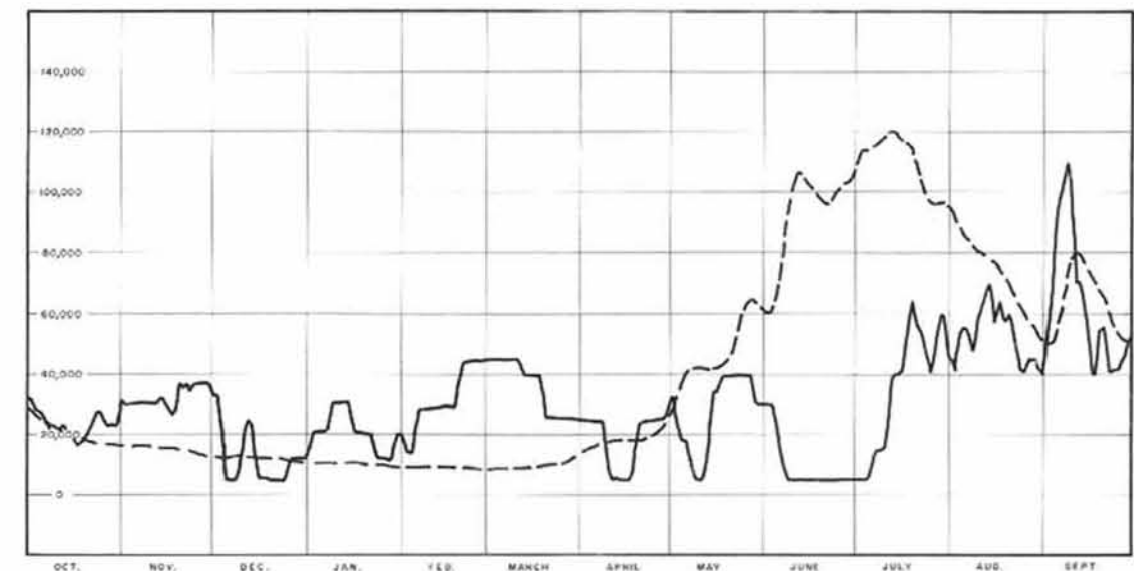
KOOTENAI RIVER AT LIBBY DAM



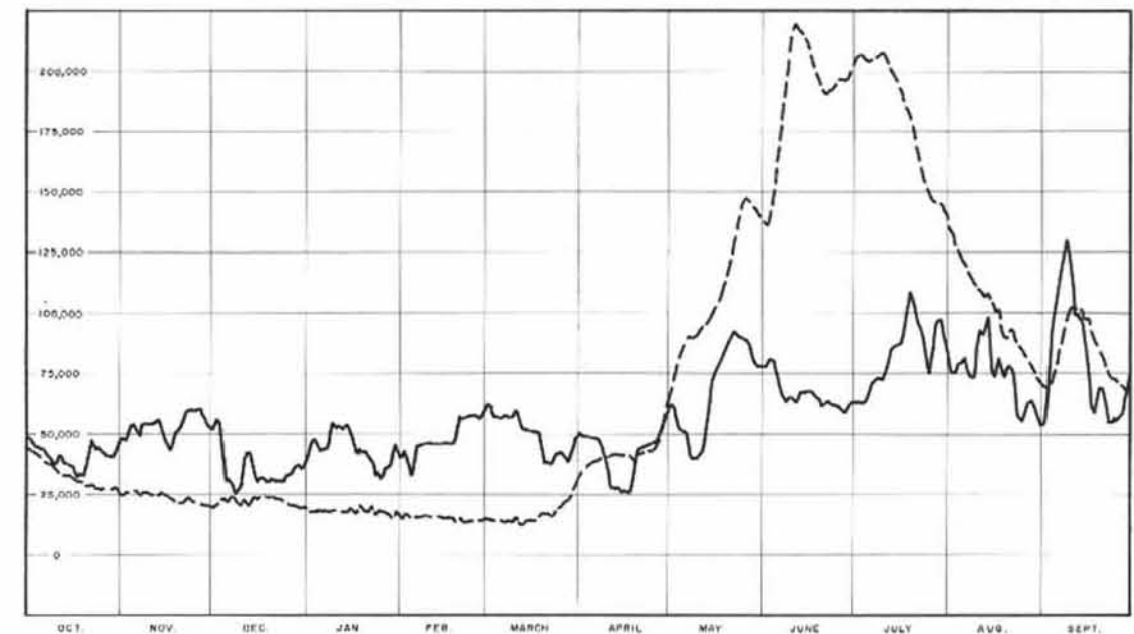
DUNCAN RIVER AT DUNCAN DAM



COLUMBIA RIVER AT MICA DAM



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 1978.

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 for a 30-year period. No additional downstream power benefits were realized during the year from the operation of Treaty dams 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.

TRANSMISSION LINE
under construction
for Mica project.



Other Benefits

Benefits from the two special agreements that were specific to the drought conditions during the 1976-77 operating year but extended into the current report year have been described in the previous report. These benefits consisted of extra energy generated in the United States system early in 1977 and improvement to the low levels of Arrow reservoir during the summer of that same year. In this report year only compensatory measures were completed and no further benefits accrued under these agreements. The new Agreement to Enhance Filling of Mica Reservoir provided greater assurance that the reservoir would refill completely in spite of an initial storage deficit and a forecasted water supply that appeared marginal. These agreements all supplement Treaty operating plans and have not created conflicts with operations under those plans. The effects have been beneficial in both countries in accordance with the intent of the Treaty.

CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty, the detailed operating plans developed by the Entities, and the flood control operating plan for Treaty reservoirs. Special operating agreements improved system operation and were consistent with the intent of the Treaty.
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. Regulation by the Treaty storage projects during the 1978 freshet period contributed only minor flood control benefits in Canada and the United States because of average runoff conditions.
4. Finally, the Board concludes that the objectives of the Treaty are being met.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARDUnited StatesCanadaMembers

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Chief, Engineering Division,
Civil Works Directorate,
Office, Chief of Engineers,
U.S. Army,
Washington, D.C.

Mr. G.M. MacNabb, Chairman
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Natural Sciences & Engineering
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Deputy Minister,
Ministry of the Environment,
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Mr. E.M. Clark
Regional Director,
Pacific and Yukon Region,
Inland Waters Directorate,
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Vancouver, B.C.

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Division,
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Victoria, B.C.

Secretaries

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Hydrologic Engineering Section,
Engineering Division,
Civil Works Directorate,
Office, Chief of Engineers,
U.S. Army,
Washington, D.C.

Mr. E.M. Clark
Regional Director,
Pacific and Yukon Region,
Inland Waters Directorate,
Department of the Environment,
Vancouver, B.C.

1) As of August 1978.

2) Vice Mr. Walter W. Duncan as of 2 August 1978.

COLUMBIA RIVER TREATY ENTITIES

United States

Canada

Mr. S. Sterling Munro, Chairman 1)

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

Mr. R.W. Bonner, Chairman

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

Brigadier General Richard M. Wells 2)

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

- 1) Vice Mr. Donald P. Hodel as of January 1978.
- 2) Vice Major General Wesley E. Peel as of June 1978.

RECORD OF FLOWS
AT THE
INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	49,000	48,500	51,400	39,700	40,000	62,600	50,300	62,900	78,200	63,300	75,500	54,500
2	46,600	47,500	56,300	45,800	43,400	61,000	48,900	60,900	78,200	63,400	75,200	62,300
3	44,300	49,500	53,200	47,700	34,100	57,000	48,900	55,100	81,300	62,800	75,100	81,200
4	44,300	53,600	38,600	45,800	32,300	56,600	48,900	51,900	80,300	62,900	79,200	98,900
5	43,900	54,500	30,700	42,800	36,900	56,500	48,600	51,500	73,800	64,500	79,400	110,000
6	42,600	50,800	31,000	43,400	44,900	57,200	48,400	51,400	68,400	70,200	81,600	117,000
7	41,400	49,000	29,600	44,000	45,500	57,400	47,900	46,000	66,500	72,800	75,500	122,000
8	39,100	54,300	24,800	47,700	45,800	56,600	47,300	39,500	63,100	73,100	72,700	131,000
9	38,100	54,600	26,900	54,800	46,100	56,500	42,000	39,800	64,100	73,700	74,100	124,000
10	36,800	54,500	30,600	52,400	46,000	57,800	31,200	40,000	66,100	72,400	82,900	109,000
11	38,700	54,500	40,000	53,200	45,800	60,100	27,400	42,100	63,900	75,400	93,400	99,100
12	41,100	54,700	41,900	52,400	45,800	53,800	27,900	43,200	63,700	83,500	90,400	99,100
13	37,200	56,200	42,000	52,400	45,900	51,500	27,700	51,300	67,200	86,200	95,100	97,300
14	37,200	50,300	37,800	53,600	45,800	51,200	27,800	63,800	67,200	87,100	98,700	90,300
15	36,900	47,400	30,100	49,000	45,800	51,400	26,600	74,200	67,600	87,500	75,400	81,800
16	35,500	46,300	31,600	43,100	46,000	51,000	26,400	76,600	68,100	87,600	73,100	63,800
17	31,700	43,500	32,200	41,700	45,800	51,100	26,100	79,500	66,400	90,000	81,800	57,800
18	33,100	44,900	31,200	43,500	45,500	51,000	26,600	82,800	65,200	103,000	78,300	64,900
19	33,300	50,600	30,600	42,000	50,800	44,300	35,500	85,700	64,300	109,000	74,100	69,200
20	33,500	51,900	30,900	43,100	56,900	37,300	43,700	87,700	61,300	104,000	78,200	69,100
21	40,200	54,300	30,300	40,800	56,600	38,000	44,600	90,400	63,100	96,500	78,600	64,900
22	47,200	59,400	30,200	39,400	56,800	37,700	44,500	92,700	63,500	93,900	75,700	54,300
23	43,800	59,900	30,200	32,000	56,900	38,000	45,300	90,900	62,300	90,800	60,800	54,800
24	44,300	60,100	30,000	34,500	57,400	42,000	45,600	90,100	62,300	83,100	56,100	56,000
25	44,000	59,800	32,700	31,800	57,600	42,100	45,700	89,600	62,100	74,000	55,700	55,700
26	42,600	60,000	33,300	32,800	56,800	42,300	46,800	89,100	61,000	79,600	60,300	57,400
27	40,700	60,200	33,600	36,300	57,000	40,000	48,000	87,800	59,200	88,000	63,800	59,700
28	40,700	58,300	36,400	36,200	58,400	38,200	51,800	82,100	59,800	96,900	64,300	67,200
29	40,600	53,600	37,200	42,500		41,500	55,100	78,600	61,900	98,100	60,900	80,800
30	42,000	52,500	35,600	45,800		48,000	59,100	78,100	63,600	91,400	56,700	83,000
31	45,700		36,900	41,000		48,700		77,700		82,000	53,500	
Mean	40,500	53,200	35,100	43,600	48,100	49,600	41,500	68,800	66,500	82,800	74,100	81,200

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1978 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	16,400	19,000	17,100	2,920	13,400	13,300	19,200	18,700	17,500	19,300	12,800	11,900
2	8,100	20,800	17,300	4,310	13,600	13,600	16,400	20,100	17,200	19,400	12,800	10,900
3	8,820	21,900	12,300	16,700	13,800	7,400	14,300	21,400	19,900	21,100	12,600	5,750
4	19,000	22,000	6,990	17,000	13,300	6,280	12,800	20,500	22,200	21,800	12,400	5,360
5	10,500	20,600	7,230	14,400	4,710	5,050	11,700	18,600	24,100	21,900	12,400	5,560
6	12,900	15,100	10,800	14,400	5,190	4,890	11,000	16,600	24,800	21,800	12,400	12,800
7	15,500	21,400	8,060	10,400	12,200	4,830	10,300	15,400	26,400	23,000	12,400	14,700
8	15,000	19,700	5,620	4,160	11,500	4,840	9,600	15,000	24,900	20,000	12,100	15,000
9	8,210	15,500	16,400	5,690	11,600	5,060	9,230	15,900	26,400	18,800	11,600	15,200
10	5,080	20,900	15,200	14,200	11,800	4,960	8,940	20,700	25,200	13,600	15,500	15,100
11	8,720	20,900	5,570	14,200	11,200	4,620	9,320	22,800	18,900	16,800	15,900	13,300
12	11,100	16,300	7,370	14,300	4,870	4,590	9,750	21,300	15,200	18,000	15,900	9,920
13	15,000	4,780	9,710	14,200	5,260	4,620	9,550	19,200	18,400	17,800	11,100	10,500
14	15,000	7,090	10,800	13,000	11,600	4,340	9,330	20,500	20,800	17,500	6,120	10,600
15	13,400	12,600	7,500	4,170	9,950	4,270	9,000	26,300	20,300	17,000	7,610	10,800
16	4,780	12,800	7,990	5,430	11,800	4,330	8,940	29,300	19,500	14,400	9,880	10,000
17	6,090	12,700	11,400	13,700	11,600	4,200	8,850	27,300	16,400	11,100	5,940	5,820
18	10,000	19,600	6,690	13,700	9,840	4,220	8,780	25,800	12,800	17,300	10,200	5,580
19	6,020	20,000	6,180	13,700	4,880	3,490	8,650	25,100	12,800	17,600	10,400	8,990
20	19,000	19,500	5,870	13,900	5,240	3,930	9,070	25,500	17,200	17,100	5,700	10,200
21	18,300	20,000	7,620	13,300	11,800	4,380	9,680	26,800	15,400	10,300	5,560	10,500
22	6,500	19,900	5,420	4,300	11,900	4,930	9,810	28,200	12,000	6,720	10,300	13,900
23	15,200	20,100	5,920	5,380	12,100	5,460	9,500	25,800	11,400	6,610	11,200	15,000
24	6,110	20,200	5,090	13,300	12,400	7,140	9,110	22,800	10,700	5,940	11,100	15,100
25	16,000	20,200	4,960	12,800	12,700	9,130	9,020	21,300	10,100	7,510	11,900	15,000
26	10,600	20,900	4,880	13,700	5,270	9,570	9,640	19,300	10,100	9,110	9,340	15,000
27	7,840	13,400	5,480	13,700	5,560	10,500	12,000	17,800	15,700	11,500	8,460	14,900
28	9,310	5,300	14,100	13,300	13,000	11,700	15,700	17,600	15,400	14,200	6,280	14,900
29	9,100	18,900	14,400	4,740		13,400	17,900	18,200	15,100	14,000	9,370	14,800
30	4,840	16,100	14,700	5,520		14,800	18,500	17,600	17,600	13,600	11,900	14,900
31	5,760		13,600	13,200		18,700		17,000		10,900	12,000	
Mean	10,900	17,300	9,430	10,900	10,100	7,180	11,200	21,200	17,800	15,300	10,800	11,700

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1978 in cubic feet per second.

PROJECT INFORMATION

Power and Storage Projects,
Northern Columbia Basin

Plate No. 1

Project Characteristic Data

Duncan Project

Table No. 1

Arrow Project

Table No. 2

Mica Project

Table No. 3

Libby Project

Table No. 4

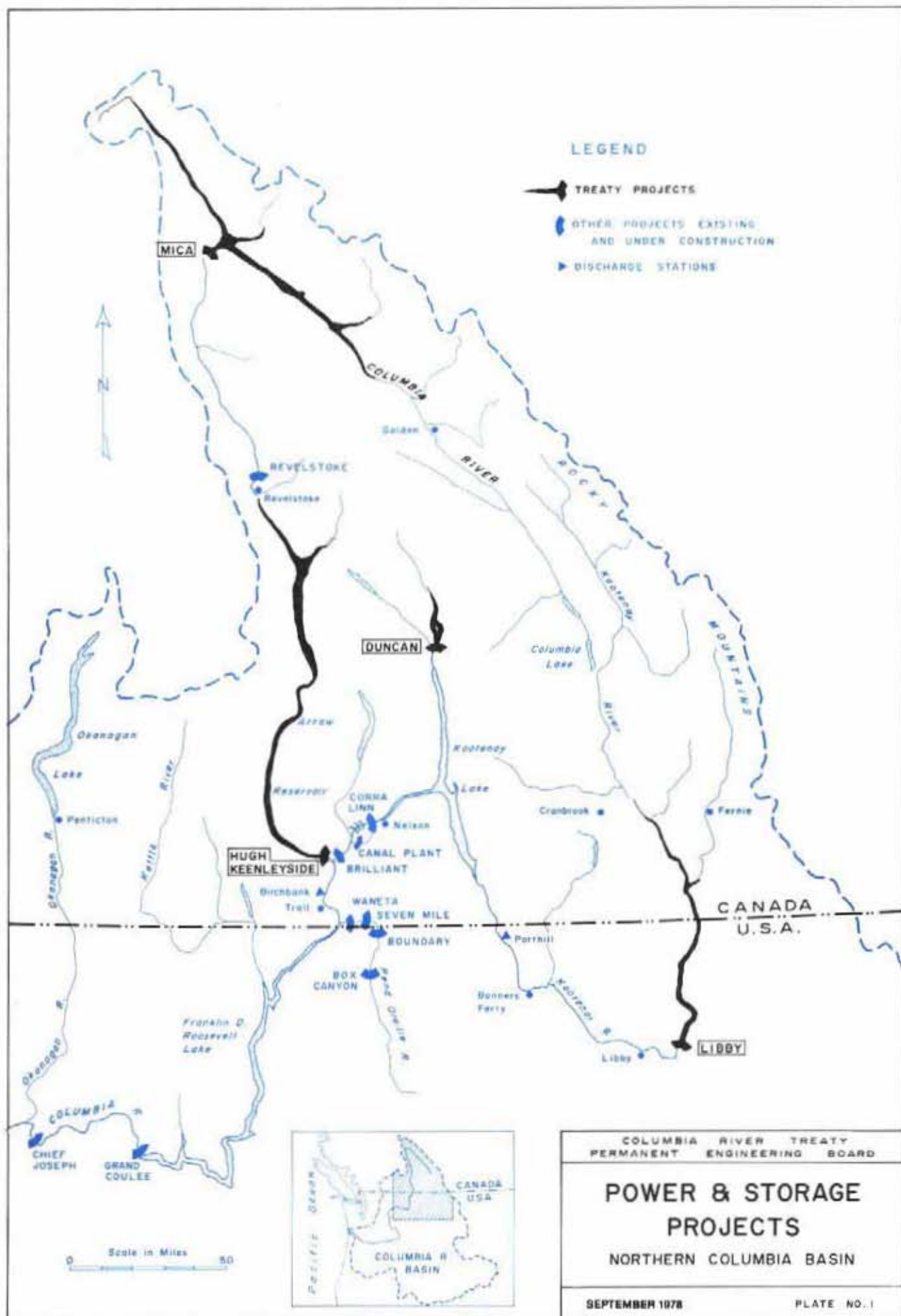


TABLE 1

DUNCAN PROJECTDuncan 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 PROJECTHugh 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 3MICA PROJECTMica Dam and McNaughton 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 PROJECTLibby Dam and Lake Koocanusa

Storage Project

Construction began	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	5,809,000 ac-ft
Usable Storage Capacity	4,934,000 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