

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C.

Ottawa, Ontario

30 SEPTEMBER 1986



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, Chief of Engineers
ATTN: DAEN-ECZ-B
Washington, D.C. 20314

19 February 1987

OFFICIAL FILE COPY

No. Date
MAR 09 1987

Referred To:

3-9-4

Action Taken

☐ ANS. ☐ NO REPLY

By Date

Due Date: 3-23

Mr. James J. Jura
Chairman, United States Entity
Columbia River Treaty
Bonneville Power Administration
Department of Energy
P. O. Box 3621
Portland, Oregon 97208

Dear Mr. Jura:

At the meeting of the Permanent Engineering Board with the Canadian and United States Entities in Vancouver, B.C., on 5 December 1987, it was agreed that the Board would be provided with a technical briefing by the entity staff on the Operating Committee's "Report on Proposed Changes to Assured Operating Plan and Determination of Downstream Power Benefit Studies." This briefing should facilitate subsequent discussions of the Board with the Entities.

The Board wishes to meet with appropriate staff members from the United States and Canadian Entities in Vancouver, B.C., on 1 May 1987 at 8:30 a.m. in the B.C. Hydro and Power Authority's Board Room. An agenda for the meeting is attached.

A similar letter is being sent by the Canadian Section of the Board to the Canadian Entity.

Sincerely,

Lloyd A. Duscha
Chairman, U.S. Section

Assign: Sienkiewicz/Lamb/Montfort/Hyde
cc: JJJ, RER, SGH, JSR, Tupper, Spigal

sjs

DRAFT
Feb. 16/87

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

AGENDA

Technical Briefing by
United States and Canadian Entity Staff

1 May 1987, 08:30 a.m.

British Columbia Hydro and Power Authority
21st Flood Board Room
970 Burrard Street
Vancouver, B.C.

- 1) Review of White Book Studies and Early and Current AOP's
 - irrigation depletions
 - project flow constraints
 - shifting and shaping
- 2) Review of Operating Committee Report, 20 June 1986
 - a) Overview
 - need for studies
 - procedures
 - limitations of results
 - b) Firm Energy Shaping
 - concept
 - effect on system operation
 - study results
 - c) Firm Energy Shifting
 - concept
 - effect on system operation
 - study results
 - d) Water Budget Minimum Flows
 - basic requirements
 - effect on system operation
 - study results

- e) Updated Streamflows
 - basic flows
 - updated flows-as used in Step 1 studies
 - factors affecting updated flows
 - correction of errors
 - data gaps
 - irrigation depletions
 - pumping requirements
 - relation to White Book studies
 - study results
 - f) Realistic AOP
 - effects of combining separate items
 - study results
- 3) Capacity Credit Limitations
- status
 - review of technical aspects

United States Entity

Columbia River Treaty

P.O. Box 3621, Portland, Oregon 97208

Chairman:
Administrator
Bonneville Power Administration
Department of Energy

In reply refer to: PRCB

March 12, 1987

Member:
Division Engineer
North Pacific Division
Corps of Engineers
Department of the Army

MEMORANDUM

TO: Addressees

FROM: John M. Hyde, Secretary *John M. Hyde*
United States Entity

SUBJECT: Summary of 5 December 1986 Meeting Between Columbia River Treaty
Permanent Engineering Board (PEB) and U.S. and Canadian Entities

Attached is a copy of the Summary of Twenty-Fifth Meeting, Permanent Engineering Board and United States and Canadian Entities describing the meeting held December 5, 1986, in Vancouver, B.C. This summary is prepared by the PEB without our input.

The summary is consistent with my notes of the meeting except for the omission of what I believe to be a key statement. My notes recorded that PEB U.S. Section Chairman, Lloyd Duscha, stated that the PEB's Annual report would declare that "the AOP is probably wrong", i.e., updated streamflows were not used in the downstream benefit computation. The PEB's 1986 Annual Report actually states: "The calculations of downstream power benefits for 1991-92 have been done in a manner which in the opinion of the Board is not fully consistent with the intent of the Treaty."

Attachment

Addressees:

MG G. Robertson - COE
N. Dodge - COE
R. George - COE
H. Kennon - COE
S. Hickok - A
J. Jura - A
R. Ratcliffe - A
L. Johnson - AC
J. Jones - P
E. Sienkiewicz - P

G. Fuqua - PH
R. Lamb - PR
S. Montfort - PR
J. Volpe - PRC
A. Evans - PRCA
D. Jones - PRCB
R. Griffin - PS
M. Maher - PSH
R. Maney - PSP
G. Todd - PSP

26 February 1987

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Summary of Twenty-fifth Meeting

Permanent Engineering Board and United States and Canadian Entities

5 December 1986

1. The Board met with the United States and Canadian Entities in the British Columbia Hydro and Power Authority Board Room, 970 Burrard Street, Vancouver, B.C. at 2:00 pm on 5 December 1986 with the following in attendance:

United States

Canada

Permanent Engineering Board

L.A. Duscha, Chairman
J.E. Harper
T.L. Weaver
S.A. Zanganeh
Q.L. Fugua

B.E. Marr
E.M. Clark
H.M. Hunt
R.O. Lyons
D.B. Tanner
C.B. Marriott

Entities

J.J. Jura
MG G.R. Robertson
H.H. Kennon
E.W. Sienkiewicz
R.D. Griffin
N.A. Dodge
M. Maher
J.M. Hyde

C.A. Johnson
D.R. Forrest
T.J. Newton

Mr. Duscha, on behalf of the Board, thanked B.C. Hydro for lunch and for the use of facilities for the meeting.

2. Current Status Briefing by Entities

- a. Operation of Mica, Arrow, Duncan and Libby

Mr. Newton summarized operation of the Mica, Arrow and Duncan projects with reference to the Entities Annual Report. He noted that operation of the projects had prevented flood damages in the United States.

Mr. Dodge described operation of the Libby project and noted that flows had been the second lowest in the 50 year history, the reservoir had filled to the 92 percent level and there had been a lower firm energy capability for the year. Two flood peaks had occurred, one on 25 February, the other in the spring freshet period. System regulation of the spring freshet from 719,000 to 388,000 cfs at the Dalles resulted in substantial flood damage prevention.

b. Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1991-92

Mr. Forrest advised that the Assured Operating Plan had been prepared on the same basis as last year. Studies conducted during the year had been useful but no agreement had been reached on changes. Mr. Hyde stated that the Downstream Power Benefits had been calculated on the same basis as last year and that there had not been any significant change.

c. Detailed Operating Plan 1986-87

Mr. Griffin advised that this Plan had also been developed on the same basis as last year. Criteria had been taken from the A.O.P. developed in 1981. There have been minor changes to the second and fourth year rule curves for Arrow reservoir.

d. Entities Studies on Proposed Changes to Assured Operating Plan and Determination of Downstream Power Benefits

MG Robertson stated that last year the Entities had agreed to study and report on this topic by June 1986. This was done and the Entities had discussed results of the work during the morning meeting. Discussions had concentrated on the need to assess the potential to market the benefits and on the impact of intertie access. Benefits can be identified, the main issue is how the benefits can be used without access to the intertie. The United States Entity is not currently able to provide the rules that will apply to intertie access.

Mr. Harper considered the intertie to be outside the scope of the Treaty and believed that the Entities could agree on other factors. He asked how the Entities plan to proceed and noted that an A.O.P. is needed, regardless of the intertie considerations. Mr. Marr also noted that the intertie is not covered by the Treaty.

Mr. Johnson stated that since the Canadian Entity cannot take advantage of benefits without intertie access, in the short term, there is no Canadian benefit. He considered that the incremental benefits could be substantial but emphasized that the United States must resolve the policy on access to intertie transmission. MG Robertson considered that this problem is not likely to be resolved until next summer.

Mr. Duscha noted that economic studies are needed in relation to benefits. He also noted that there is a difference of opinion as to how the A.O.P. and Downstream Benefits should be determined. Mr. Duscha proposed that the Board receive a technical briefing from the Entity staffs before discussing the United States Entity position with the Entities. MG Robertson noted in reply to Mr. Duscha that it was the Entities belief that they are operating within the scope of the Treaty. He agreed to the proposed meeting and advised that the Entities will be continuing their studies.

In reply to a question from Mr. Harper, Mr. Dodge advised that the Water Budget is being implemented in the Detailed Operating Plan.

Mr. Duscha read from the last paragraph of the Summary of the Board's Annual Report to 30 September 1986. The Entities had no objection to this wording. For convenience the last sentence is quoted - "The issue of using updated streamflows in these calculations is still under review by the Entities and it is the opinion of the Board that this outstanding issue should be resolved."

- a. The next annual meeting of the Board with the Entities will be in Portland, Oregon on 2 December 1987.
- b. The meeting to provide a technical briefing for the Board will likely be held in Vancouver, B.C. in February or March 1987, if possible. A subsequent meeting of the Board with the Entities will be scheduled after the briefing meeting.

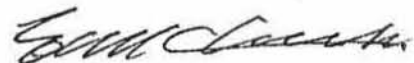
4. Other Business

- a. MG Robertson advised that this would be his last meeting with the group. He expressed his appreciation for the good working relationships which he had developed.

- b. New Appointments

It was noted that Mr. J.J. Jura, Administrator, Bonneville Power Administration is now Chairman of the United States Entity and that Mr. M. Maher is co-chairman of the United States Section of the Hydrometeorological Committee.

This document represents a
consensus of Board members



Secretary, Canadian Section



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

31 December 1986

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

The Honourable Marcel Masse
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 twenty-second Annual Report, dated 30 September 1986, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1985 to 30 September 1986.

Respectfully submitted:

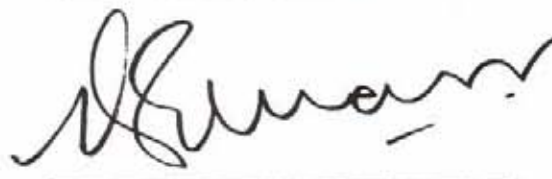
For the United States

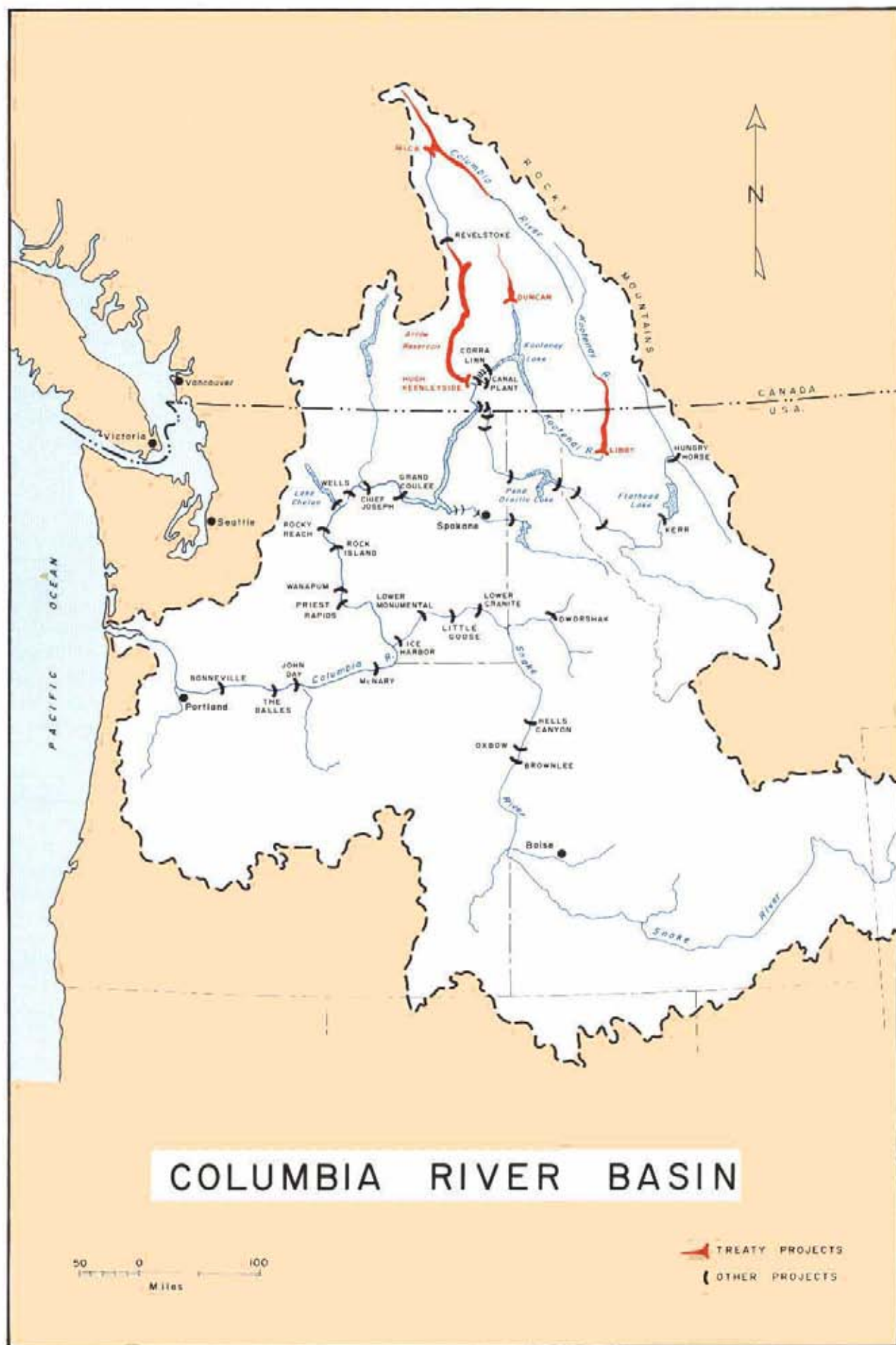
For Canada


Lloyd A. Duscha, Chairman


G.M. MacNabb, Chairman


J. Emerson Harper


B.E. Marr



**ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA**

**COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD**

Washington, D.C.

Ottawa, Ontario

30 SEPTEMBER 1986

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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 twenty-second 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.

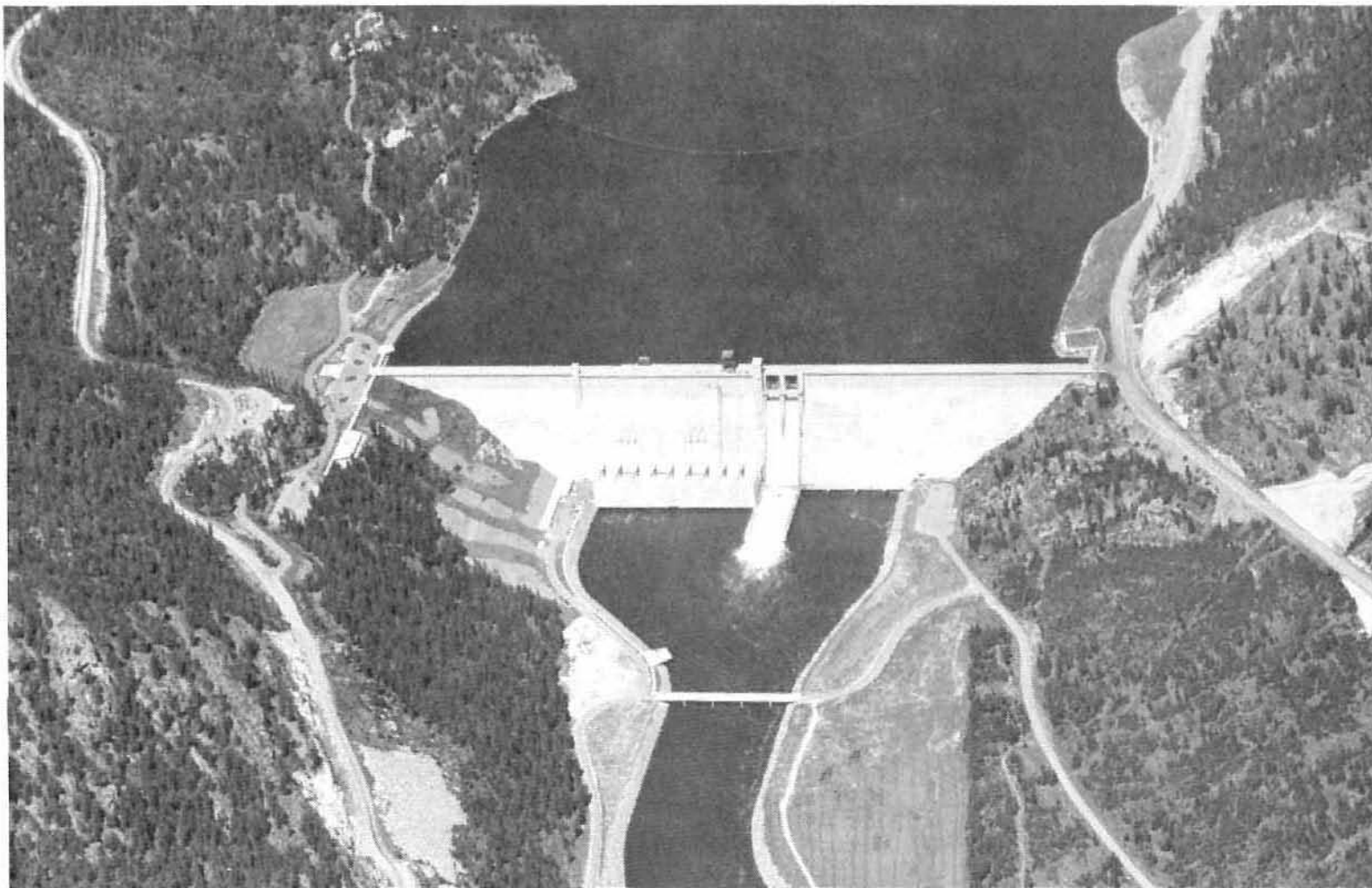
The Duncan, Arrow, Mica and Libby storage projects were operated throughout the year in accordance with the objectives of the Treaty and the terms of operating plans developed by the Entities. Operations under an agreement between the Entities relating to the use of non-Treaty storage and refill enhancement for Mica and Arrow reservoirs did not conflict with Treaty operations. Reservoir operations provided minor flood control in late February, and in the spring, controlled freshet flows to well below damaging levels. (Pages 27-35)

Studies pertaining to development of the hydrometeorological network and power operating plans are being continued by the Entities to ensure operation of projects in accordance with the terms of the Treaty. The Board has received a report from the Entities on studies of the effects of updated streamflow records on the calculation of downstream power benefits and of issues affecting the determination of Assured Operating Plans. These studies are continuing. The calculations of downstream power benefits for 1991-92 have been done in a manner which in the opinion of the Board is not fully consistent with the intent of the Treaty. The issue of using updated streamflows in these calculations is still under review by the Entities and it is the opinion of the Board that this outstanding issue should be resolved. (Pages 21-25)

INTRODUCTION

The Columbia River Treaty, which provides for cooperative 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 1985 to 30 September 1986, 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. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included. The report notes that Entity studies are underway to assess the effects of updated streamflow records on the calculation of downstream power benefits and to examine other issues affecting the determination of Assured Operating Plans. Discussion is provided regarding the operations of Treaty reservoirs and of the resulting power and flood control benefits, and conclusions of the Board are presented.

**LIBBY DAM**

The dam and reservoir, Lake Kootenai. The powerhouse is at the left of the spillway.

Kootenai River, Montana

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 streamflow 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.



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

Duncan River, British Columbia

- (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

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.

VISITOR'S CENTRE
at Revelstoke Dam
downstream from
Mica development.



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.

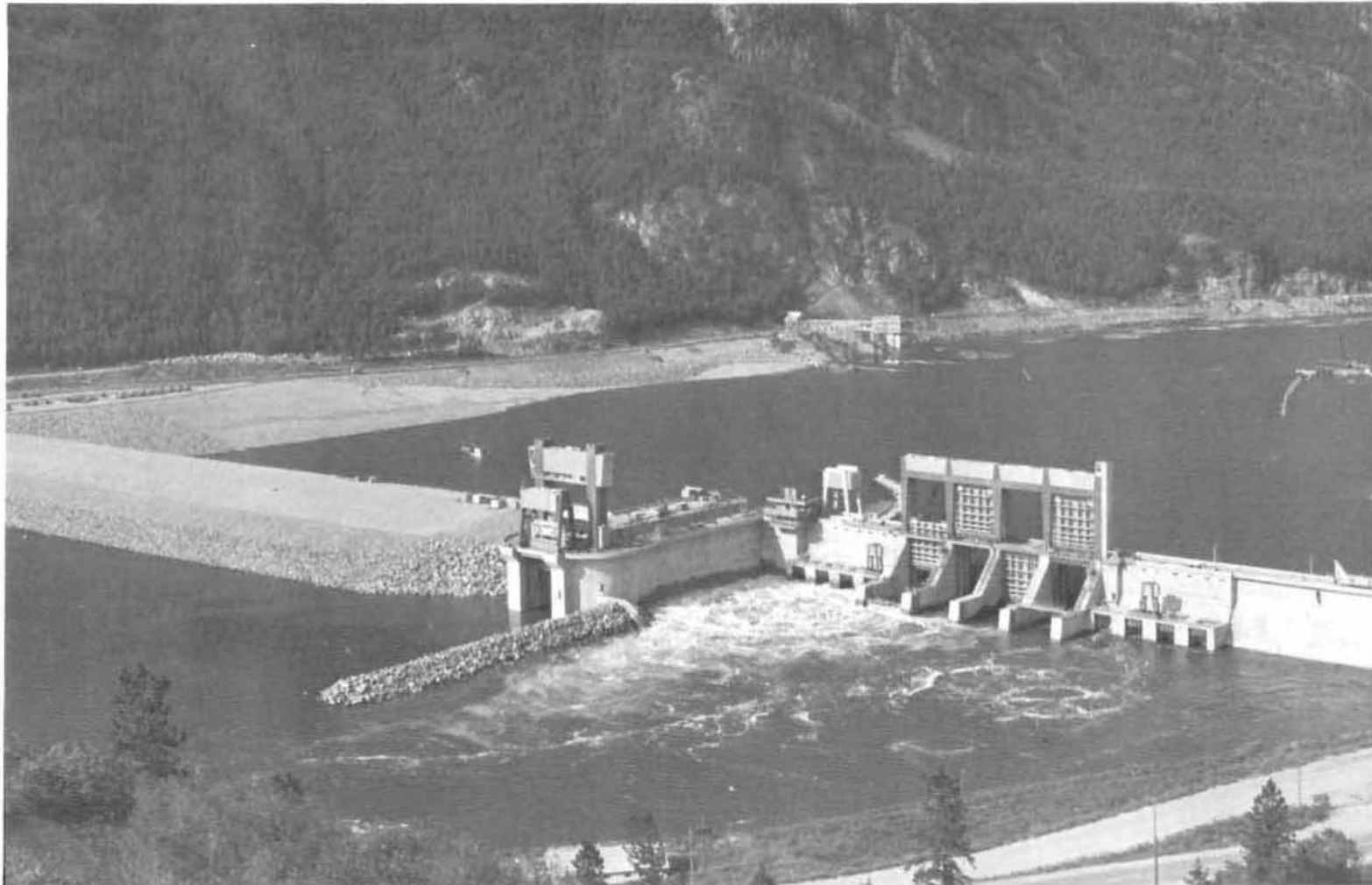
The names of Board members, alternate members and secretaries are shown in Appendix A.

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 hydrometeorological system as required by Annex A of the Treaty.



HUGH KEENLEYSIDE DAM

Columbia River, British Columbia
Concrete spillway and discharge works with navigation lock and earth dam.

ENTITIES

General

Article XIV(1) of the Treaty provides that Canada and the United States shall each designate one or more entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the entities are specified in the Treaty and its 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 the Bonneville Power Administration was transferred to the Department 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.

The names of the members of the two entities are shown in Appendix B. It is noted that on 18 July 1986 Mr. James J. Jura succeeded Mr. Peter T. Johnson as Chairman 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, Article XIV(2) of the Treaty requires that the entities be responsible for:

- (a) coordination 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 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 cooperating 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.

KOOTENAY CANAL PLANT
made possible by
Treaty regulation.



ACTIVITIES OF THE BOARD

Meetings

The Board met in Portland, Oregon on 5 December 1985 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 the following documents and reports and made copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculations available for review:

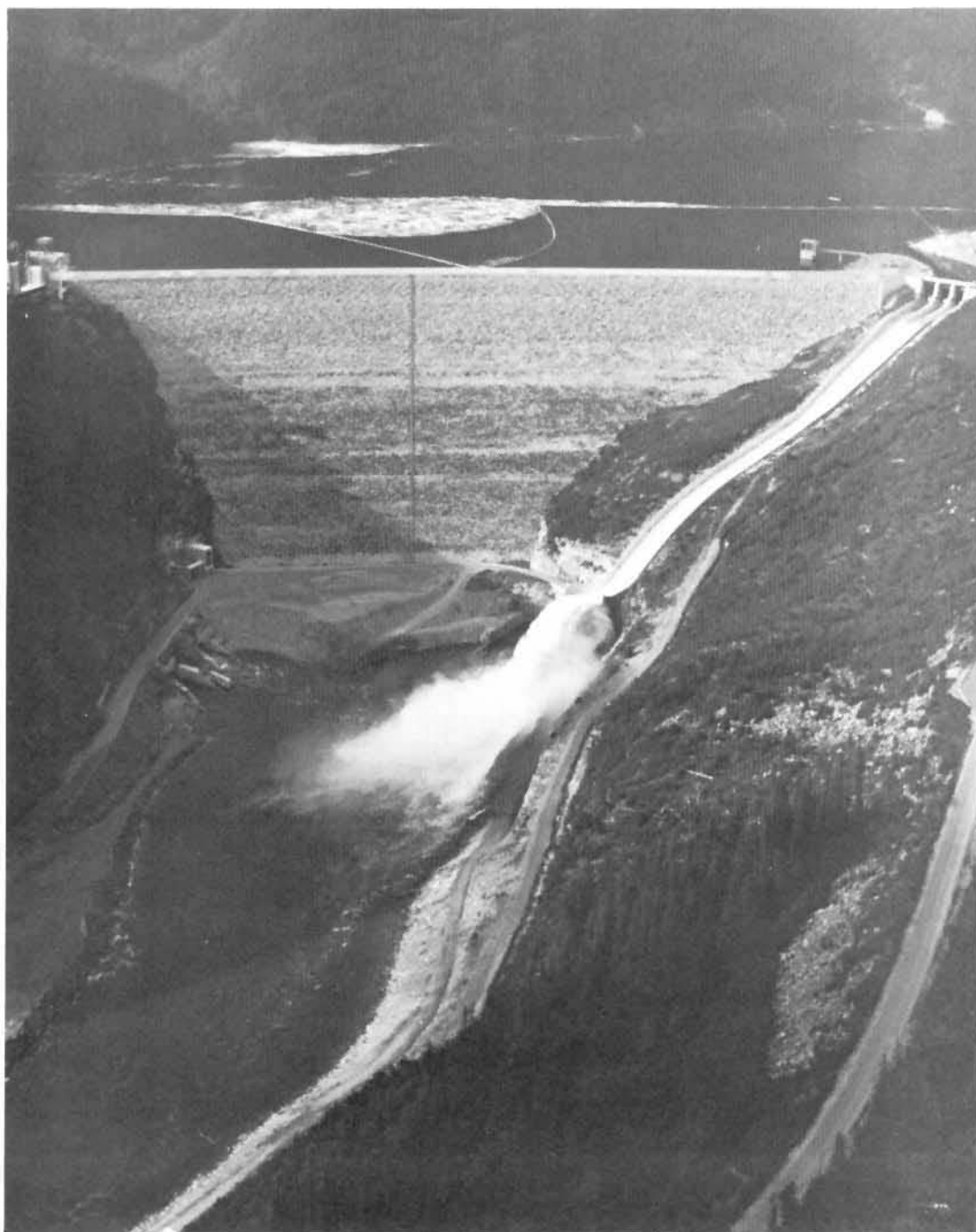
- Report of Columbia River Treaty Canadian and United States Entities 1 October 1984 through 30 September 1985
- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1990-91
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1985 through 31 July 1986, plus a copy of the Entities' agreement on this document
- Revised Hydrometeorological Committee Documents, November 1985
- Entity Agreement, 5 December 1985, on the 1990-91 Assured Operating Plan and Determination of Downstream Power Benefits and on studies necessary to address outstanding issues with respect to preparation of these documents in future years.

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

- Report of Columbia River Treaty Canadian and United States Entities 1 October 1985 through 30 September 1986
- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1991-92, plus a copy of the Entities' agreement on this document
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1986 through 31 July 1987, plus a copy of the Entities' agreement on this document
- Report on Proposed Changes to Assured Operating Plan and Determination of Downstream Power Benefit Studies.

Report to Governments

The twenty-first Annual Report of the Board was submitted to the two governments on 31 December 1985.



MICA DAM

Columbia River, British Columbia

The earth dam with spillway in operation. The underground powerhouse is at the left.

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 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 planned for the future.

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.

The project is shown in the picture on page 5 and project data are provided 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 at present has no associated power facilities, however, installation of generators is planned for the future.

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 10 and project data are provided 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 16 and project data are provided in Table 3 of Appendix D.

MICA DAMSITE
preparation in 1966
showing diversion
tunnel outlets.



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, completed in 1976, had four units with a total installed capacity of 420 megawatts.

Construction of four 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 these units. That unit is in place and the total installed capacity for the five units is 525 megawatts.

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 2 and project data are provided in Table 4 of Appendix D.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. British Columbia Hydro and Power Authority has assumed responsibility for reservoir maintenance and debris clean-up.

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.

LAKE KOOCANUSA in
British Columbia,
view from Wardner Bridge.



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 report "Revised Hydrometeorological Committee Documents" dated November 1985. The report provides up-to-date listings of the hydrometeorological stations and facilities that constitute the network. The Board concurs with these documents.

During the year the Corps of Engineers installed a GOES satellite downlink in Portland, Oregon. This enables both Canadian and United States satellite stations to be reported directly to the Columbia River Operational Hydromet Management System (CROHMS) computer in Portland with no need for relay through other communication channels.

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 commitment of the Canadian Entity to operate the Canadian Treaty storage and provide the Entities with a basis for system planning. Canada's commitment to operate under an Assured Operating Plan is tied directly to the benefits produced by that plan. At the beginning of each operating year, a Detailed Operating Plan which includes Libby reservoir 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.

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 Entities have been using this 30-year record for part of the downstream benefit calculations but have updated and extended the record for general use and have been using the updated record for the specified 30-year period to develop Assured Operating Plans. In its 1984 Annual Report the Board stated that the updated 30-year record should be used to calculate the Downstream Power Benefits as well as to develop the Assured Operating Plans. The Board advised the Entities accordingly and noted that this position should be reflected in the document "Columbia River Treaty, Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans".

Under an agreement dated 5 December 1985 the Entities agreed to study the effects of updated streamflows on the calculation of Downstream Power Benefits, and other issues affecting the determination of Assured Operating Plans. The Entities also agreed to accept that the 1990-91 Assured Operating Plan and Downstream Power Benefits be calculated on the same basis as recent years. A report on these studies, received by the Board after the end of the report year, indicates that revising operating procedures to produce increased coordination of Treaty storage with current operation of the United States Columbia River system can result in sizeable net benefits to both Canada and the United States. However, additional analysis is needed before the Entities can agree on such coordination.

These studies are continuing and the Entities have agreed to again calculate the Assured Operating Plan and Downstream Power Benefits on the same basis as in recent years. The Board does not agree that this method is correct in that it does not use streamflow data in all cases that have been updated to reflect current best estimates of irrigation depletion etc.

The Assured Operating Plan for operating year 1990-91, 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. This Plan is essentially the same as the Plan for the preceding operating year. The Assured Operating Plan for operating year 1991-92 was received from the Entities after the end of the report year.



SPILLWAY and LOCK CONSTRUCTION, Hugh Keenleyside Dam in 1966.

Early in this report year the Entities provided the Board with the Detailed Operating Plan for Canadian Treaty storage and Libby reservoir for the operating year ending 31 July 1986. The Detailed Operating Plan for the operating year ending 31 July 1987 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. This agreement remained in effect throughout the report year. Operations under the agreement did not interfere with Treaty operations and were consistent with Treaty objectives.

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.

Under the December 1985 agreement, the Entities are continuing to study the issues affecting future development of Assured Operating Plans, including water budget and updated streamflows. The Board has stated that the Assured Operating Plans are for optimum operation for power and flood control. The Board notes, however, that the Entities may agree to provide water for fish migration under detailed operating arrangements providing this does not conflict with Treaty requirements and that such arrangements do 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 1990-91. 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, are available to the Board. A report on determination of downstream power benefits for the operating year 1991-92 was received from the Entities after the end of the report year. The Board notes, as discussed in the preceding section of this report, that the updated streamflows have not been used in these determinations of downstream benefits and therefore in the opinion of the Board the determinations do not fully reflect in all aspects the intent of the Treaty.

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 and is still in effect.

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.



LIBBY DAM and POWERHOUSE on Kootenai River in Montana.

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 1985 through 31 July 1986
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1986 through 31 July 1987
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1985-86
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1986-87.

In addition, the following agreement was in effect during this period:

- 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.

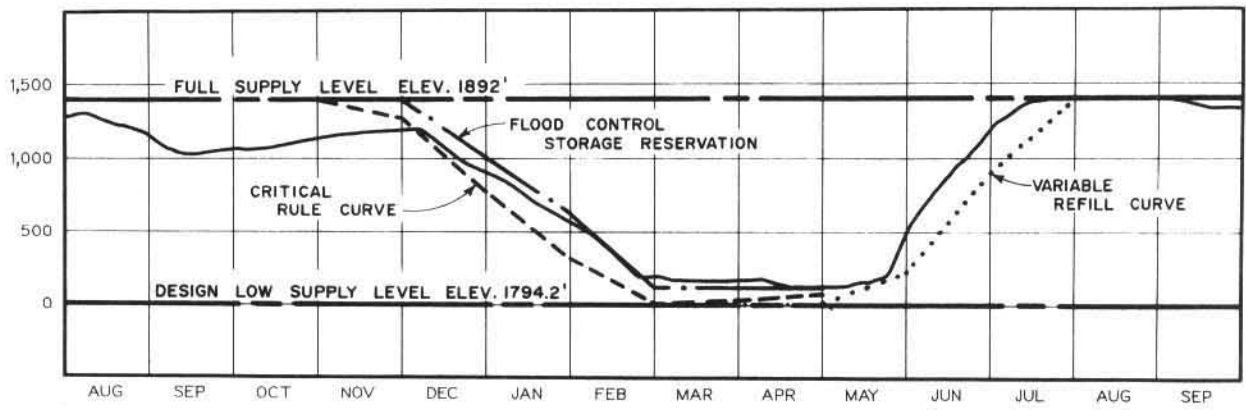
Power Operation

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.

Treaty reservoirs did not refill during the 1985 freshet, but high inflows during September 1985 resulted in Treaty storage at Mica and Arrow reservoirs being full at the start of the report year. Duncan and Libby reservoirs did not refill and all reservoirs had commenced drafting by 1 October 1985. Normal drawdown for power purposes occurred at all reservoirs during most of the winter. Heavy rains in late February required flood control operation of the system for two weeks to alleviate flooding on the lower Columbia River.

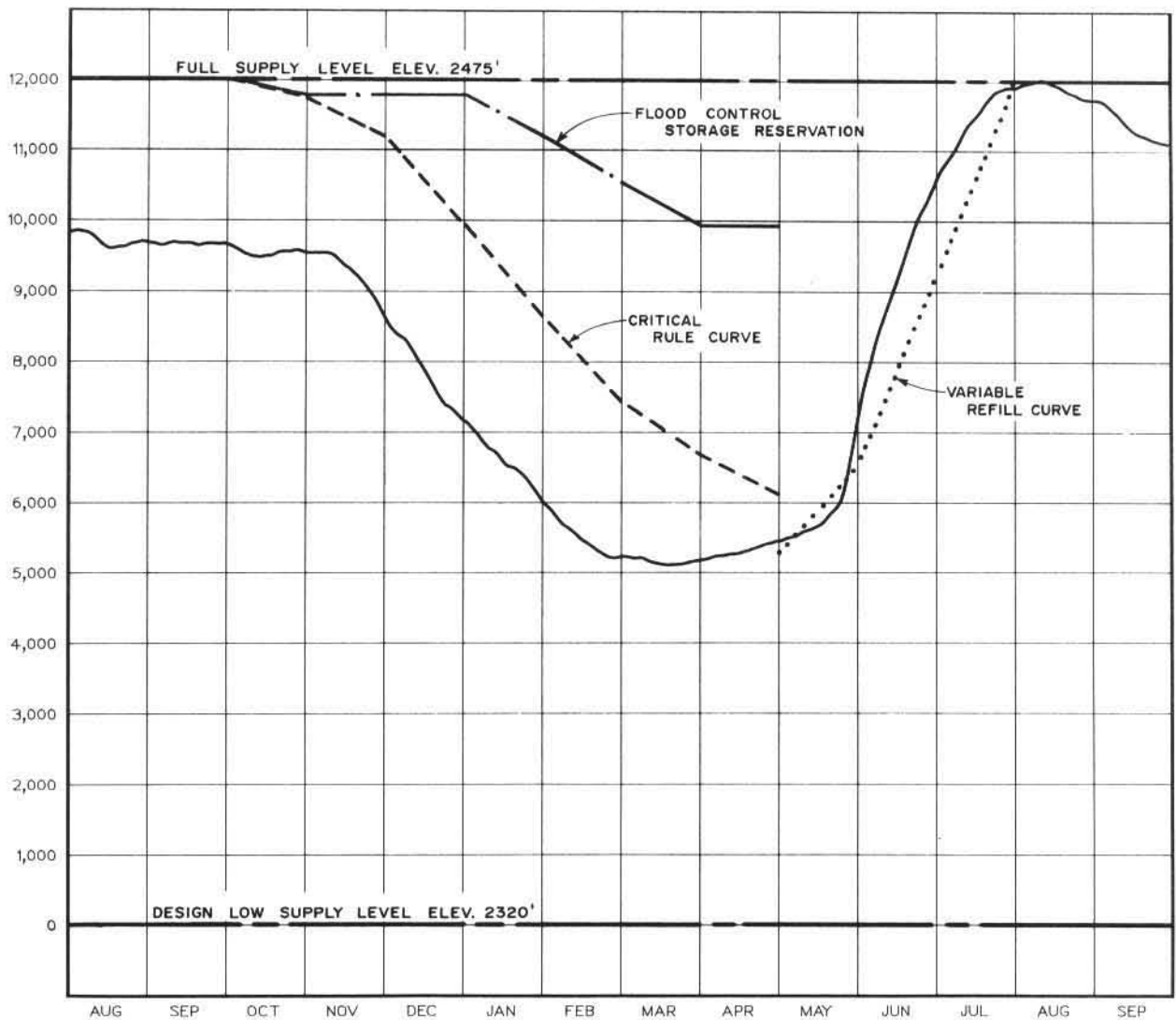
Although the 1986 freshet volume was below average, all Treaty reservoirs filled by the end of July. Extremely high temperatures late in May, resulting in high unregulated inflows to the Columbia River, required daily flood control operation at Treaty reservoirs through most of June. Drafting for power operation had begun at all reservoirs before the end of September.

Storage was transferred between Arrow and Revelstoke storage accounts during the year as permitted under the Entities Storage Agreement of April, 1984. These storage transfers were accomplished without disrupting Treaty operations.



DUNCAN RESERVOIR

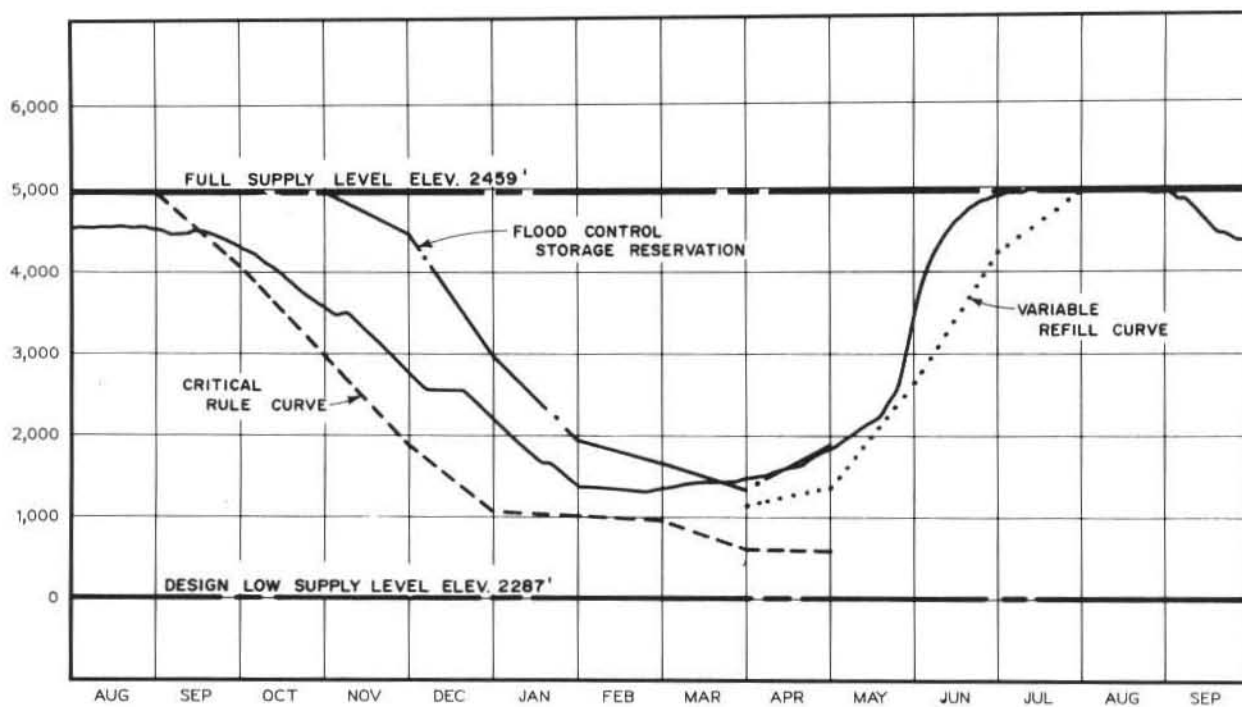
USABLE RESERVOIR STORAGE IN 1,000 ACRE FEET



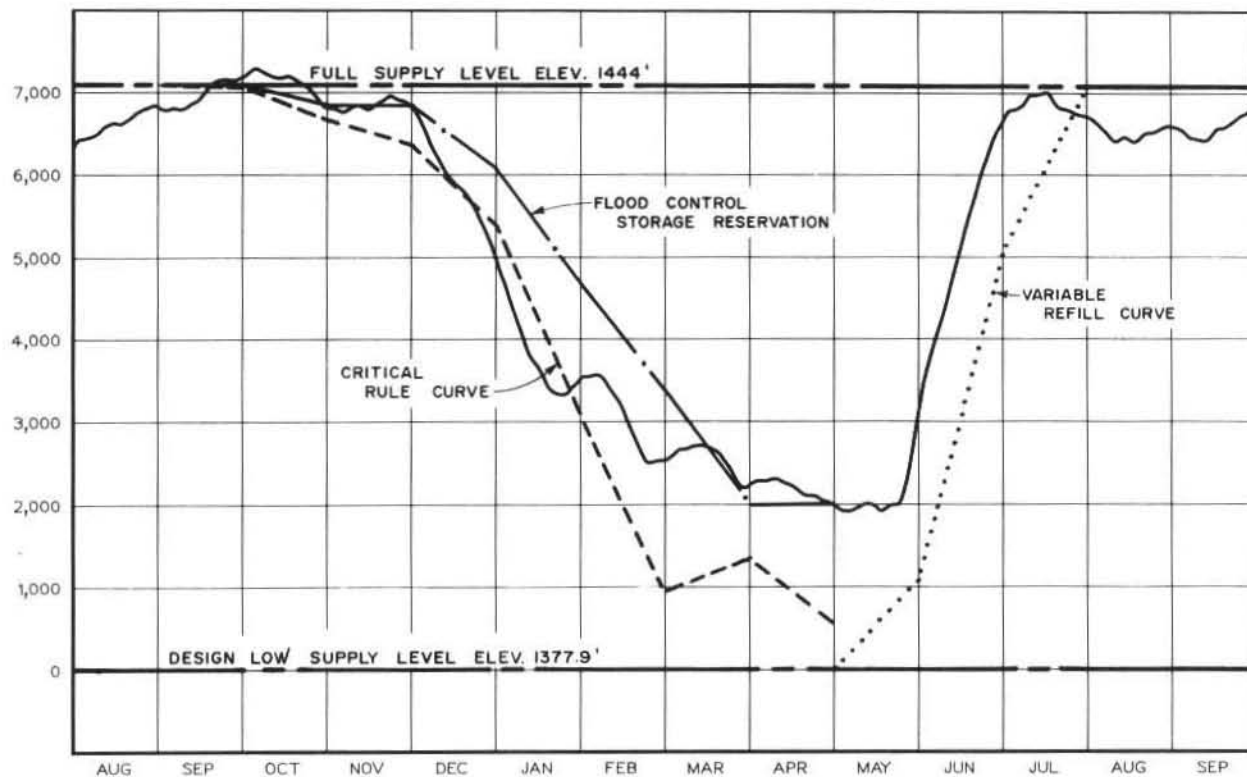
MICA RESERVOIR

HYDROGRAPHS — Duncan and Mica reservoir levels for 14-month period ending 30 September 1986.

USABLE RESERVOIR STORAGE IN 1,000 ACRES FEET



LIBBY RESERVOIR



ARROW RESERVOIR

HYDROGRAPHS — Libby and Arrow reservoir levels for the 14-month period ending 30 September 1986.

Commencing in the 1984 report year, 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. In this report year the water budget of 3.45 million acre-feet for Priest Rapids on the Columbia River was fully utilized between 5 May and 1 June.

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 forecast 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.

CONSTRUCTION
of Duncan Dam
in 1966.



Duncan reservoir began the report year at elevation 1872.5 feet, nineteen and one half feet below full pool. Until December, discharge was held at the minimum 100 cfs and the reservoir partially refilled. Outflows were then increased and drafting continued through mid-February. Flood control operation at the end of February halted the rapid drafting and levels were held steady for flood control requirements through March, April and May. The year's lowest level, 1807.5 feet, was reached on 21 April 1986. Rapid filling began mid-May. Duncan reservoir filled quickly in June and July, reaching normal full pool elevation of 1892 feet on 23 July. The reservoir was maintained full until mid-September, then drafted to elevation 1888.5 feet at the end of September.

Arrow reservoir was at elevation 1445.6 feet at the start of the report year, 1.6 feet above its normal full pool elevation of 1444 feet. Drafting began in October. Heavy drafting occurred through December and January due to cold dry weather. Flood control operations to mitigate flooding due to heavy rainfall in February and March slowed drafting of the reservoir. By 7 May 1986 Arrow reservoir reached its lowest elevation of the year at 1399.6 feet.

Rapid refill began on 21 May. Inflows peaked on 31 May at 121,000 cfs and Arrow reservoir filled rapidly through June and July. By 18 July 1986 the reservoir reached elevation 1443.4 feet and Treaty storage was full, considering storage held in the Treaty storage account at Revelstoke reservoir. Throughout August and September reservoir levels were held in the 1438 to 1440 foot range and the reservoir ended the report year at elevation 1441.5 feet.

On 1 October 1985, Mica reservoir was at elevation 2452 feet, twenty-three feet below normal full pool elevation, although Treaty storage was full. Throughout the fall and winter months, Treaty storage was drafted under project flows ranging between 5,000 and 40,000 cfs. By 20 March 1986, the reservoir reached its lowest level of the year at 2401.7 feet. Treaty storage continued to draft until 3 May, bottoming at 1.22 million acre-feet, although the reservoir rose due to filling of non-Treaty storage space.

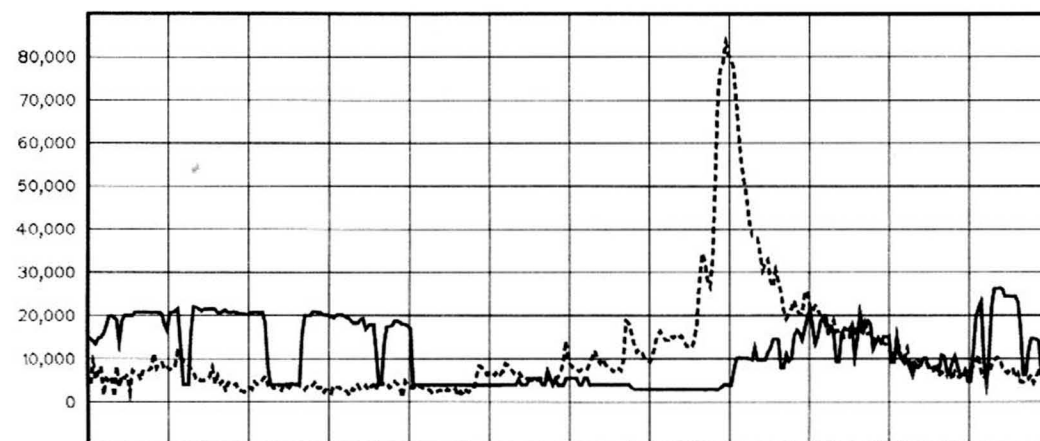
Warm weather in late May and early June produced high inflows, peaking at 108,000 cfs on 1 June. The reservoir filled rapidly and Treaty storage was full by 10 July 1986. Mica reservoir reached its full pool elevation of 2475 feet by 10 August. Treaty storage remained full to the end of September while drafting of non-Treaty storage lowered the reservoir to 2466.4 feet at the end of the report year.

Libby reservoir began the report year at elevation 2444.3 feet, with drafting of storage already underway. Rapid drafting continued until the end of January when outflows were reduced to 4,000 cfs. The lowest level of the year, 2353.8 feet, was reached 24 February. Outflows were reduced further to 3,000 cfs in late April to ensure that the reservoir would refill. Rapid filling began late in May and the peak inflow of 83,400 cfs occurred on 31 May. Outflows were increased to 10,000 cfs on 4 June ending the rapid refill. The lake reached its normal full pool elevation of 2459 feet on 20 July and remained full throughout the summer. Drafting began in September and by 30 September the reservoir had fallen to elevation 2445.2 feet.

Flood Control Operation

Twice during the report year Treaty reservoirs were operated on a daily basis as specified in the Flood Control Plan. In late February heavy rainfall in the lower Columbia River basin produced the highest recorded discharges for the winter season at The Dalles, Oregon. Treaty storage was put on a daily operation from 23 February until 5 March to reduce flooding downstream and to allow evacuation of space filled at downstream reservoirs during flood control operations. During the 1986 freshet, flood control was provided by normal refill of Treaty projects and other storage reservoirs in the Columbia River basin. Daily operation of Treaty reservoirs was in effect from 28 May to 20 June 1986. The freshet was controlled to well below damaging levels.

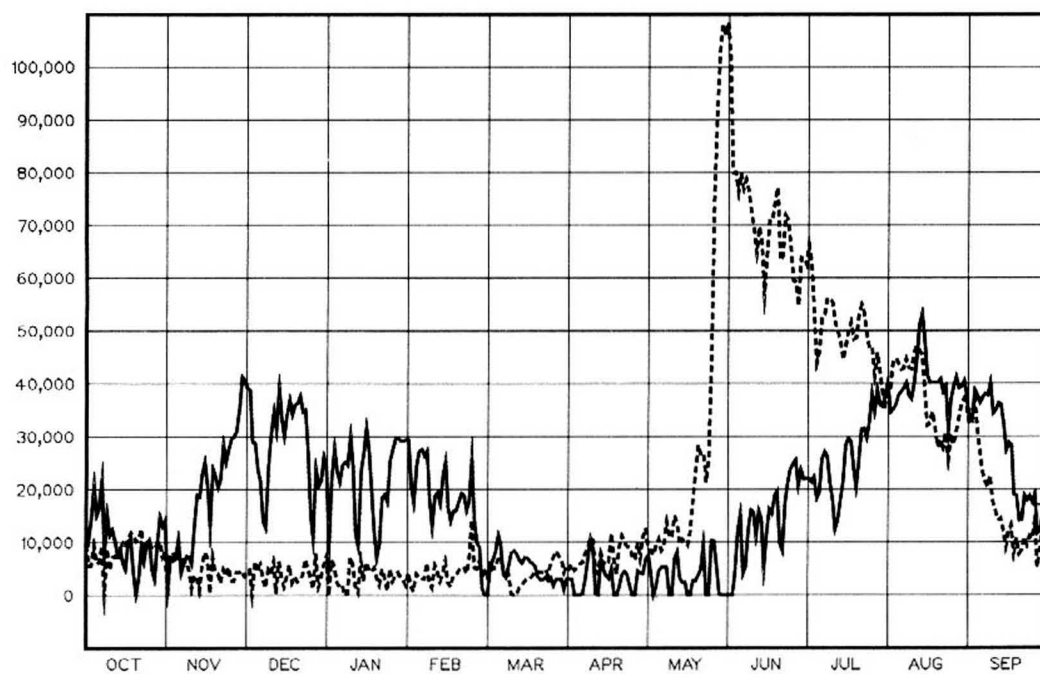
DISCHARGE IN CUBIC FEET PER SECOND



KOOTENAI RIVER AT LIBBY DAM

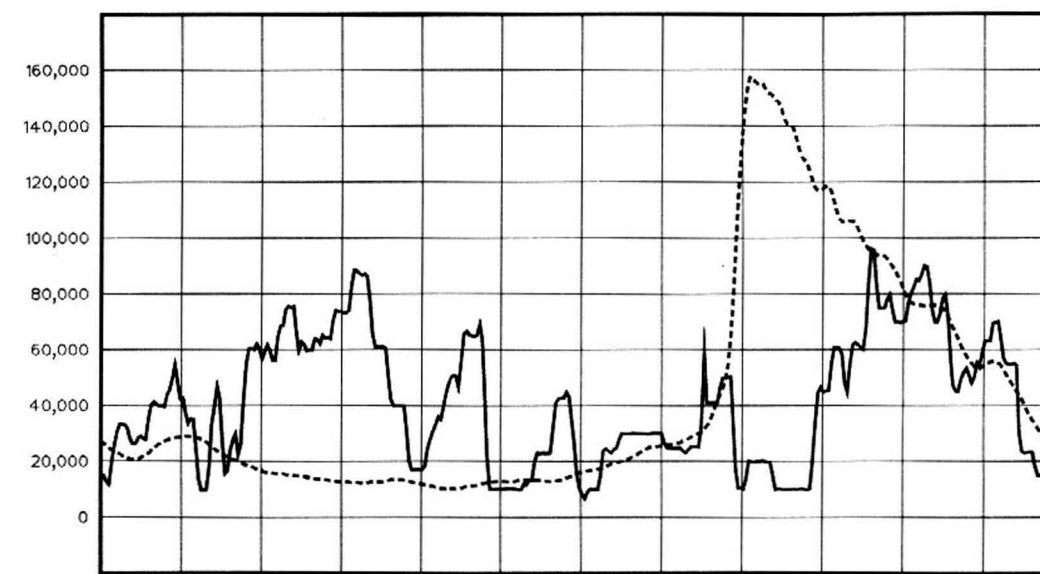


DUNCAN RIVER AT DUNCAN DAM

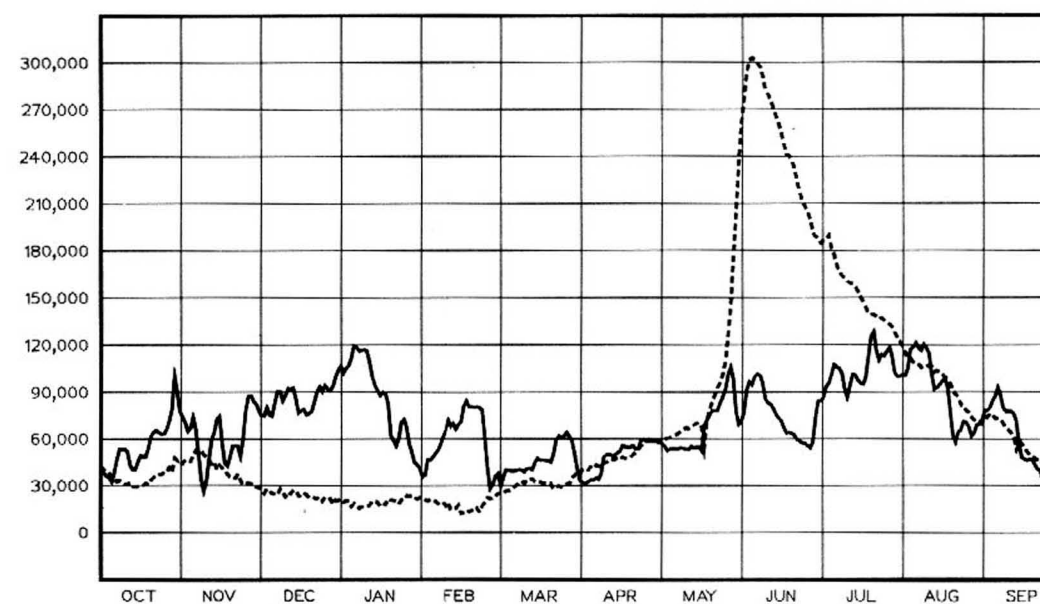


COLUMBIA RIVER AT MICA DAM

DISCHARGE IN CUBIC FEET PER SECOND



COLUMBIA RIVER AT HUGG KEENLEYSIDE DAM



COLUMBIA RIVER AT BIRCHBANK

LEGEND
 — Observed Flows
 - - - Pre-Project Flows
 HYDROGRAPHS — Observed and pre-project flows
 for year ending 30 September 1986.

BENEFITS

Flood Control Provided

Without regulation by Columbia River system reservoirs, significant flooding would have occurred in late February 1986 due to heavy rainfalls and observed levels of 18.5 feet at Vancouver, Washington would have been 22.9 feet. Treaty reservoirs, however, did not play a large role in reducing levels of this flood due to rainfall distribution over the basin and to operating constraints that limited the rate of shutdown of Arrow reservoir outflows. Without regulation by upstream reservoirs, the 1986 freshet would have produced an above average peak discharge at Trail, British Columbia and at The Dalles, Oregon, and would have caused significant flooding in the United States.

It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about eight feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about sixteen 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 34 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 719,000 cfs to 388,000 cfs. Regulation by the Treaty storage projects during the 1986 freshet period contributed minor flood control benefits in Canada and large benefits in 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.

INSTALLING NESTING PLATFORMS
at Libby Dam, Montana.



Power Benefits

Downstream power benefits in the United States which arise from operation of the Canadian Treaty storage were pre-determined for the first thirty years of operation of each project and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement. The United States Entity delivers capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. The benefits of additional generation made possible on the Kootenay River in Canada as a result of regulation provided by Libby, and generation at the Mica and Revelstoke projects, are retained wholly within Canada. The benefits from Libby regulation which occur downstream 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.

CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty. Operation reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and an agreement between the Entities relating to the use of non-Treaty storage and refill enhancement of Mica and Arrow reservoirs. Operation under the agreement 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. The Assured Operating Plans and Downstream Power Benefits for 1991-92 have been calculated on the same basis as in recent years which in the opinion of the Board does not fully reflect the intent of the Treaty.
3. The Entities' report on studies of issues which affect development of the Assured Operating Plans and the determination of the Downstream Power Benefits including water budget and updated streamflows has been provided to the Board.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

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	<u>Members</u>	
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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 and Parks, Victoria, B.C.
	<u>Alternates</u>	
Mr. Alex Shwaiko 4630 North 20th Street, Arlington, Virginia		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 Manager, Power and Special Projects Section, Ministry of Environment and Parks, Victoria, B.C.
	<u>Secretaries</u>	
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.

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Canada

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Mr. Verle Farrow	1969-1972		
Mr. Walter W. Duncan	1972-1978		
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1) Chairman

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Department of Energy,
Portland, Oregon

Major General George R. Robertson
Division Engineer,
U.S. Army Engineer Division, North Pacific,
Portland, Oregon

Canada

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

1) Vice Mr. Peter T. Johnson as of 18 July 1986.

RECORD OF FLOWS
AT THE
INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	15,100	22,500	22,700	21,200	16,200	12,600	21,300	11,200	19,300	19,300	16,100	6,120
2	15,200	26,200	22,400	21,100	7,190	12,600	19,600	10,900	17,800	22,700	15,800	6,110
3	15,100	29,800	21,900	21,200	6,870	12,800	17,700	11,700	16,800	20,400	10,900	11,900
4	14,500	33,400	22,100	21,400	6,690	13,000	16,500	13,500	19,100	19,700	10,700	20,600
5	13,800	36,200	22,000	21,400	6,730	13,300	15,500	14,900	20,200	15,900	14,900	21,000
6	15,100	23,500	22,100	21,200	6,670	13,100	14,000	15,100	19,000	18,100	12,100	19,500
7	15,500	15,100	22,300	21,200	6,420	13,600	14,000	14,800	18,200	20,100	11,000	10,500
8	17,200	12,500	17,800	21,000	6,290	17,600	15,300	14,400	17,400	19,800	10,200	6,170
9	18,200	11,700	10,100	20,700	6,190	19,300	15,900	14,300	16,600	19,300	10,700	12,400
10	20,100	23,000	6,710	20,400	6,270	18,000	15,800	14,100	16,500	19,200	8,760	22,100
11	20,600	25,500	6,040	20,300	6,250	16,400	16,200	13,900	15,800	19,300	7,340	24,300
12	20,400	25,600	5,890	20,300	6,120	14,900	15,900	13,100	17,900	17,200	9,800	24,700
13	16,700	25,400	5,990	20,200	6,050	14,100	14,600	13,900	15,300	12,200	9,000	24,800
14	18,000	24,900	6,080	20,000	6,040	14,200	13,500	15,400	14,700	12,200	8,730	24,900
15	19,800	25,100	6,000	17,500	6,650	12,700	12,900	14,500	14,300	16,800	10,600	25,000
16	21,300	25,200	5,940	18,600	6,540	12,100	12,600	13,300	14,500	18,100	11,300	25,100
17	22,100	25,300	6,000	18,900	7,060	11,500	12,300	12,700	15,200	18,200	9,070	25,100
18	21,900	25,200	5,820	19,000	7,420	12,000	12,000	12,700	16,800	18,400	8,280	25,300
19	21,900	24,800	5,640	12,000	7,030	11,700	11,600	13,800	17,400	18,400	8,890	24,900
20	21,900	23,900	5,650	7,700	6,780	11,600	11,300	16,400	17,600	13,000	8,970	22,900
21	21,900	23,600	6,310	7,290	6,480	11,700	11,600	19,100	16,100	16,800	8,120	15,700
22	22,300	23,500	18,200	16,400	6,540	12,000	14,200	19,100	12,000	20,900	11,000	8,620
23	22,500	22,900	20,600	19,100	6,380	11,200	19,800	17,400	11,600	19,000	10,900	8,100
24	22,900	22,700	21,200	19,600	6,350	11,300	19,000	15,700	13,300	18,800	8,140	14,000
25	25,700	22,600	21,300	19,700	9,310	14,000	17,000	15,500	11,700	20,000	7,920	15,200
26	28,400	22,900	21,300	19,800	13,000	13,000	15,000	17,400	13,700	17,800	9,760	15,100
27	27,700	22,800	21,300	19,900	14,400	11,400	13,600	20,600	17,100	15,200	10,800	15,500
28	27,400	23,200	21,200	19,600	13,500	12,700	12,700	22,900	18,300	15,200	9,040	13,100
29	27,200	22,800	21,100	19,500		13,700	12,100	23,200	17,600	14,700	7,130	8,340
30	26,000	22,900	21,100	19,500		15,900	11,600	22,200	16,700	15,200	7,430	8,210
31	22,200		21,100	19,300		21,000		20,900		16,000	8,010	
Mean	20,600	23,800	15,000	18,900	7,760	13,700	14,800	15,800	16,300	17,700	10,000	16,800

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1986 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	38,700	74,200	74,900	102,000	36,700	37,700	33,200	57,600	71,300	84,600	101,000	77,900
2	38,200	70,400	74,600	105,000	46,500	29,800	32,200	57,200	77,100	86,500	100,000	77,900
3	36,500	64,800	80,000	107,000	46,800	35,700	31,200	55,300	90,900	93,600	105,000	80,200
4	35,200	66,700	75,500	112,000	48,300	40,200	32,500	52,600	96,500	95,600	117,000	84,500
5	32,600	74,200	74,700	120,000	50,900	40,100	33,500	53,300	94,600	101,000	119,000	87,400
6	38,000	66,400	82,700	118,000	52,900	39,400	33,500	53,600	99,400	107,000	121,000	92,900
7	46,600	51,000	90,400	116,000	57,400	39,400	34,900	53,700	101,000	106,000	118,000	87,900
8	53,400	34,100	90,200	116,000	62,200	39,900	34,100	53,200	100,000	105,000	116,000	79,800
9	53,300	26,500	84,400	117,000	65,700	40,100	37,900	54,200	96,200	102,000	120,000	77,800
10	53,300	33,300	87,500	116,000	72,000	39,800	48,800	53,900	85,900	92,200	118,000	77,600
11	52,200	47,000	92,200	109,000	68,100	39,300	49,800	53,400	83,000	86,700	114,000	77,800
12	43,700	59,300	91,900	99,700	70,000	40,800	50,100	53,100	82,400	94,300	101,000	75,900
13	40,400	64,300	92,600	94,400	66,000	41,500	49,500	55,000	79,500	101,000	91,700	71,000
14	40,400	72,400	85,400	90,700	69,100	40,300	49,400	54,600	76,000	101,000	92,900	56,300
15	45,400	74,500	76,500	87,900	71,000	44,900	50,900	54,700	73,500	97,400	94,800	48,000
16	49,500	57,200	77,900	89,900	80,800	47,500	52,000	54,800	71,800	95,900	97,100	47,200
17	48,900	44,700	78,700	88,900	84,600	46,700	55,900	52,300	67,500	95,000	98,600	46,300
18	48,700	42,800	75,500	82,500	80,600	46,700	55,000	68,900	64,000	99,800	93,400	46,900
19	54,200	48,500	76,300	62,300	80,500	46,100	54,700	72,000	64,400	112,000	78,400	47,000
20	61,300	55,600	77,700	59,000	80,000	46,000	54,600	75,100	63,600	126,000	62,100	43,400
21	64,100	56,000	83,800	55,400	80,400	45,200	55,600	78,000	62,500	128,000	57,500	40,700
22	65,200	55,300	89,900	60,400	79,700	50,200	53,700	78,200	59,800	116,000	64,200	39,900
23	64,300	48,800	93,600	70,600	78,700	59,300	53,700	78,500	58,600	110,000	65,800	34,500
24	63,000	60,100	90,300	72,300	61,500	61,900	59,000	82,900	57,700	114,000	70,800	31,900
25	63,200	78,100	94,200	67,000	41,000	61,100	59,500	86,900	57,300	113,000	70,800	31,500
26	66,500	87,200	92,100	56,400	28,100	61,700	59,000	92,000	55,700	116,000	67,900	31,500
27	71,800	87,600	90,600	51,700	30,600	64,200	58,800	101,000	54,500	118,000	61,700	33,200
28	78,800	84,200	93,800	45,000	36,100	61,900	59,000	106,000	58,000	113,000	63,400	34,900
29	100,000	82,300	99,600	43,400		58,300	58,500	97,600	73,600	102,000	68,700	35,000
30	90,200	77,800	104,000	41,100		50,000	58,400	77,500	84,500	99,800	69,600	35,000
31	77,500		107,000	35,700		40,500		69,200		100,000	71,400	
Mean	55,300	61,500	86,400	83,600	61,700	46,300	48,300	67,300	75,400	104,000	90,000	57,700

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1986 in cubic feet per second.

PROJECT INFORMATION

Power and Storage Projects,
Northern Columbia Basin

Plate No. 1

Project Data

Duncan Project
Arrow Project
Mica Project
Libby Project

Table No. 1
Table No. 2
Table No. 3
Table No. 4

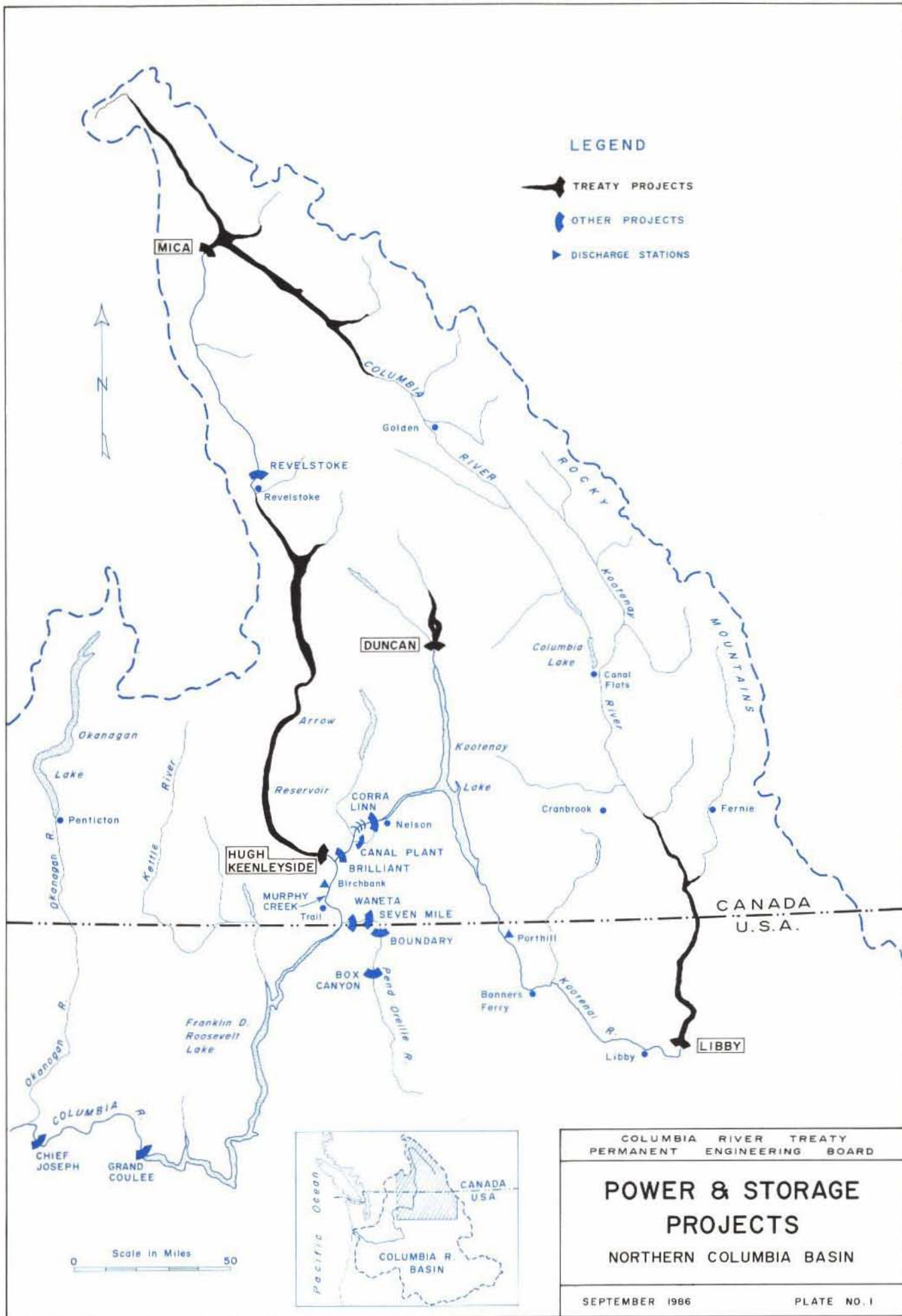


TABLE 1

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 Project	
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	
5 units at 105 mw	525 mw
Head at full pool	352 feet
Maximum Turbine Discharge	
of 5 units at full pool	26,500 cfs