COLUMBIA RIVER TREATY

FLOOD CONTROL OPERATING PLAN

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For the United States Entity

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The Flood Control Operating Plan is accessible at
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I - INTRODUCTION

1-1. Authority

a. Mica, Arrow, and Duncan. Article XIV, Paragraph 2(h) of the Columbia River Treaty between Canada and the United States of America provides that the powers and duties of the Canadian and United States Entities include the preparation of flood control operation plans for the Canadian storage. Paragraph 5, Annex A to the Treaty further provides that the United States Entity will submit flood control operating plans which may consist of or include flood control storage reservation diagrams and associated criteria for Canadian storage.

b. Libby. Paragraph 5 of the Protocol Annex to Exchange of Notes (herein referred to as the "Protocol") provides that the Entities shall, pursuant to Article XIV(2)(a) of the Treaty, cooperate on a continuing basis to coordinate the operation of Libby Dam with the operation of hydroelectric plants on the Kootenay River and elsewhere in Canada in accordance with the provisions of Article XII(5) and Article XII(6) of the Treaty.

1-2. Purpose and Scope. The purpose of the Flood Control Operating Plan for Canadian storage is to prescribe criteria and procedures by which the Canadian Entity will operate Mica, Duncan and Arrow Reservoirs to achieve desired flood control objectives in the United States and Canada. The purpose of including Libby Reservoir in the Flood Control Operating Plan is to meet the Treaty requirement to coordinate its operation for flood control protection in Canada. Because Canadian storage is an integral part of the overall Columbia River reservoir system, flood control operation plans for this storage must be related to the flood control plan of the Columbia River as a whole. The principles of the Columbia River system operation are therefore contained in the document. Detailed operating instructions for each of the four Treaty projects are presented, together with appropriate Flood Control Storage Reservation Diagrams and other working curves.

1-3. Changes. Annex A, paragraph 5 of the Treaty states that "After consultation with the Canadian Entity the United States Entity may from time to time as conditions warrant adjust these storage reservation diagrams within the general limitation of flood control operation." Accordingly, appropriate storage reservoir diagrams and text contained in this document will be changed in the future if new regulation criteria or objectives warrant such a change.

1-4. References.

a. The following are the references to flood control rights, requirements, and objectives contained in the Columbia River Treaty documents:

1. Operation by Canada--Article IV of the Treaty between the United States and Canada, dated 17 January 1961.
2. Payment for Flood Control--Article VI and XIV.
3. Kootenai River Development--Article XII.
4. Principles of Operation--Annex A, Paragraph 5.
5. Details of flood control operation--Paragraphs 1, 2, and 5 of Protocol, Annex to Exchange of Notes, dated 22 January 1964.

1-5. Treaty Organization. The organizational body primarily responsible for the implementation of the Flood Control Operating Plan is the Columbia River Treaty Operating Committee. This committee is composed of representatives of the Canadian and United States Entities, and is charged with the responsibility to prepare and implement Assured Operating Plans and Detailed Operating Plans in accordance with the Principles and Procedures and the Flood Control Operating Plan. The Operating Committee, which functions as a single international coordinating body, is organized into a Canadian and a United States Section with each Section responsible for coordination with interested groups, bodies, and agencies in its country. The United States Section of the Operating Committee is composed of members of Bonneville Power Administration and the Northwestern Division, North Pacific Region, Corps of Engineers (formerly the North Pacific Division).

The Canadian Section is composed of members of British Columbia Hydro and Power Authority. Each Section of the Operating Committee is responsible to its respective Entity, through their respective Coordinator.

1-6. Flood Control System Design. The Main Water Control Plan for the Columbia River was prepared by the Corps of Engineers for the Columbia River Review Report of 1948, House Document 531, 81st Congress, 2nd Session. About 23,000,000 acre-feet of upstream reservoir storage in the United States was proposed for flood regulation for the lower Columbia River. The principle objective was to reduce the 1894 flood of record (natural flow of 1,240,000 cubic feet per second (cfs)) to a regulated flow of 800,000 cfs as measured at The Dalles, Oregon. A secondary objective was to control flows to below 600,000 cfs whenever possible, major flood damage begins at about 600,000 cfs in the lower Columbia. However, several of the reservoir storage projects proposed in the water control plan proved to be infeasible to construct. This led to a re-examination of the projects proposed in the 1948 Review Report in the mid-to-late 1950's. During this same time, negotiations were conducted between the United States and Canada on development of storage projects within the Canadian portion of the Columbia River Basin and technical studies were performed that supported the Treaty negotiations. The technical work is documented in Special Inter-Agency Study, United States and Canadian Storage Projects, Columbia River and Tributaries, January 1955. Canadian storage was eventually adopted into the Main Water Control Plan replacing storage projects in the United States that were no longer possible to build. This is described in the Corps of Engineers' Columbia River Review Report of 1958 (with Supplement Report on Canadian Storage), House Document 403, 87th Congress, 2nd Session. The design principles of reducing the 1894 flood to 800,000 cfs and controlling flows to below 600,000 cfs whenever possible were used in the development and allocation of flood control storage space in Canada.

1-7. Development of Flood Control Operating Plan. The initial development of the Flood Control Operating Plan for Canadian storage was performed in 1965. The United States Entity was represented by members of the North Pacific Division, Corps of Engineers, Bonneville Power Administration, and the Bureau of Reclamation. The Canadian Entity was represented by members of British Columbia Hydro and Power Authority. Upon completion of the Flood Control Operating Plan in draft form in 1968, the Task Force was dissolved. In 1971 the Flood Control Operating Plan was updated and modified by the Corps of Engineers in certain details to reflect changed conditions since 1968; however, this plan preserves the essence of the original draft. The revised version was reviewed in 1972 by the Columbia River Treaty Operating Committee. Inasmuch as the Flood Control Operating Plan for Columbia River Treaty Storage is but a part of the overall Flood Control Plan for the Columbia River Basin, the technical studies were performed and the operating criteria were developed by the North Pacific Division, Corps of Engineers to assure the development of a plan which would integrate the flood regulation in both the United States and Canada. The initial Flood Control Operating Plan was based upon flood regulation studies made using spring runoff data for the period 1928-1958, as well as for the Columbia River Basin Standard Project Flood and the historical flood of record, the 1894 flood. Operating rules were established with an objective of providing regulation procedures that would apply for large, as well as small floods, that would be self-adjusting to cope with under or over forecasted events; and that would be consistent with the criteria of refilling reservoirs. Using unregulated daily flows for each flood event in the study period, the system operation was simulated by digital computer to test the operating criteria. These simulations reflected the best estimate of the extent of reservoir evacuation prior to the flood to serve power demands for the 1980 load year, and utilized volume-of-runoff forecasts simulated from recorded meteorological data. The development of the Flood Control Operating Plan is described in Flood Regulation by Columbia Treaty Projects, January 1971, a paper written by the principle engineers of the work and published in the American Society of Civil Engineers' Hydraulics Journal.

1-8. Revisions to the 1972 Flood Control Operating Plan as Published in 1999. The 1999 revision to the Flood Control Operation Plan was initiated in response to changes in flood control criteria and the development of new procedures that have taken place since the original document was completed. Key revisions to the 1972 plan are listed below:

a. Update to flood stage information for Bonners Ferry, Montana in Section IV.

b. New storage reservation diagrams for Mica and Arrow that represent a maximum allowable exchange of flood control space of 3,500,000 acre-feet from Arrow to Mica. The development of these diagrams is documented in the Corps' Summary Report, Proposed Reallocation of Flood Control Space, Mica and Arrow Reservoirs, March 31, 1995. This work was prepared for the Operating Committee at the request of the Canadian Section.

c. Removal of the reference to reservoir elevations in the 1972 Mica storage reservation diagram. This was requested by the Canadian Section in the fall of 1997.

d. Replacement of the 1972 Libby storage reservation diagram with a diagram revised in 1987. The development of the 1987 diagram is documented in the Corps' Review of Flood Control, Columbia River Basin, Columbia River and Tributaries Study, CRT-63, June 1991.

e. Addition of a procedure to help guide the spring refill operation at Libby and Duncan when full flood control evacuation is not achieved due to IJC requirements at Kootenay Lake. This procedure was a by-product of regulation studies documented in the Corps' Status Report, Work to Date on the Development of the VARQ Flood Control Operation at Libby Dam and Hungry Horse Dam, January 1999.

f. Removal of the September 1972 flood control outflow diagrams for Libby and Mica. This change was initiated following regulation studies performed for the Corps' Columbia River Basin, System Flood Control Review, Preliminary Analysis Report, February 1997.

g. Modification to the irrigation depletion adjustment on Chart 2 for determining upstream storage corrections used in the computation of the control flow at The Dalles. This change is based on a comparison of the current level of irrigation documented in BPA's Modified Streamflows, 1990 Level of Irrigation, Columbia River and Coastal Basins, 1928-1990, July 1993, with irrigation levels in the 1972 plan that were projected to occur in future years.

h. General clarification of the flood control procedure.

1-9. Revisions to the 1999 Flood Control Operating Plan. This 2003 revision to the Flood Control Operation Plan (FCOP) was initiated to respond to several errata items in the 1999 FCOP update, to more clearly define the procedures for the effective transfer of storage between Mica and Arrow, and to update the on-call storage procedures with respect to timing of the request of said storage. Key revisions to the 1999 plan are listed below:

a. Equation in Section 6-6.b.(3) computed only the Mica end-of-March draft point. The equation was updated to compute the end-of-December draft point as indicated by the text in that section. Table 3 was re-done to reflect the corrected equation.

b. Table 2 contained erroneous data. Entries repaired and footnotes made more explanatory.

c. Chart 8 had a mis-labeled curve. It was corrected.

d. Some portions of the text of Section 6-6 were omitted from the 1999 update. Specifically, provisions for notification of the U.S. Entity by the Canadian Entity of the amount of Mica-Arrow flood control swap and establishment of the AOP as the default Mica-Arrow flood control swap were re-instated. The new text was fully coordinated with and approved by the Treaty Operating Committee.

e. In Appendix A, the text indicates that consultation for acquisition of on-call storage may start as early as 01 January. Charts 5 and 9, on-call storage reservation diagrams for Arrow and Mica, respectively, indicate that drawing on on-call storage may begin as early as 01 Demember. The text in Appendix A was made consistent with the aforementioned charts and was modified to more realistically reflect how early in the year consultations for acquiring on-call storage must begin.

f. Chart 1-A was updated to include data through the 2002 Water Year.

II - PRINCIPLES OF COLUMBIA RIVER FLOOD CONTROL REGULATION

2-1. Flood Control Objective. The basic objective for flood regulation is to operate reservoirs to reduce to non-damaging levels the stages at all potential flood damage areas in Canada and the United States insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space. Flood control regulation is composed of the following elements:

a. Procedures to develop forecasts of seasonal runoff volume and daily streamflows.

b. Storage reservation diagrams to define the flood control storage space required in each reservoir as a function of the time of year and the seasonal runoff volume. The diagrams are designed to provide an orderly drawdown of each reservoir prior to the reservoir refill period with consideration to project and functional operating limits.

c. Procedures to develop and adjust flood control flow targets for the lower Columbia River as measured at The Dalles, Oregon. The controlled flow is designed to prevent reservoir space from filling too soon, thus resulting in damaging uncontrolled flows in the lower Columbia River. The first controlled flow of the runoff season is called the Initial Controlled Flow (ICF).

d. Procedures to guide refill of flood control space at each reservoir with consideration to assured refill criteria. The flood control regulation is to be conducted in a manner that does not jeopardize refill of reservoirs insofar as possible.

e. Local flood control operating criteria and project operating limits.

2-2. Columbia River Flood Characteristics. Flood flows are typically experienced in the Columbia River Basin during May and June as a result of the melting of the accumulated winter snowpack. Maximum flood peaks result from heavy snow accumulation and a prolonged period of intense snowmelt, occasionally augmented by heavy rain. Natural streamflow recedes during July and August and remains at relatively low levels throughout the winter. Occasionally, heavy rains augmented by unseasonable low-elevation snowmelt, can cause flood flows in the lower Columbia River and its tributaries during the fall and winter months.

2-3. Seasonal Regulation. The general nature of the flood control operation involves two seasonal periods, the reservoir evacuation period (normally the low water period from October through March), and the reservoir refill period (normally the high-flow period from May through July).

2-4. Evacuation of Reservoirs. At the end of summer, reservoirs are usually close to full after storing water during the spring runoff while meeting water resource objectives for hydropower generation, recreation, and instream fishery flows. In the fall, from late October through early December, a small amount of storage space is required at Mica and Arrow to assure that releases do not exceed natural magnitudes if flooding is occurring in the lower Columbia River. In the winter months, reservoirs are drafted in accordance with their storage reservation diagrams to provide storage space for the spring runoff. The storage reservation diagrams are designed to require flood control storage space be made available prior to April 1 of each year. Evacuating the reservoirs prior to 1 April is done for a number of reasons. It positions the reservoirs for the possibility of requiring flood regulation in April due to early spring runoff. It avoids the problem of being unable to draft reservoirs in April, if so required, due to high streamflows. And, it allows major lakes to fall to normal minimum elevations under free-flow conditions and reach equilibrium prior to the spring runoff. In order to assure the required flood control storage space is achieved prior to 1 April and the drawdown is done in an orderly manner with consideration to project operating limits, it is necessary to initiate evacuation of reservoirs by either 1 December or 1 January.

2-5. Refill of Reservoirs. Refill of reservoirs generally occurs during the high flow period from April through July. Depending on the distribution of the spring runoff, refill can extend into August. Normally, the reservoirs are at or near their minimum annual drawdown levels during April, and either evacuation or refill of reservoir storage may occur during April depending upon runoff conditions. Refill is initiated by either the system flood control operation that is necessary to meet the controlled flow for the lower Columbia River as measured at The Dalles, Oregon, to meet assured refill criteria as determined by flood control refill curves, or to meet other objectives of the agreed-to hydroelectric plan as per Article XIV(2)h of the Treaty. Reservoirs are divided into five major categories according to the operating rules for accomplishing refill (see section 2-8).

2-6. Controlled Flow at The Dalles. The controlled flow is the target flow for lower Columbia River flood control as measured at The Dalles, Oregon. Storage in upstream reservoirs to meet flood control objectives at this point generally will result in adequate control at other flood damage areas in Canada and the United States. Should flood control at the upstream points be jeopardized by the controlled flow regulation at The Dalles, however, the regulation procedures will be modified in accordance with the detailed rules in sections 2-8, 5-3, 6-3, 8-2, and 9-2 of the Flood Control Operating Plan. The controlled flow is a function of the projected volume of the Columbia River spring runoff as measured at The Dalles, Oregon and the amount of upstream storage space that is available for system flood control. Refill of upstream reservoir storage is regulated in a manner that provides the desired controlled flow at The Dalles. While a discharge of 450,000 cfs is considered a bank-full level, higher controlled flows will be used for high magnitude floods to prevent storage space from filling too soon, thus resulting in damaging uncontrolled flows in the lower Columbia. The first controlled flow of the runoff season is called the ICF. The ICF is used in conjunction with unregulated streamflow forecasts to guide the determination of when to begin refill of reservoirs.

2-7. Flood Control Refill Curves. Flood Control Refill Curves help guide the refill of reservoirs during the spring refill period and ensure the flood control regulation does not adversely affect refill insofar as possible. They define the lower limit of reservoir drawdown that can be filled with a 95 percent assurance. Their derivation is based on the current 95 percent exceedance volume runoff forecast corrected for refill of upstream storage and project outflows that are anticipated to occur during the ensuing flood season. They are updated daily, if necessary, using the residual volume inflow forecast and computer simulations of forecasted streamflow and reservoir regulation to predict the distribution of runoff. Daily inflows into the reservoirs are accounted for and deducted from the 95 percent confidence inflow forecast to determine the residual volume inflow forecast.

2-8. Reservoir Categorization. The rules and diagrams required to accomplish refill of storage space divide the reservoirs in the Columbia River system into the following five major categories.

CATEGORY I - Reservoirs operated under fixed releases primarily for flood control of the lower Columbia.

Reservoirs in this category are on upstream tributaries of the Columbia River and cannot be operated on a day-to-day basis for flood control of the lower Columbia due mainly to the relatively long time that it takes for a change in the outflow at these reservoirs to have a significant effect upon streamflow in the lower Columbia River as measured at The Dalles, Oregon. Hungry Horse, Libby, Duncan, Mica and Brownlee are examples of reservoirs in this category. These reservoirs are operated to a specified release based on the volume of runoff forecast at the reservoirs, and this release will be maintained until the reservoir is filled or it becomes necessary to adjust the specified release because of the runoff pattern, a modified forecast, or because the reservoir is nearly full and the inflows are forecast to continue at a high rate. Downstream from most of the reservoirs in this category there are local flood hazard areas and the fixed release pattern may have to be changed occasionally to provide better flood protection in these areas. Usually, the storage operation required at these reservoirs for protection at major damage areas downstream will result in the necessary local flood protection with little modification.

CATEGORY II - Reservoirs operated for tributary flood protection with incidental flood regulation for the lower Columbia.

Most of the reservoirs in this category are used mainly to provide irrigation water. Flood control use for certain of these reservoirs is available under formal operating agreements. For others, flood control benefits will be obtained through informal arrangements calling for delayed filling. The Upper Snake River, the Boise River, Payette River and the Yakima River Basin Reservoirs are examples of this category.

CATEGORY III - Major lakes with projects operated to control lake elevations during non-flood period.

There are several major natural lakes in the upper Columbia Basin controlled by dams during the low-flow period. The regulation of these lakes during the high-flow period is such that the natural storage effect of the lakes is preserved to the maximum extent possible. There are limiting factors, however, that must be considered in the interest of local conditions. Kootenay, Flathead, and Pend Oreille Lakes are examples of this category.

CATEGORY IV - Reservoirs operated with variable releases primarily for flood control of the lower Columbia.

Reservoirs in this category are those in which outflows have a relatively brief time of travel (two days or less) to the lower Columbia flood area, and have sufficient flexibility to permit variable releases on a day-to-day forecast basis. These reservoirs provide the final major storage regulation of the flood control system and are used primarily to maintain the desired controlled flow in the lower Columbia and at the same time provide local flood protection. John Day, Grand Coulee and Arrow Reservoirs are in this category.

CATEGORY V - Run-of-River Projects on the main stem Columbia and major tributaries.

Run-of-river projects have only limited reservoir storage capacity, which is used primarily for power pondage. Provisions are made in the operating requirements for these run-of-river projects to replace the volume of valley storage lost due to the construction of these reservoirs. The effect of the run-of-river projects on the total regulation of the Columbia River flood flows is minor, but the operating requirements for these projects provide for establishment of specific outflows individually on a day-to-day basis, for Columbia River flood regulation. Chief Joseph, Wanapum, Priest Rapids, McNary, and Bonneville projects are example of this category.

III - FLOOD CONTROL STORAGE SPACE REQUIREMENTS

3-1. Primary Storage. The Columbia River Treaty refers to two types of flood control storage space that will be provided by Canadian storage. Storage space, which is committed for use, is herein defined as Primary Storage. The volumes of Primary Storage are defined in Article IV, paragraph 2(a) of the Treaty as being 1,270,000 acre-feet at Duncan, 7,100,000 acre-feet at Arrow, and 80,000 acre-feet at Mica projects. The same paragraph also stipulates that the Canadian Entity may exchange flood control storage at Arrow for flood control storage additional to that defined above at Mica, provided the Entities agree that the exchange would provide the same effectiveness for control of floods on the Columbia River at The Dalles, Oregon. Following the ratification of the Treaty in September 1964, a mutual agreement between the Entities exchanged 2,000,000 acre-feet of flood control space from Arrow to Mica. This exchange combination of 5,100,000 acre-feet in Arrow and 2,080,000 acre-feet in Mica is contained in the original 1972 Flood Control Operating Plan. In 1995, at the request of the Canadian Entity, the U.S. Entity completed an analysis of exchanging additional flood control space from Arrow to Mica. The U.S. Entity concluded that an additional exchange up to 1,500,000 acre-feet to Mica (3,500,000 acre-feet total transfer) would not adversely affect flood control as measured at The Dalles and at Birchbank, as long as the Canadian Entity agreed to augment the storage space in Mica with 500,000 acre-feet of storage space. This resulted in a flood control combination of 3,600,000 acre-feet at Arrow and 4,080,000 acre-feet at Mica. Canada can choose to exchange flood control space up to these maximum amounts and the appropriate storage reservation diagrams for Arrow and Mica will be prepared in accordance with the procedures set forth in paragraph 6-6.

3-2. On-Call Storage. Article IV, paragraph 2(b) of the Columbia River Treaty requires that Canada shall operate any storage in addition to the Primary Storage in the Columbia River Basin in Canada, within the limits of existing facilities, as the United States Entity requires to meet flood control needs in the United States that cannot adequately be met by the flood control facilities in the United States and Primary Storage. Paragraph I(1) of the Protocol further defines this need as arising only in the case of potential floods which would result in a peak discharge in excess of 600,000 cfs at The Dalles after the use of all related United States storage capacity existing and under construction in January 1961, Libby storage, and the Primary Storage. A complete description of the On-Call storage flood control procedure is contained in Appendix A.

3-3. Flood Control Storage Use after the Expiration of 60 Years. Article IV, paragraph (3) of the Columbia River Treaty requires that Canada shall continue to operate, within the limits of existing facilities, any storage in the Columbia River Basin in Canada to meet the needs of flood control in the United States. Canada will receive payment for flood control as per Article VI, paragraph (4) when called upon by the United States. Paragraph I(2) of the Protocol establishes the need for the use of Canadian storage as: "The United States entity will call upon Canada to operate storage under Article IV(3) of the Treaty only to control potential floods in the United States of America that could not be adequately controlled by all the related storage facilities in the United States of America existing at the expiration of 60 years from the ratification date but in no event shall Canada be required to provide any greater degree of flood control under Article IV(3) of the Treaty than that provided for under Article IV(2) of the Treaty." The operation of Canadian storage if called upon, will be based on the same type of operation as established under this Flood Control Operating Plan.

IV - FLOOD PROTECTION OBJECTIVES

4-1. Basic Flood Protection Objective. The basic objective for flood regulation is to operate reservoirs to reduce to non-damaging levels the stages at all potential flood damage areas insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space. The stages at which damages commence and hence the limits to which the flows should be reduced have been established for this document considering the existing state of development and are subject to review in the future. Canadian storage will be operated (together with United States storage projects) to control floods to non-damaging levels wherever possible, in accordance with the following objectives.

4-2. Columbia River in the United States. Flooding in the Columbia River downstream from the mouth of the Snake River begins when the river reaches elevation 17.8 feet NGVD (1959 USGS adjustment) at Vancouver, Washington (16 feet, Columbia River Datum). The corresponding flow measured at The Dalles, Oregon is approximately 450,000 cfs. Significant damage begins at elevation 24 feet NGVD (22.2 feet, Columbia River Datum). The corresponding flow at The Dalles, Oregon is approximately 600,000 cfs. Because large floods cannot be regulated to 450,000 cfs, the desired goal is to control major floods to 600,000 cfs in the lower Columbia River at The Dalles. Damage commences in the mid-Columbia area in the vicinity of Hanford, Washington, when flows reach 400,000 cfs as measured at the Priest Rapids project. The regulation required for The Dalles normally will achieve the desired protection in the mid-Columbia area.

4-3. Columbia River in Canada. At Revelstoke, major damage occurs when the river stage exceeds elevation 1,450 feet (Geodetic Survey of Canada (GSC) 1961 datum) as measured at the highway bridge. Flows at Revelstoke should not exceed 200,000 cfs with Arrow Reservoir at elevation 1,446 feet. Damage commences at Castlegar when the stage exceeds elevation 1,400 feet and major damages occur when the stage rises above elevation 1,405 feet. It is assumed that if flood control requirements at Trail are met this will achieve flood protection at Castlegar. Damage commences at Trail when flows exceed 225,000 cfs as measured at the gage at Birchbank and it is a desired goal to limit major floods to 280,000 cfs. These flows correspond to elevations at the old highway bridge at Trail of about 1,347 feet and 1,352 feet (GSC 1951 datum).

4-4. Kootenai River in United States and Canada. The river stage at Bonners Ferry, Idaho is influenced by the backwater effects of Kootenay Lake and the amount of flow in the Kootenai River. Flood damage at Bonners Ferry, Idaho, occurs when the stage exceeds 1764 feet NGVD (approximately 50,000 cfs when Kootenay Lake is at 1750 feet NGVD). This was determined in 1997 following a levee survey study conducted by the Seattle District, Corps of Engineers for the Columbia River Basin, System Flood Control Review, Preliminary Analysis Report, February 1997. Originally, flood damage began at 1770 feet NVGD (approximately 75,000 cfs when Kootenay Lake is at 1750 feet NGVD) and the authorization of Libby and its associated water control plans were designed to this stage. In some years local inflow downstream from Libby Dam may cause the flood stage of 1764 feet to be exceeded so that control to this limit will not always be possible. Major damage at Bonners Ferry occurs at 1774 feet NGVD. The major damage stage at Creston, B.C. is elevation 1,763 feet, GSC 1961 datum. It is considered that if the stage at Bonners Ferry is controlled to 1770 feet, flood protection at Creston will be achieved. Damage commences at Nelson when Kootenay Lake reaches elevation 1,755 feet and major damage stage is elevation 1,759 feet, both GSC 1961 datum.

V - SYSTEM FLOOD CONTROL OPERATION

5-1. Definition of Control Periods. As described in Section II, there are two basic seasonal periods for flood control regulation of the annual spring snowmelt runoff in the Columbia River Basin, the period covering the evacuation of reservoirs and the period spanning the refill of reservoirs. These flood control regulation periods are formally called the Flood Control Storage Evacuation Period and the Flood Control Refill Period.

a. The Flood Control Storage Evacuation Period is defined as that period beginning when evacuation is required by the Flood Control Storage Reservation Diagrams contained in this plan, and ending with the beginning of the Flood Control Refill Period.

b. The Flood Control Refill Period is defined as commencing 20 days prior to the date the unregulated mean daily discharge is forecast to exceed 450,000 cfs at The Dalles, Oregon. The unregulated discharge at The Dalles is the mean daily discharge that would occur without regulation of upstream storage reservoirs in the basin, and with the storage effects of natural lakes based on presently existing outlet restrictions with control dams on freeflow. The end of the Flood Control Refill Period will be when no further flood potential exists at any of the damage areas described in Section IV.

5-2. System Operation During the Flood Control Storage Evacuation Period. Drawdown of reservoirs during the Flood Control Storage Evacuation Period is based on the rules and rule curves contained in the agreed-to hydroelectric operating plans and with the Flood Control Storage Reservation Diagrams presented in this report. The flood control space requirements are based upon monthly forecasts of volume runoff. If volume forecasts as late as 1 April or 1 May indicate that it is necessary to evacuate additional storage in order to provide required flood control storage space, such evacuation will be made as soon as possible within the limits of discharge capacity at each project. To the extent possible, project outflows during evacuation will be limited so that downstream channel capacities and flood stages are not exceeded, both locally and at The Dalles, Oregon. The storage space at each project required for flood regulation will be held vacant until storing is required during the Flood Control Refill Period in accordance with the guidelines set forth in this plan.

5-3. System Operation during the Flood Control Refill Period. Refill of reservoirs during the Flood Control Refill Period is based on the rules and rule curves in this plan and in the agreed-to hydroelectric operating plans. The basic objective of the system flood control operation during the Flood Control Refill Period is to regulate the flood runoff to non-damaging levels if possible and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available flood control storage space. This day-to-day regulation is accomplished by first establishing a controlled flow objective at The Dalles and adjusting releases from Category I and Category IV storage projects to meet that controlled flow. The rules governing the refill of Category I through IV reservoirs are described in Paragraph 2.8. The procedure to determine the controlled flow for the Columbia River at The Dalles is described in Paragraphs 5.4 and 5.5. Flood Control Refill Curves help guide the refill of reservoirs. The development of these curves is discussed in Paragraph 5-6.

5-4. Establishment of the ICF. Chart 1 will be used to establish the ICF to which control will be attempted at The Dalles. The ICF is a function of the seasonal volume runoff forecast adjusted for major upstream reservoir storage. Chart 2 will be used to compute the deductions for upstream storage and are based on the storage space usable for flood regulation during the refill period. The usable space is based upon the space estimated to be available at the start of the refill period minus anticipated natural and involuntary storage. Storage corrections are not made for all reservoirs listed in Table 1, inasmuch as the effects of some of the reservoirs are minor or are included in the forecasting procedures. Storage effects of future reservoir projects may be included in the computation of storage corrections required for use in Chart 1, at such time as they become operational. Intermediate values of the ICF will be interpolated between month-end values shown in Chart 1, using residual runoff volume forecasts computed on a daily basis.

5-5. Adjustment of the Controlled Flow. The ICF established by Chart 1 will be maintained by the regulation of upstream reservoirs until the end of the flood control period, or until revised forecasts indicate the necessity for the controlled flow to be changed. Change in the controlled flow at The Dalles will be made based primarily upon day-to-day forecasts of streamflow and reservoir regulation by computer simulations, together with the latest volume forecasts of runoff. Additional guidance in adjusting the controlled flow during the period of flood regulation can be obtained by referring to Chart 3. This chart defines the controlled flow at The Dalles as a function of the forecasted runoff on the date of the ICF and the percent of storage space filled in Category IV projects.

5-6. Computation of Flood Control Refill Curves. Flood Control Refill Curves help guide the refill of reservoirs during the spring refill period and ensure the flood control regulation does not adversely affect refill insofar as possible. Refill can commence prior to regulation to meet the ICF at The Dalles, Oregon if the reservoir is at or below its Flood Control Refill Curve. The curve defines the lower limit of reservoir drawdown that can be filled with a 95 percent assurance. Their derivation is based on the current 95 percent exceedance volume runoff forecast corrected for refill of upstream storage and outflows projected to occur during the ensuing flood season. They are updated daily, if necessary, using the residual volume inflow forecast and computer simulations of forecasted streamflow and reservoir regulation to predict the distribution of runoff. The curves are calculated by subtracting the sum of the following components from the first-of-month 95 percent assured inflow forecast: the accumulated runoff from 1 May to date, the upstream storage space to be filled, and the anticipated project outflow for the balance of the refill period. A sample form for making this computation is shown as Table 2.

VI - OPERATION OF ARROW RESERVOIR

6-1. Operating Rules during the Flood Control Storage Evacuation Period. The amount of Primary Storage space to be supplied at Arrow will be based on the forecast volume of runoff at The Dalles. Chart 4 is the Flood Control Storage Reservation Diagram for a 5,100,000 acre-feet space allocation of primary storage that was adopted in 1972. Chart 4 reflects an exchange of two million acre-feet of flood control storage from Arrow to Mica. Chart 5 is the Flood Control Storage Reservation Diagram for a 3,600,000 acre-foot allocation of primary storage space, which reflects a total of 3,500,000 acre-foot exchange from Arrow to Mica. This is the maximum amount of flood control space that can be exchanged from Arrow to Mica without adversely affecting flood control at The Dalles, provided that 500,000 acre-feet of additional storage is provided in Mica. The development of Chart 5 is documented in the Corps' Summary Report, Proposed Reallocation of Flood Control Space, Mica and Arrow Reservoirs, March 31, 1995. Such exchange of flood control space between Arrow and Mica is provided for in Paragraph 5(d), Annex A, of the Treaty. Agreement on the amount of storage space to be exchanged each year and preparation of an appropriate Flood Control Storage Reservation Diagram will be provided in accordance with Paragraph 6-6 below. In order to provide approximately 250,000 acre-feet of required storage space to assure that releases do not exceed natural magnitudes during October through December, the Canadian Entity may utilize the surcharge storage space between elevation 1,444 and 1,446 feet. This space would be in lieu of the required evacuation of 250,000 of storage contents below elevation 1,444 feet, as shown on Charts 4 and 5.

6-2. Operating Rules during the Flood Control Refill Period.

a. Following flood control evacuation Arrow Reservoir will be regulated so that it does not exceed the elevations corresponding to the storage requirement during April and May, as defined by its Storage Reservation Diagram, until storage of water for flood control or refill commences, or involuntary storage occurs as the result of inflows exceeding the maximum discharge capacity of all project facilities. Arrow Reservoir is a Category IV reservoir in the system regulation of the annual Columbia River runoff (see Paragraph 2-8). Controlled storage of water in Arrow for flood control will commence two days prior to the time that the unregulated mean daily discharge at The Dalles is forecast to exceed the ICF. The ICF will be determined in accordance with the procedure outlined in Paragraph 5.4.

b. Releases from Arrow project during the Flood Control Refill Period will be based primarily on computer simulations of forecasted streamflow and reservoir regulation of the Columbia River system above The Dalles, to be made daily throughout the Flood Control Refill Period. The storage of water at Arrow, together with the storage at the other two Category IV projects (Grand Coulee and John Day) will be adjusted to provide the required controlled flow at The Dalles (see Paragraph 5-5). The rate of filling of Arrow storage space can be guided by the use of Chart 6, which specifies the percent of daily total Grand Coulee and Arrow storage increment that is to be stored at Grand Coulee.

c. In years when the unregulated volume of runoff at The Dalles is forecast to equal or exceed the 1894 flood runoff, and 7,100,000 acre-feet of storage space has been evacuated in accordance with On-Call requirements, storage to elevation 1,446 feet will be required to supply the necessary flood control storage. In years when the unregulated volume of runoff is forecast to be less than 1894 flood runoff but greater than normal in Canada, the Canadian Entity after consulting with the United States Entity may use the additional storage between elevations 1,444 and 1,446 feet for flood control in Canada.

d. If the storage space available for refill exceeds that indicated by Arrow's Storage Reservation Diagram, then the above operating rules are applicable only to the storage amounts required for flood control. Outflows during the filling of the excess storage space may be modified from those specified above if required to serve Firm Energy Load Carrying Capability (FELCC, defined in "Pacific Northwest Coordination

Agreement", September, 1964) or to meet other objectives of the agreed-to hydroelectric operating plan. If the excess storage space is filled in this manner, then the United States Section may specify the beginning of the Arrow flood control operation as other than that defined in this section. The duration of storage under each operation will be determined by accumulating the amount of water stored. During the filling of excess storage space, outflows will be limited so that damage levels described in Section IV will not be exceeded.

6-3. <u>Flood Control in Canada.</u> If the rate of filling vacated storage at Arrow required to control the flow at Trail, BC exceeds the rate of storage requirement for control of the lower Columbia, the requirement for Trail will take precedence, and to the extent possible appropriate adjustments will be made at other Category IV projects to compensate for this effect. In cases when additional storage space in Arrow Reservoir between elevation 1,444 and 1,446 feet is operated for the purpose of flood control in Canada, the operation of the additional storage will be established on the basis of short-term streamflow and reservoir simulation for the Columbia River Basin above Trail.

6-4. <u>Flood Control Refill Curve.</u> The Flood Control Refill Curve for Arrow project will be used to help guide refill from 1 April through 31 July. It identifies the maximum space that can be refilled with 95 percent confidence. This curve will be computed daily using the latest available 95 percent volumetric runoff forecasts of residual inflow volume to Arrow Reservoir corrected for upstream storage at Mica. If at any time during the refill period, the elevation of Arrow Reservoir is at or below the elevation determined by the Flood Control Refill Curve, the mean daily outflow may be reduced to 5,000 cfs or the minimum outflow established by the appropriate Detailed Operating Plan, unless higher flows are required to serve FELCC or to meet other objectives of the agreed-to hydroelectric plan. At such time as it is determined by the Operating Committee that the danger of flooding has passed, both in the United States and Canada, and the elevation of Arrow Reservoir is above the Flood Control Refill Curve, the outflow of Arrow project may be increased to approach the inflow, so as to decrease the rate of filling and minimize the chance of sudden increases in outflow when the reservoir is full. The outflow from Arrow project will be based on simulations of forecasted streamflow and reservoir regulation and the elevation of the reservoir will not be required to be lower than that determined by the Flood Control Refill Curve.

6-5. Operating Limits. The maximum outflows required from the Arrow project shall be within the limits of the project outflow capacity as agreed in the Report on the Arrow Project dated 25 August 1965. The minimum average weekly outflow for the Arrow project is 5,000 cfs. The maximum rate of change in Arrow project's outflow for flood control is normally 25,000 cfs per day unless a larger change is necessary to accomplish the objectives of the plan. The normal full reservoir elevation for the Arrow project is elevation 1,444 feet (except it shall be elevation 1,446 feet in maximum flood years, as defined in paragraph 6-1), and the minimum reservoir elevation is approximately 1,378 feet as measured in Lower Arrow Lake. These operating limits may be modified or added to from time to time as agreed by the Entities.

6-6. Exchange of Storage between Mica and Arrow. As provided for under the Treaty, Canada may exchange flood control storage space between Mica and Arrow if the Entities agree that the exchange gives the same degree of flood protection at The Dalles. The Corps' Summary Report, Proposed Reallocation of Flood Control Space, Mica and Arrow Reservoirs, March 31, 1995, confirms that both a 3.6 / 4.08 and 5.1 / 2.08 MAF allocation of primary flood control space between Arrow and Mica, respectively, provides an equivalent level of flood protection at The Dalles. The Corps assumes that the default allocation of primary flood control space selected in the appropriate Assured Operating Plan (AOP) is the expected flood control operation. During preparation of the DOP, the Canadian Entity may select a flood control storage space combination between Arrow and Mica consistent with the requirements of this Section that is different than was included in the AOP. During the operating year, but no later than 1 November, Canada may select a flood control storage space combination between Arrow and Mica consistent with the requirements of this Section that is different than was included in the DOP. Appropriate revisions to the Arrow and Mica Flood Control Storage Reservation Diagrams will be prepared by the United States Entity in the following manner to reflect the agreed storage exchange. An example of this process is contained in Table 3.

a. Arrow.

(1) The new Storage Reservation Diagram is constructed by proportionally adjusting the rule curves of Chart 4 (5.1 million acre-feet maximum draft) to reflect the new maximum draft amount. The revised 31 December and 31 March draft points at Arrow for a given water supply forecast is computed by (units in million acre-feet):

$$\text{Draft}_{\text{Arrow Revised}} = \text{Draft}_{\text{Chart4}} * \left(\left(5.1 - \text{Exchange}\right)/5.1\right)$$

Where the maximum additional exchange is 1.5 million acre-feet which is equivalent to the maximum Arrow draft of 3.6 million acre-feet on Chart 5.

(2) The end-of-month draft requirements for January and February are linearly interpolated from the 31 December and the 31 March required draft amounts.

(3) The 31 October and 30 November draft amounts remain at 250,000 acre-feet.

b. Mica.

(1) The 0.5 million acre-feet of Mica compensation storage (CS) is directly proportional to the amount exchanged and is computed by (Exchange and CS are in millions of acre-feet):

$$\text{CS} = \text{Exchange} * (0.5/1.5)$$

(2) The new Storage Reservation Diagram is constructed by proportionally adjusting the rule curves of Chart 7 (2.08 million acre-feet maximum draft) to reflect the additional exchange amount, plus the Mica compensation storage. The revised 31 December and

31 March draft points at Mica for a given water supply forecast are computed by (units in million acre-feet):

$$\text{Draft}_{\text{Mica Revised}} = \left(\frac{2.08 + \text{Exchange} + \text{CS}}{2.08} \right) * \text{Draft}_{\text{Mica Chart7}}$$

(3) The end-of-month draft requirements for January and February are linearly interpolated from the 31 December and the 31 March required draft amounts.

(4) The 31 October and 30 November draft amounts remain at 200,000 acre-feet.

6-7. Regulation during Fall and Winter Floods. In the event of occurrence of winter floods in the lower Columbia River, Arrow project will be operated so that insofar as possible, outflow will not exceed the natural lake outflow which would have occurred prior to the construction of Arrow or Mica project or any future project upstream of Arrow Reservoir. Water stored during this operation will be evacuated at the direction of the Operating Committee following the flood. No more than 250,000 acre-feet of storage space in Arrow Reservoir will be obligated for this operation. The Canadian Entity may utilize the storage space between elevation 1,444 and 1,446 feet. This space would be in lieu of the required evacuation of 250,000 acre-feet of storage contents below elevation 1,444 feet, as shown on the Flood Control Storage Reservation Diagram.

VII - OPERATION OF MICA RESERVOIR

7-1. Operating Rules during the Flood Control Storage Evacuation Period. The Flood Control Storage Reservation Diagram, Chart 7, shows the Primary Storage requirement for each month-end during the evacuation period as a function of volume forecasts at The Dalles. This chart reflects an exchange from Arrow to Mica of 2,000,000 acre-feet of flood control storage space that was adopted in 1972. Chart 8 is the Flood Control Storage Reservation Diagram for a 4,080,000 acre-feet allocation of primary storage space which is the maximum limit of flood control space that can be exchanged from Arrow to Mica. This space consists of the original 80,000 acre-feet prescribed in the Treaty, plus an exchange of 3,500,000 acre-feet from Arrow to Mica, and up to an additional 500,000 acre-feet of compensation storage space agreed to by Canada to ensure the same effectiveness for system flood control at The Dalles, Oregon. Agreement on the amount of storage space to be exchanged each year and preparation of an appropriate Flood Control Storage Reservation Diagram will be provided in accordance with Paragraph 6-6. When an exchange less than the maximum limit is agreed to, a revised Flood Control Storage Reservation Diagram will be prepared by the Corps of Engineers and forwarded to the Operating Committee prior to the evacuation period. Should On-Call storage space be utilized at Mica Reservoir, Chart 9 specifies maximum storage space requirements in terms of forecasted Mica inflow volumes. The United States Entity may elect to call for less storage than that indicated by Chart 9, if they so desire.

7-2. Operating Rules during the Flood Control Refill Period. Mica is a Category I reservoir in the system regulation of the Columbia River spring runoff (as described in Section 2-8). Mica Reservoir will be regulated so that it does not exceed the elevations corresponding to the storage space requirement during April and May, as defined on Charts 7, 8 and 9, until storage of water for flood control or refill begins. If Mica Reservoir is evacuated for purposes other than flood control to elevations lower than those corresponding to storage space requirements indicated by Chart 7, or 8, only the amount of storage space indicated by the Flood Control Storage Reservation Diagram will be operated by the Corps of Engineers of the United States Section specifically for the purpose of flood control. The beginning of the Mica flood control operation will be specified by the Corps of Engineers of the United States Section, based on the timing and magnitude of the runoff, and the duration of this operation will be determined by the daily accumulation of the amount of water stored.

7-3. Flood Control Refill Curve. The Flood Control Refill Curve for Mica project will be used to help guide refill from 1 April through 31 July. It will be computed daily using the latest available forecasts of residual inflow volume to Mica Reservoir expected during the refill period. If the elevation of Mica Reservoir is at or below the computed Flood Control Refill Curve, the mean weekly outflow may be reduced to 3,000 cfs, or the minimum outflow established by the appropriate Detailed Operating Plan, unless higher outflows are required to serve FLCC or to meet other objectives of the agreed-to hydroelectric operating plan. At such time as it is determined by the Operating Committee that the danger of flooding has passed both in the United States and Canada, and the elevation of Mica Reservoir is above the Flood Control Refill Curve, the outflow at Mica project may be increased to approach the inflow to decrease the rate of filling and minimize the chance of sudden increases in outflow when the reservoir fills. The outflow from Mica project during this period will be based on forecasts made by computer simulation of streamflow and reservoir regulation. The elevation of the reservoir during this period will not be required to be lower than that determined by the Flood Control Refill Curve.

7-4. Operating Limits. The maximum controlled outflows through the regulating outlets at Mica project shall be within the limits of the project discharge capacity as agreed in the Report on the Mica Discharge Capacity dated 22 November 1967. The minimum average weekly outflow for Mica project is 3,000 cfs established in the Treaty. The normal full reservoir elevation for Mica project is elevation 2,475 feet. The normal minimum reservoir elevation for the Mica project is elevation 2,320 feet. The Operating Committee will determine the maximum elevation for the purposes of development of the flood control rule curves in the hydroelectric operating plan studies. Operating limits may be modified or added to from time to time as agreed by the Entities.

7-5. Regulation during Fall and Winter Floods. In the event of occurrence of fall and winter floods in the lower Columbia River, Mica project will be operated so that insofar as possible the outflow from Arrow will not exceed the natural lake outflow which would have occurred prior to the construction of Arrow or Mica project or any future project upstream of Arrow Reservoir. Water stored during this operation will be evacuated at the direction of the Operating Committee following the flood.

VIII - OPERATION OF DUNCAN RESERVOIR

8-1. Operating Rules during the Flood Control Storage Evacuation Period. The amount of Primary Storage to be supplied in Duncan Reservoir will be based on the forecast volume of inflow to that project. Flood Control Storage Reservation Diagram, Chart 10, shows the storage space requirements applicable to each month-end during the evacuation period, as related to volume forecasts at Duncan. Evacuation requirements for On-Call storage are also shown on Chart 10. If the evacuation of Duncan Reservoir in accordance with Chart 10 would result in a violation in the 1938 International Joint Commission Order for Kootenay Lake, then the operation will be modified as described in paragraph 9-5 to preclude such a violation.

8-2. Operating Rules during the Flood Control Refill Period. Duncan is a Category I reservoir in the system regulation of the annual Columbia River runoff. (See paragraph 2-8). Duncan Reservoir will be regulated so as not to exceed to the extent possible the elevations corresponding to the storage space requirement during March, April, or May, as defined on Chart 10, until storage for system flood control or refill commences (Section V). Storage for downstream flood control will begin 10 days prior to the day the unregulated mean daily discharge at The Dalles is forecasted to exceed the ICF. At that time, the mean daily outflow from Duncan Reservoir will be reduced to 100 cfs. This outflow will be continued throughout the Flood Control Refill Period, unless higher outflows are determined to not be detrimental to flood control, or higher outflows are necessary to compensate for trapped storage conditions caused by restrictions at Kootenay Lake (see Paragraph 9-6). If the storage space available for refill exceeds that indicated by Chart 10, then the above operating rules are applicable only to the storage amounts required by Chart 10. Outflows during the filling of the excess storage space may be modified from those specified above if required to serve FLCC or to meet other objectives of the agreed-to hydroelectric operating plan. If the excess storage space is filled in this manner, then the United States Section may specify the beginning of the Duncan flood control operation as other than that defined in this section. Duration of storage under each operation will be determined by daily accumulating the amount of water stored. During the filling of excess storage, outflows will be limited so that damage levels described in Section IV will not be exceeded.

8-3. Flood Control Refill Curves. The Flood Control Refill Curve for Duncan project will be used to help guide refill during the period 1 April through 31 July. This curve will be computed daily on the basis of the latest available forecast of residual inflow volume to Duncan project. If at any time during the refill period the elevation of Duncan Reservoir is at or below the elevation determined by the Flood Control Refill Curve, the mean daily outflow may be reduced to 100 cfs or the minimum flow stipulated in the appropriate Detailed Operating Plan, unless higher flows are required to serve FLCC or to meet other objectives of the agreed-to hydroelectric operating plan. At such time as it is determined by the Operating Committee, that danger of flooding has passed both in the United States and Canada, and the elevation of Duncan Reservoir is above the Flood Control Refill Curve, the outflow at Duncan project may be increased in order to decrease the rate of filling and minimize the risk of high outflows after the reservoir fills. The outflow from Duncan project during this period will be based on forecasts made by computer simulation of streamflow and reservoir regulation. The elevation of the reservoir during this period will not be required to be lower than that indicated by the Flood Control Refill Curve.

8-4. Operating Limits. The maximum controlled outflows through the regulating outlets at Duncan project shall be within the limits of the project discharge capacity as agreed in the Supplemental Report of the Duncan Project Discharge Capacity, dated 28 March 1966. The normal maximum outflow is 10,000 cfs. The minimum average weekly outflow for the Duncan project is 100 cfs as agreed by the Entities on 8 November 1966. The maximum rate of change in Duncan project's outflow is normally 4,000 cfs per day unless a larger change is necessary to accomplish the objectives of the Flood Control Operating Plan. The normal full elevation for Duncan Reservoir is elevation 1,892 feet. The minimum elevation for Duncan Reservoir is 1794.2 feet. These operating limits may be modified or added to from time to time as agreed by the Entities.

IX - OPERATION OF LIBBY RESERVOIR

9-1. Operating Rules during the Flood Control Storage Evacuation Period.

a. The amount of flood control storage space to be evacuated at Libby Reservoir is based on the forecast volume of inflow to the project. Flood Control Storage Reservation Diagram, Chart 11, shows the storage space requirements applicable to each month-end during the evacuation period. This chart was designed to meet the requirements in the operation of Kootenay Lake as set by the 1938 International Joint Commission order. However, if the operation in accordance with Chart 11 would result in violation of the Order, then this operation will be modified as described in paragraph 9-5 to preclude such a violation.

b. For Libby Dam, Paragraph V of the Protocol Annex to Exchange of Notes provides that the "entities shall, pursuant to Article XIV (2)(a) of the Treaty, cooperate on a continuing basis to coordinate the operation of that dam with the operation of hydroelectric plants on the Kootenay River and elsewhere in Canada in accordance with the provisions of Article XII (5) and Article XII (6) of the Treaty." Consistent with the Treaty and Paragraph V of the Protocol Annex to Exchange of Notes, the United States entity may from time to time as conditions warrant adjust the flood control operation at Libby Dam.

9-2. Operating Rules during the Flood Control Refill Period. Libby project, a Category I reservoir in the Columbia River system (see Paragraph 2-8), will be operated so that it does not exceed to the extent possible the storage requirements during April and May shown on Chart 11 until storing for system flood control or refill commences. Storage of water for flood control will begin 10 days prior to the day the unregulated mean daily discharge at The Dalles is forecast to exceed the ICF, determined in accordance with the procedures outlined in Section V. The regulation of flows in the interest of the lower Columbia River generally provides adequate flood reduction in the lower Kootenai River. In some cases, however, it may be necessary to regulate the outflow at Libby project in the interest of the

Kootenai River in accordance with the storage reservation requirement as shown on Chart 12. Libby project will be regulated in a manner to not cause flooding at Bonners Ferry, Idaho (Paragraph 4-4), insofar as possible within the limitation of maintaining a minimum outflow of 4,000 cfs at the project. At such times as it is determined that danger of flooding has passed both in the United States and Canada, and the elevation of Libby Reservoir is above the Flood Control Refill Curve, the outflow at Libby project may be increased to approach inflow in order to decrease the rate of filling and minimize the chances of sudden increases in outflow when the reservoir is full. The outflow from Libby project during this period will be based on forecasts made by computer simulation of streamflow and reservoir regulation. The elevation of the reservoir during this period will not be required to be lower than that determined by the Flood Control Refill Curve.

9-3. Flood Control Refill Curve. The Flood Control Refill Curve for Libby project will be used to help guide refill from 1 April through 31 July. It will be computed daily based on the latest available estimate of residual inflow volume expected during the refill period. If the elevation of Libby is at or below the computed Flood Control Refill Curve, the outflow may be reduced to 4,000 cfs, or the minimum outflow contained in the appropriate Detailed Operating Plan, unless higher flows are required to serve FLCC or to meet other objectives of the agreed-to hydroelectric operating plan.

9-4. Operating Limits. The normal full pool elevation for Libby project is elevation 2,459 feet. The normal minimum pool elevation is 2,287 feet. The minimum project outflow is 4,000 cfs. Maximum allowable rates of change in outflow is such that tailwater changes do not exceed one foot per hour or four feet per day from 1 May to 30 September, and one foot per half-hour or six feet per day from 1 October to 30 April. These operating limits may be modified or added to from time to time.

9-5. Priority Draft for Libby and Duncan. Both Libby and Duncan are required to operate in accordance with the 1938 International Joint Commission Order for Kootenay Lake (Order). The evacuation of storage as required by each project's Storage Reservation Diagram can result in a violation of the Order on allowable lake levels. If this occurs, the outflows at either Libby or Duncan, or both, are required to be reduced to provide the natural Kootenay Lake inflow to preclude such a violation. This may require Libby or Duncan, or both, to reduce outflows to match reservoir inflow and can result in not reaching the flood control space requirement by the end of the evacuation period, thus trapping storage above the flood control rule curve. The Columbia River Treaty does not elaborate on how to prioritize the draft of Libby and Duncan during trapped storage conditions. The Operating Committee is responsible to develop and implement a real-time plan of operation, including the appropriate drafting priority. Factors to consider in developing a plan are listed below:

a. The regulation specified in the Detailed Operating Plan. This regulation is developed based on the rules and rule curves contained in the agreed-to hydroelectric operating plans, the Storage Reservation Diagrams in this plan, and a modeling strategy for handling trapped storage conditions that was agreed to by the Operating Committee.

b. Flood protection for the Columbia River as specified in paragraphs 4-2 and 4-3. Normally, flood protection in the Columbia River is not affected by the draft priority of either Libby or Duncan. This is due to the routing characteristics of Kootenay Lake. However, for each occurrence of trapped storage the regulation effects on the Columbia River need to be assessed using daily streamflow forecasts and reservoir simulations before deciding on the priority draft regulation.

c. Local flood protection on the Kootenai River as specified in paragraph 4-4. The hydraulic backwater effects of Kootenay Lake will likely dampen or negate any effects of the draft priority at Kootenai River damage centers. However, for each occurrence of trapped storage the regulation effects on the Kootenai River need to be assessed using daily streamflow forecasts and reservoir simulations before deciding on the priority draft regulation. Impacts to locally owned levees on the Kootenai River should also be considered in formulating a regulation plan.

d. Other project requirements. If the results of streamflow forecasts and reservoir simulations are inconclusive in determining the impact on flood protection at damage centers on the Kootenai River and the Columbia River, other project purposes need to be considered in formulating a real-time regulation plan. These may include, but are not limited to, hydropower generation, fish habitat, water quality, recreation, and at-site operating limits.

9-6. Trapped Storage During the Flood Control Refill Period. When flood control evacuation requirements are not met and trapped storage conditions exist at either Libby or Duncan (paragraph 9-5), outflows higher than those originally anticipated for the ensuing flood season may need to be released during the Flood Control Refill Period to avoid filling the reservoirs too early. The following steps provide guidance in selecting outflows during the refill period.

a. Step 1: Adjusting the Outflow for Trapped Storage.

(1) Determine the trapped storage by computing the difference between the actual May 1 reservoir storage space and the space required for flood control.

$$S_{trapped} = S_{srd} - S_{actual}$$

Where:
$S_{trapped}$ is the trapped storage in million acre-feet (Maf)
S_{srd} is the storage space requirement for flood control in Maf
S_{actual} is the actual storage space drafted by May 1 in Maf

(2) Estimate the duration of the system flood control operation using Chart 13. Select the appropriate curve based on the runoff forecast and the level of the latest projected control flow at The Dalles.

(3) Compute the outflow adjustment for trapped storage:

$$Q_{trapped} = (S_{trapped} / DUR) * 500$$

Where:

$Q_{trapped}$ is the outflow adjustment in kcfs/day

$S_{trapped}$ is the trapped storage in Maf

DUR is the estimated duration of system flood control in days

The term 500 converts Maf/days to ksfd

(4) Compute the new outflow adjusted for trapped storage:

$$Q_{adj} = Q_{int} + Q_{trapped}$$

Where:

Q_{ajd} is the new outflow adjusted for trapped storage

Q_{int} is the initial outflow planned for the ensuing flood season

b. Step 2: Updating the Outflow. Update the outflow throughout the refill period as new runoff forecasts are developed.

(1) Repeat Step 1 (Adjusting the Outflow for Trapped Storage) using the latest volume runoff forecasts.

(2) Compute adjustment for the prior outflows during the refill period:

$$Q_{pr} = (Q_{adj} - Q_{pr}) * (DUR_{pr} / (DUR - DUR_{pr}))$$

Where:

Q_{pr} is the adjustment for the prior outflows during the refill period, in kcfs

Q_{adj} is the outflow adjusted for trapped storage from Step 2(1), in kcfs

Q_{pr} is the prior average outflows during the refill period, in kcfs

DUR_{pr} is the number of days of the prior outflows during the refill period

DUR is the estimated duration of system flood control in days from Step 2(1)

(3) Compute the updated outflow adjusted for trapped storage:

$$Q_{uadj} = Q_{adj} + Q_{pr}$$

Where:

Q_{uadj} is the updated adjusted outflow

Q_{adj} is the outflow adjusted for trapped storage from Step 2(1)

Q_{pr} is the prior release adjustment

c. Step 3. Use of Streamflow Forecasts. Use daily streamflow forecasts to evaluate the performance of the outflows adjusted for trapped storage throughout the refill period. If necessary, reduce the outflow to provide protection from local flooding. Once local flooding is over, return to the adjusted outflow. During the final stages of refill, use streamflow forecasts to adjust the outflow as necessary to ensure refill while avoiding unwanted spill.

X - IMPLEMENTATION OF FLOOD CONTROL OPERATING PLAN

10-1. Responsibilities. The Columbia River Treaty Operating Committee will oversee the implementation of the Flood Control Operating Plan. Both the United States and Canadian Sections of the Operating Committee are responsible for assembling the necessary project data, forecasts, and other related data necessary for determining the flood control storage space and refill requirement. The United States Section, after consultation with the Canadian Section, will determine the flood control storage space requirements during the Flood Control Storage Evacuation period, calculate Flood Control Refill Curves, and determine day-to-day reservoir operation for flood control during the refill period in accordance with these curves. The Corps of Engineers of the United States Section is responsible for issuing instructions in accordance with the Flood Control Operating Plan.

10-2. Flood Control Regulation during the Flood Control Storage Evacuation Period. During the Flood Control Storage Evacuation Period the operation of Canadian storage will be in accordance with the applicable Detailed Operating Plan, which is based on rules and rule curves in the agreed-to hydroelectric operating plans and the evacuation requirements of this Flood Control Operating Plan. Unless otherwise agreed by the Canadian and United States Sections, outflows during this period will be specified from the whole of Canadian storage by the United States Section of the Operating Committee on a weekly basis, except that outflows from Arrow project will be specified daily when operated in accordance with Section 6-7. The Canadian Section of the Operating Committee will determine the daily distribution of these weekly storage releases to each Canadian storage project. The Operating Committee will assure that the resulting operation does not violate the Flood Control Storage Reservation Diagrams. Maximum end-of-month storage targets for any month shall be established no later than the 10th day of that month, unless otherwise agreed by the Operating Committee. Each section of the Operating Committee is responsible for directing the operation of its reservoirs so that these specified storage targets are not exceeded.

10-3. Flood Control Regulation during the Flood Control Refill Period. During the Flood Control Refill Period the United States Section will specify daily outflows from the Canadian storage reservoirs. At such time as the Flood Control Operating Plan requires, individual project discharge will be specified and each section will be responsible for directing the operation of its reservoirs in accordance with the specified discharges. Regulation during the Flood Control Refill Period is guided by daily computer simulations of streamflow and by the charts contained in this plan. The end of the Flood Control Refill Period will be when the Operating Committee agrees that no further flood potential exists at any of the damage areas described in Section IV. This transition point in the operation of the Columbia River Treaty reservoirs will be promptly conveyed by the United States Section of the Operating Committee to the Canadian Section.

10-4. Operation Below 450,000 cfs. In low runoff years when the maximum unregulated discharge at The Dalles is less than 450,000 cfs, there is no formal Flood Control Refill Period as defined in Section V. Releases may therefore be specified weekly from the whole of Canadian Storage under this condition. During floods having unregulated flows exceeding 450,000 cfs, a Flood Control Refill Period exists, and the United States Section will normally request individual project outflows on a daily basis. However, the United States Section may relinquish that right during all or part of the Flood Control Refill period if it determines that the weekly specification of releases from the whole of Canadian Storage will not compromise the objectives of the intended flood control regulation. Such a situation may occur during floods having regulated discharges below 450,000 cfs and unregulated discharges slightly greater then 450,000 cfs. In this case daily control of individual Canadian storage projects may be initiated at any time by the United States Section if changed conditions so warrant.

10-5. On-Call Storage. Calls for the use of On-Call storage space shall be processed in accordance with Paragraph 1.(3) of the Protocol to the Treaty. Consideration of the need for On-Call storage will be initiated by the Operating Committee as soon after 1 January as conditions indicate that a call may be necessary. If a call may be necessary, results of these considerations will be reported to the respective Entities, together with the assessment of the effects of the drawdown on the production of power as provided for in agreed-to hydroelectric operating plans. When the forecast of unregulated April through August runoff for the Columbia River at The Dalles exceeds the following values, the United States Entity may, at its discretion, initiate formal consultation with the Canadian Entity on the need for On-Call storage as required in Paragraph 1.(3) of the Protocol to the Treaty. (See Appendix A for background concerning those values):

Date of Forecast	Forecast of Unregulated April through August Runoff Volumes in Millions of Acre-feet at The Dalles
1 January	105
1 February	108
1 March	110
1 April	111

A formal call for On-Call storage space may or may not be made by the United States Entity following the above consultation. If the call is made and confirmed in writing, the Canadian Entity will indicate its acceptance, proposed modifications, or rejection as soon as possible but not later than 10 days after receipt of the formal call. Such action will also be confirmed in writing. Upon acceptance of the above call by the Canadian Entity the Operating Committee will proceed as provided for herein. In the event the Canadian Entity should indicate rejection or modification, procedures of Paragraph 1.(3) of the Protocol to the Treaty shall apply. Evacuation of reservoirs to obtain On-Call storage space will be in accordance with procedures described in Sections VI, VII and VIII of this report.

10-6. <u>Compensation to Canada for Operation of On-Call Storage</u>. Article VI of the Treaty requires that the United States shall pay Canada 1,875,000 dollars for each of the first four calls for On-Call Storage. In addition, Article VI of the Treaty requires that for each and every call made, the United States shall deliver electric power equal to the power lost by Canada as a result of operating the storage to meet the flood control need for which the call was made, delivery to be made when the loss of hydroelectric power occurs. The agreed-to hydroelectric operating plans set out the method for calculating the normal daily energy outputs and capacity capabilities from Mica and downstream projects in Canada during the period 1 January to 31 August. If the energy outputs and/or capacity capabilities at Mica, and projects downstream in Canada therefrom, fall below the normal values during operation of On-Call storage, the Operating Committee will arrange for hourly energy and/or capacity deliveries to be scheduled by the United States Entity to the Canadian Entity to supplement the electrical outputs from these projects. In addition, if the Mica project fails to refill when On-Call storage is utilized, the Canadian Entity will be entitled to energy and/or capacity deliveries in the succeeding operating year as described in the agreed-to hydroelectric operating plans.

10-7. Runoff Forecasts. The forecast procedures used to obtain the seasonal runoff volume forecasts for each project will be developed by the project owner in consultation with the Operating Committee. Procedures for the day-to-day forecasts of streamflow and reservoir regulation will be developed by the United States Section of the Operating Committee. Prior to each flood season's operation, the Operating Committee shall review any data and forecasting procedures as may be desired. Changes required to obtain improved results will be made. Using the agreed forecast procedure, each section of the Operating Committee shall be responsible for supplying the seasonal runoff volume forecast for the projects for which the section is responsible. The seasonal runoff volume forecasts for Columbia River at The Dalles shall be supplied by the United States Section of the Operating Committee. Seasonal runoff volume forecasts will be made from available hydrometeorological data beginning 1 January and revised at the beginning of each month through 1 June as the season advances. Forecasts shall be made available to the other section no later than the seventh day of each month, unless otherwise specified by the Operating Committee. If unusual hydrometeorological conditions prevail within the month, the Operating Committee may take action to obtain forecasts at an intermediate period between the normal month-end evaluation. Day-to-day streamflow forecasts shall simulate all hydrometeorological elements affecting streamflow and reservoir regulation. Inasmuch as the development of these forecasts depends upon coordinated system operation for the entire Columbia River Basin, it is necessary that this effort be centralized. Forecasts of this type will be the responsibility of the United States Section. The Operating Committee shall review the computer simulations for adequacy. The computer simulations shall be made daily (including Saturdays, Sundays, and holidays unless otherwise agreed) during the refill period. Simulations will be performed on the basis of both normal and maximum snowmelt sequences, for the evaluation of flood potentials. All hydrometeorological data necessary to obtain day-to-day streamflow forecasts will be exchanged promptly between the sections of the Operating Committee.

Table 1
Reservoir Project Data for Columbia Basin Flood Control System

Project	River	Pool Elev in feet (NGVD) Min	Max	ACTIVE STORAGE, AC. FT. Total [1/]	Committed for Flood Control	Project Owner
	CATEGORY I					
Mica	Columbia	2320	2475	12,000,000	12,000,000[2/]	B.C. Hydro and Power Authority
Duncan	Duncan	1794.2	1892	1,400,000	1,400,000[2/]	B.C. Hydro and Power Authority
Libby	Kootenai	2287	2459	4,979,500	4,979,500	U.S. Corps of Engineers
Hungry Horse	S. Fk. Flathead	3336	3560	3,072,000[3/]	2,980,000[4/]	U.S. Bureau of Reclamation
Noxon	Clark Fork	2295	2331	231,000	5/	Washington Water Power Co.
Brownlee	Snake	1976	2077	975,400	975,400	Idaho Power Co.
Dworshak	N. Fk. Clearwater	1445	1600	2,016,000	2,016,000	U.S. Corps of Engineers
	CATEGORY II					
Jackson Lake	Snake	6730	6769	847,000		U.S. Bureau of Relcamation
Palisades	Snake	5497	5620	1,200,000	1,400,000 [13/]	U.S. Bureau of Relcamation
Anderson Ranch	S. Fk. Boise	4043	4196	423,000		U.S. Bureau of Relcamation
Arrowrock	Boise	2967	3216	286,600		U.S. Bureau of Relcamation
Lucky Peak	Boise	3905	3060	278,200	988,000 [13/]	U.S. Corps of Engineers
Cascade	N. Fk. Payette	4787.5	4828	653,200	5/	U.S. Bureau of Relcamation
Deadwood	Deadwood	5334	5343.5	160,400	5/	U.S. Bureau of Relcamation
5 Yakima River Res.				1,065,500	5/	U.S. Bureau of Reclamation
	CATEGORY III					
Corra Linn Dam - Kootenay L.	Kootenay	1739.32	1745.32 [6/]	673,000	7/	West Kootenay Power & Light Co.
Kerr Dam - Flathead L.	Flathead	2883	2893 [6/]	1,219,000	7/	Montana Power Co.
Albeni Falls Dam - Pend Oreille L.	Pend Oreille	2049.7	2062.5 [6/]	1,155,000	7/	U.S. Corps of Engineers
Post Falls Dam - Coeur d'Alene L	Spokane	2120.5	2128 [6/]	223,000	7/	Washington Water Power
	CATEGORY IV					
Arrow	Columbia	1378	1444 [8/]	7,100,000	7,100,000[2/,9/]	B.C. Hydro and Power Authority
Grand Coulee	Columbia	1208	1290	5,232,000	5,232,000	U.S. Bureau of Reclamation
John Day	Columbia	257	268	535,000	535,000	U.S. Corps of Engineers
	CATEGORY V					
Chief Joseph	Columbia	930	956	115,000[12/]	10/	U.S. Corps of Engineers
Wells	Columbia	767	779	125,000[12/]	125,000[11/]	Douglas County PUD
Rocky Reach	Columbia	703	707	36,000[12/]	120,000 [11/]	Chelan County PUD
Wanapum	Columbia	539	575	144, 000[12/]	500,000 [14/]	Grant County PUD
Prient Rapids	Columbia	465.9	491.5	44,000[12/]	14/	Grant County PUD
McNary	Columbia	335	340.5	205,000[12/]	10/	U.S. Corps of Engineers
The Dalles	Columbia	155	160	53,000[12/]	10/	U.S. Corps of Engineers
Bonneville	Columbia	70	75.5	87,000[12/]	10/	U.S. Corps of Engineers
Lower Granite	Snake	733	738	53,000[12/]	10/	U.S. Corps of Engineers
Little Goose	Snake	633	638	49,000[12/]	10/	U.S. Corps of Engineers
Lower Monument	Snake	537	540	20,000[12/]	10/	U.S. Corps of Engineers
Ice Harbor	Snake	437	440	25,000[12/]	10/	U.S. Corps of Engineers

1/ From best information available as of August 1998
2/ Total of Primary Flood Control and "On-Call" storage
3/ Relfects 3% of measured capacity to account for bank storage
4/ Total measured capacity between pool limits, not accounting for bank storage.
5/ Not committed but operated voluntarily by project owner for flood regulation
6/ Controlled elevation for normal power operation. May be exceeded involuntarily during flood period
7/ Normally operated to preserve natural lake storage during flood period
8/ May be operated to El. 1446 under large flood
9/ Includes involuntary storage
10/ Pondage for re-regulation of flood flows
11/ Maximum allowable for replacement of lost valley storage
12/ Normal power pondage
13/ Combined requirement for multiple reservoirs
14/ Maximum allowable for replacement of lost valley storage, combination of Wanapum and Priest Rapids storage

Table 2
Flood Control Refill Curve Computation

Project: Duncan
Gross Storage (ksfd): 705.8
Flood Control Refill Start Elevation (feet): 1795
Anticipated Outflow (cfs): 100

Most Probable Runoff Forecast (ksfd): 796.2
Forecast Time Period: May-July
95% Forecast Error (ksfd): 84.4
Runoff Forecast at 95% Assurance (ksfd): 711.8

Date	Mean Daily Inflow (ksfd)1/	Accum. Inflow (ksfd)	Residual Inflow Volume (ksfd)2/	Anticipated Outflow Thru July (ksfd)3/	Upstream Space Available (ksfd)4/	Available For Refill (ksfd)5/	Allowable Storage Contents (ksfd)6/	Flood Control Refill Curve (feet)
			711.8	9.2		702.6		1795.0
May 1	2.6	2.6	709.2	9.1	0	700.1	5.7	1795.6
2	5.3	7.9	703.9	9.0	0	694.9	10.9	1796.8
3	3.5	11.4	700.4	8.9	0	691.5	14.3	1797.5
4	3.0	14.4	697.4	8.8	0	688.6	17.2	1798.3
5	2.3	16.7	695.1	8.7	0	686.4	19.4	1798.8
6	3.2	19.9	691.9	8.6	0	683.3	22.5	1799.4
7	3.9	23.8	688.0	8.5	0	679.5	26.3	1800.2
8	4.2	28.0	683.8	8.4	0	675.4	30.4	1801.0
9	4.1	32.1	679.7	8.3	0	671.4	34.4	1801.8
10	4.3	36.4	675.4	8.2	0	667.2	38.6	1802.6
11	5.8	42.2	669.6	8.1	0	661.5	44.3	1803.7
12	6.4	48.6	663.2	8.0	0	655.2	50.6	1805.0
13	8.2	56.8	655.0	7.9	0	647.1	58.7	1806.5
14	10.1	66.9	644.9	7.8	0	637.1	68.7	1808.2
15	12.0	78.9	632.9	7.7	0	625.2	80.6	1810.3

1/ Mean daily inflow from latest streamflow forecast
2/ 95% Assured runoff forecast minus mean daily inflow
3/ End-of-day (in Date column) through July total anticipated outflow
4/ Applicable only to Arrow, available space at Mica
5/ Residual inflow volume minus anticipated outflow minus available upstream space
6/ Gross storage contents minus storage available for refill

Table 3
Arrow/Mica Flood Control Exchange Computation
Example of the Development of New Storage Reservation Diagrams

Proposed Exchange Amount from Arrow to Mica (Maf): 1.00
(Base Condition is 5.1/2.08 Maf Arrow/Mica Flood Control Space Combination, Charts 4 and 7)

Proposed Maximum Flood Control Draft at Arrow (Maf): 4.10
Proposed Maximum Flood Control Draft at Mica (Maf): 3.41[1/]

1. ARROW

Apr-Aug Runoff Forecast at The Dalles (maf)	Arrow Draft on Chart 4 31 March (maf)	New Arrow Draft for 31 December (maf)[2/]	New Arrow Draft for 31 January (maf)[4/]	New Arrow Draft for 28 February (maf)[4/]	New Arrow Draft for 31 March (maf)[3/]
<64	1.00	0.80	0.80	0.80	0.80
65	1.30	0.80	0.89	0.96	1.04
70	2.60	0.80	1.25	1.65	2.09
75	3.90	0.80	1.61	2.33	3.14
>80	5.10	0.80	1.94	2.96	4.10

2. MICA

Apr-Aug Runoff Forecast at The Dalles (maf)	Mica Draft on Chart 7 31 March (maf)	New Mica Draft for 31 December (maf)[5/]	New Mica Draft for 31 January (maf)[4/]	New Mica Draft for 28 February (maf)[4/]	New Mica Draft for 31 March (maf)[6/]
<62	0.20	0.33	0.33	0.33	0.33
65	0.58	0.33	0.54	0.74	0.95
70	1.08	0.33	0.83	1.27	1.77
75	1.58	0.33	1.11	1.81	2.59
>80	2.08	0.33	1.39	2.35	3.41

1/ Includes prorated 0.5 maf of compensation storage space agreed-to by Canada to ensure exchange does not impact system flood control. Computed using equations in Sections 6-6.b(1) and 6-6.b(2).
2/ Computed by equation in Section 6-6.a(1).
3/ Computed by equation in Section 6-6.a(1).
4/ Linearly interpolated from the 31 December and 31 March required draft amounts. Leap year should be considered when applicable.
5/ Computed by equation in Section 6-6.b(2).
6/ Computed by equation in Section 6-6.b(2).

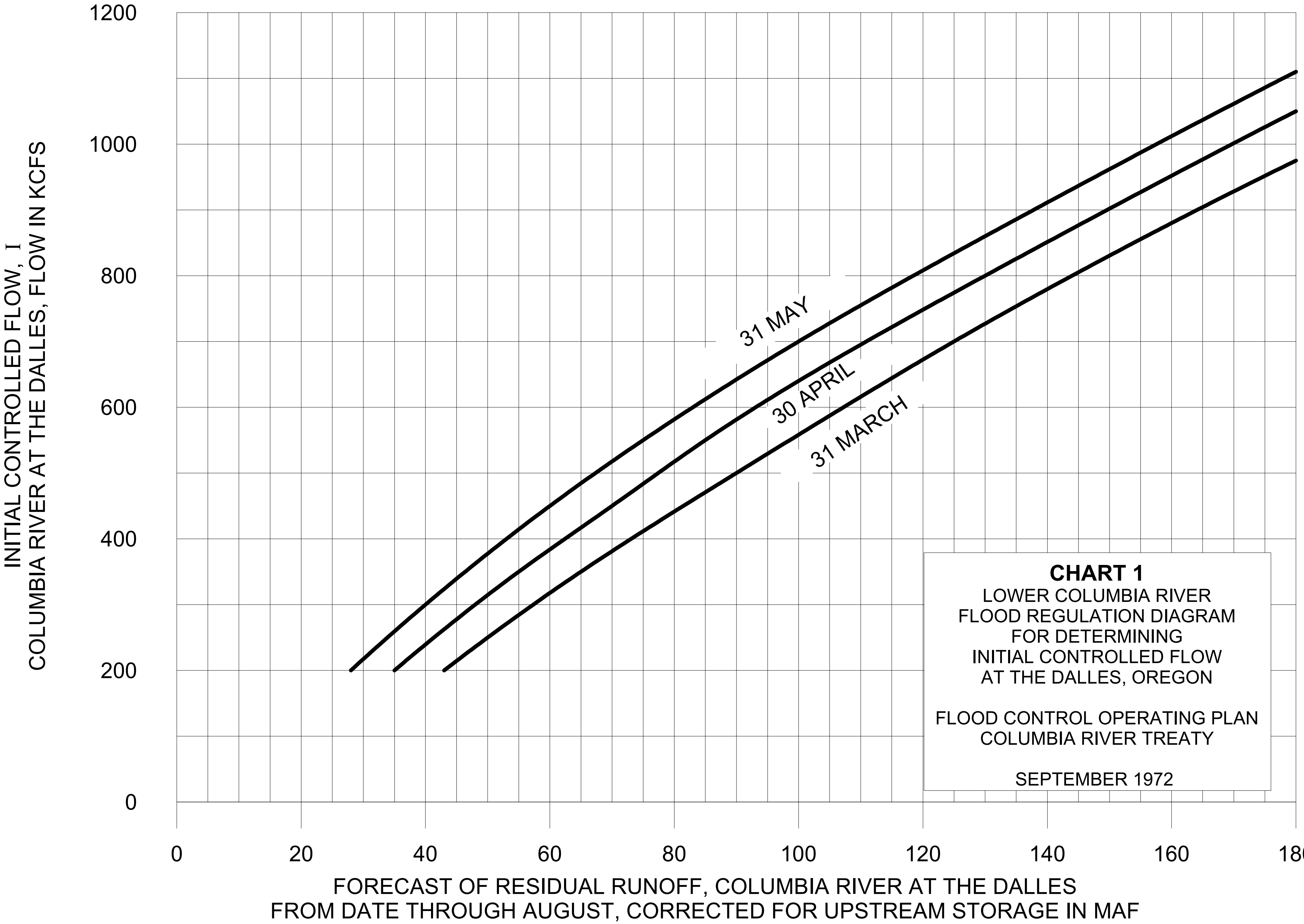

INITIAL CONTROLLED FLOW, I
COLUMBIA RIVER AT THE DALLES, FLOW IN KCFS
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
180
31 MAY
30 APRIL
31 MARCH
FORECAST OF RESIDUAL RUNOFF, COLUMBIA RIVER AT THE DALLES
FROM DATE THROUGH AUGUST, CORRECTED FOR UPSTREAM STORAGE IN MAF
CHART 1
LOWER COLUMBIA RIVER
FLOOD REGULATION DIAGRAM
FOR DETERMINING
INITIAL CONTROLLED FLOW
AT THE DALLES, OREGON
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972

Chart 2
Upstream Storage Corrections to be applied to Forecast Of Residual Runoff, Columbia River at The Dalles, Oregon
(To be used with Chart 1)

1. Cyclical Reservoirs

Project	(1) Space Available (MAF) 1/	Maximum Allowable Correction (MAF)					Correction (MAF) 4/
		Forecasted Inflow 2/	Outflow 3/			(2) Inflow Minus Outflow	
			Apr-Jul	May-Jul	Jun-Jul		
Mica							
Libby							
Duncan							
Hungry H.							
Dworshak							

2. Non-Cyclical Reservoirs

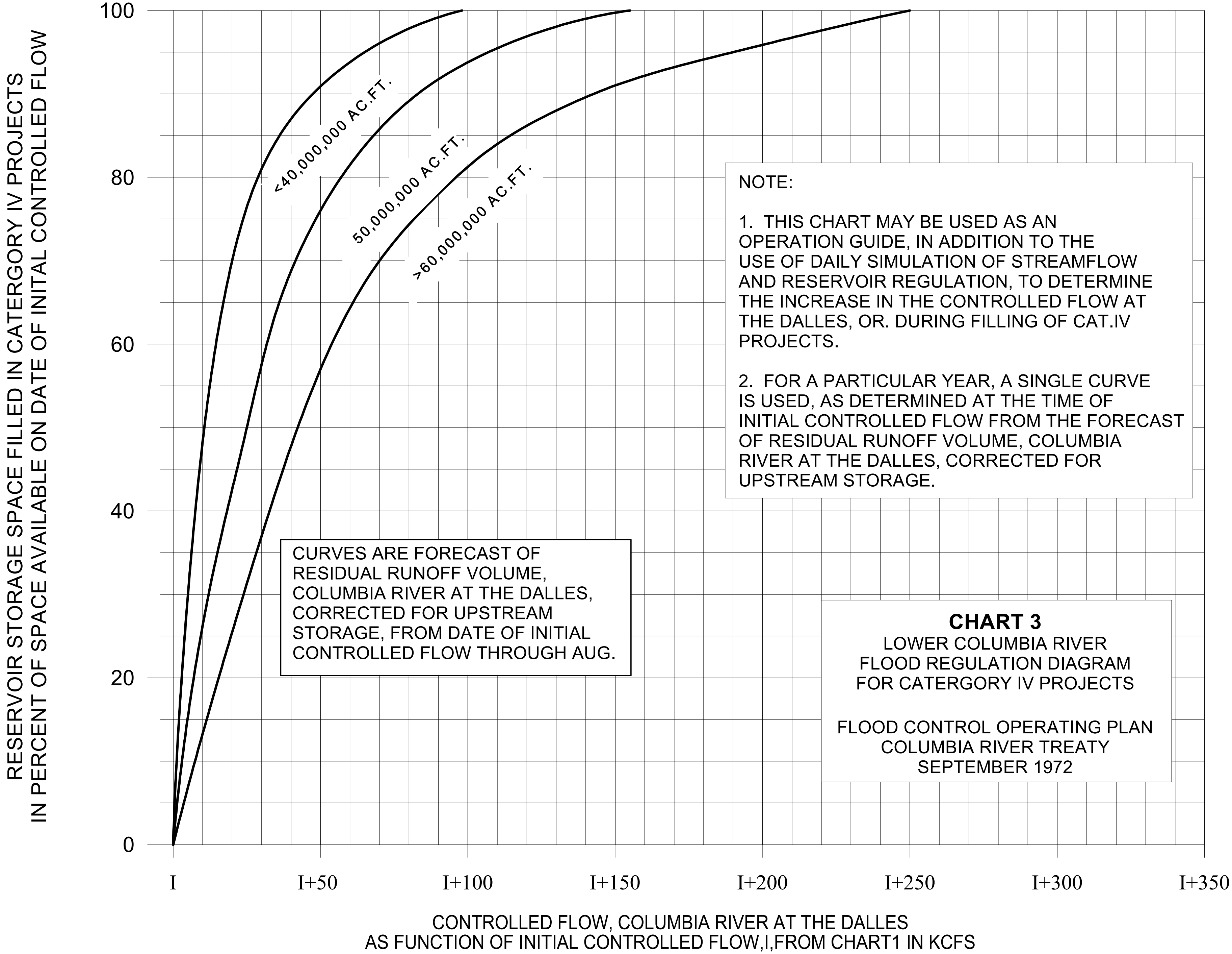
Project	(1) Space Available (MAF) 1/	(2) Maximum Allowable Correction (MAF)	Correction (MAF) 4/
Arrow		See note 6	
Flathead Lake		0.5	
Noxen		0.2	
Pend Oreille Lake		0.5	
Grand Coulee		5.23	
Brownlee		0.98	
John Day		0.5	

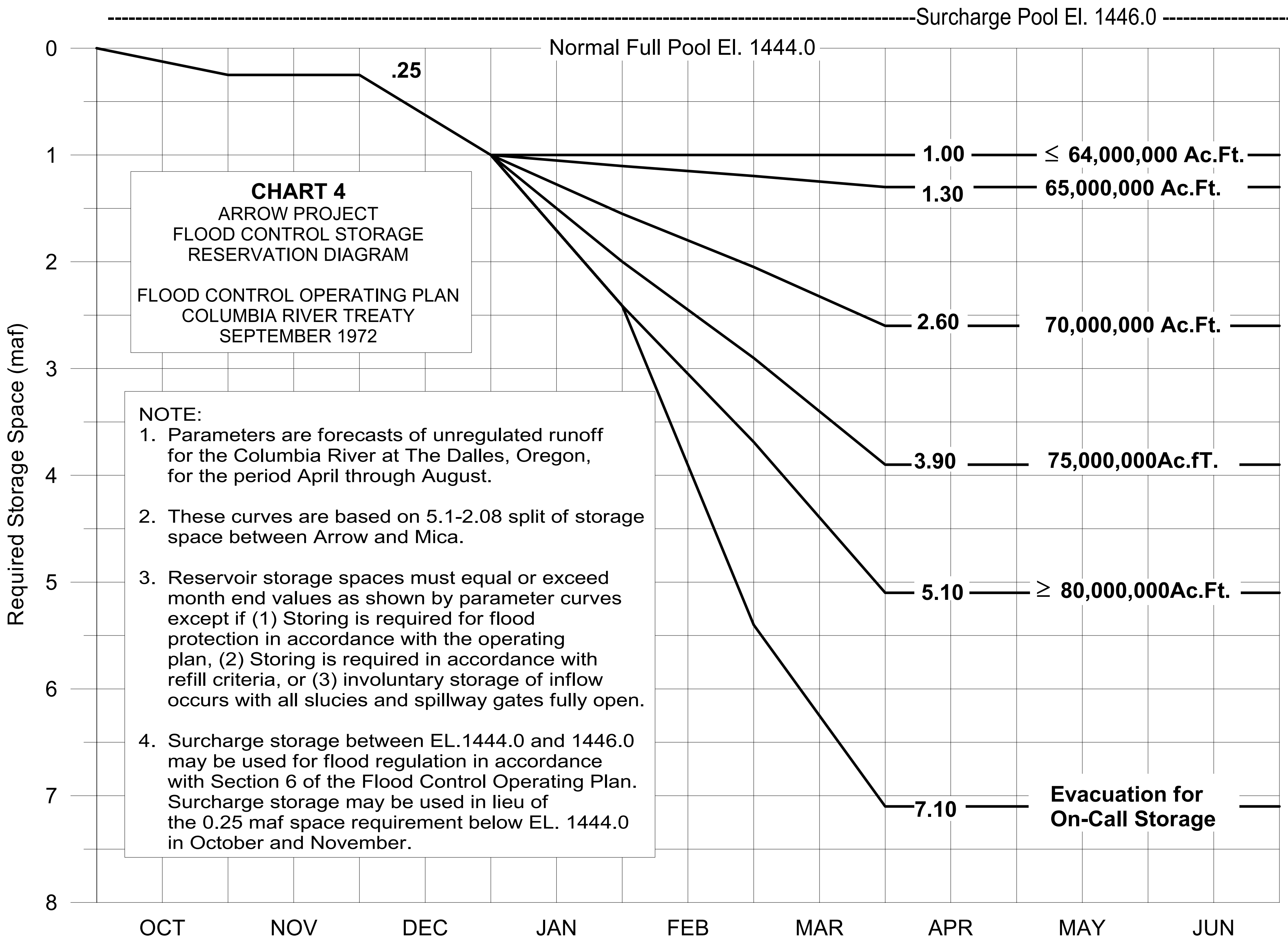
3. Depletions

1990 Level Depletions 5/ (date-Aug MAF)		
31 March	30 April	31 May
0.7	0.6	0.4

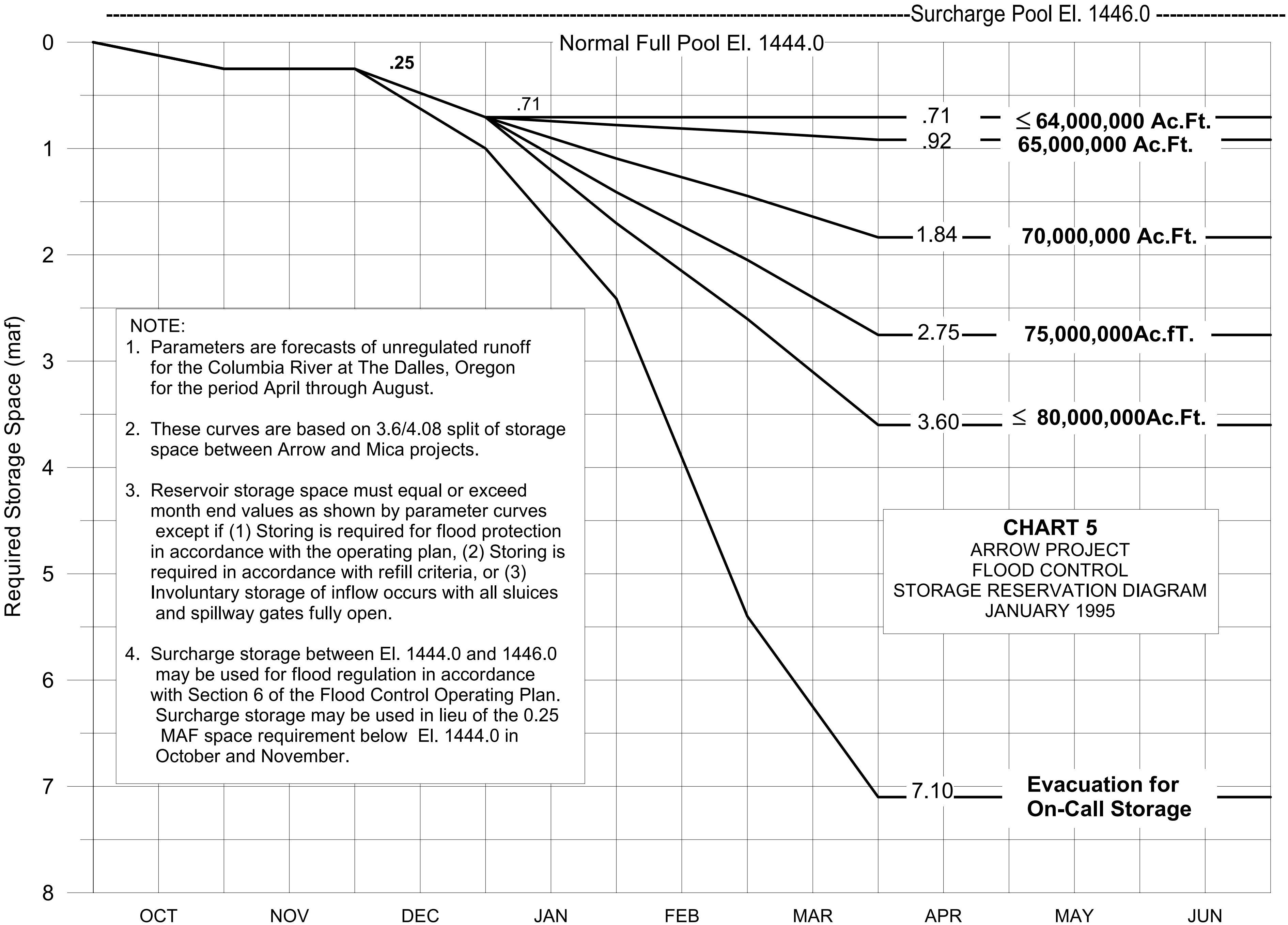
4. Total Correction = the sum storage corrections for cyclical and non-cyclical reservoirs, plus depletion corrections.

Notes:
1/ Projected storage space to be made available at start of flood control refill period.
2/ Residual runoff volume for indicated period.
3/ Anticipated outflow, or other outflow determined by Operating Committee.
4/ The lesser of column (1) or column (2)
5/ Depletions at The Dalles from Modified Streamflows, 1990 Level of Depletions, Columbia River and Coastal Basins, 1928-1989, Bonneville Power Administration, April 1993.
6/ Arrow correction is variable depending on the requested Mica/Arrow flood control shift request. For a request of no shift of flood control space, the max. allowable correction is 5.1 MAF. For a full 1.5 MAF shift request, the max. allowable correction is 3.6 MAF.


RESERVOIR STORAGE SPACE FILLED IN CATERGORY IV PROJECTS
IN PERCENT OF SPACE AVAILABLE ON DATE OF INITAL CONTROLLED FLOW
100
80
60
40
20
0
<40,000,000 AC.FT.
50,000,000 AC.FT.
>60,000,000 AC.FT.
NOTE:
1. THIS CHART MAY BE USED AS AN OPERATION GUIDE, IN ADDITION TO THE USE OF DAILY SIMULATION OF STREAMFLOW AND RESERVOIR REGULATION, TO DETERMINE THE INCREASE IN THE CONTROLLED FLOW AT THE DALLES, OR. DURING FILLING OF CAT.IV PROJECTS.
2. FOR A PARTICULAR YEAR, A SINGLE CURVE IS USED, AS DETERMINED AT THE TIME OF INITIAL CONTROLLED FLOW FROM THE FORECAST OF RESIDUAL RUNOFF VOLUME, COLUMBIA RIVER AT THE DALLES, CORRECTED FOR UPSTREAM STORAGE.
CURVES ARE FORECAST OF RESIDUAL RUNOFF VOLUME, COLUMBIA RIVER AT THE DALLES, CORRECTED FOR UPSTREAM STORAGE, FROM DATE OF INITIAL CONTROLLED FLOW THROUGH AUG.
CHART 3
LOWER COLUMBIA RIVER
FLOOD REGULATION DIAGRAM
FOR CATERGORY IV PROJECTS
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972
I
I+50
I+100
I+150
I+200
I+250
I+300
I+350
CONTROLLED FLOW, COLUMBIA RIVER AT THE DALLES
AS FUNCTION OF INITIAL CONTROLLED FLOW,I,FROM CHART1 IN KCFS



Surcharge Pool El. 1446.0
Normal Full Pool El. 1444.0
.25
1.00
≤ 64,000,000 Ac.Ft.
1.30
65,000,000 Ac.Ft.
2.60
70,000,000 Ac.Ft.
3.90
75,000,000Ac.fT.
5.10
≥ 80,000,000Ac.Ft.
7.10
Evacuation for
On-Call Storage
Required Storage Space (maf)
0
1
2
3
4
5
6
7
8
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
CHART 4
ARROW PROJECT
FLOOD CONTROL STORAGE
RESERVATION DIAGRAM
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972
NOTE:
1. Parameters are forecasts of unregulated runoff for the Columbia River at The Dalles, Oregon, for the period April through August.
2. These curves are based on 5.1-2.08 split of storage space between Arrow and Mica.
3. Reservoir storage spaces must equal or exceed month end values as shown by parameter curves except if (1) Storing is required for flood protection in accordance with the operating plan, (2) Storing is required in accordance with refill criteria, or (3) involuntary storage of inflow occurs with all slucies and spillway gates fully open.
4. Surcharge storage between EL.1444.0 and 1446.0 may be used for flood regulation in accordance with Section 6 of the Flood Control Operating Plan. Surcharge storage may be used in lieu of the 0.25 maf space requirement below EL. 1444.0 in October and November.



Surcharge Pool El. 1446.0
Normal Full Pool El. 1444.0
Required Storage Space (maf)
0
1
2
3
4
5
6
7
8
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
.25
.71
.71
.92
1.84
2.75
3.60
7.10
≤ 64,000,000 Ac.Ft.
65,000,000 Ac.Ft.
70,000,000 Ac.Ft.
75,000,000Ac.fT.
≤ 80,000,000Ac.Ft.
Evacuation for On-Call Storage
NOTE:
1. Parameters are forecasts of unregulated runoff for the Columbia River at The Dalles, Oregon for the period April through August.
2. These curves are based on 3.6/4.08 split of storage space between Arrow and Mica projects.
3. Reservoir storage space must equal or exceed month end values as shown by parameter curves except if (1) Storing is required for flood protection in accordance with the operating plan, (2) Storing is required in accordance with refill criteria, or (3) Involuntary storage of inflow occurs with all sluices and spillway gates fully open.
4. Surcharge storage between El. 1444.0 and 1446.0 may be used for flood regulation in accordance with Section 6 of the Flood Control Operating Plan. Surcharge storage may be used in lieu of the 0.25 MAF space requirement below El. 1444.0 in October and November.
CHART 5
ARROW PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
JANUARY 1995

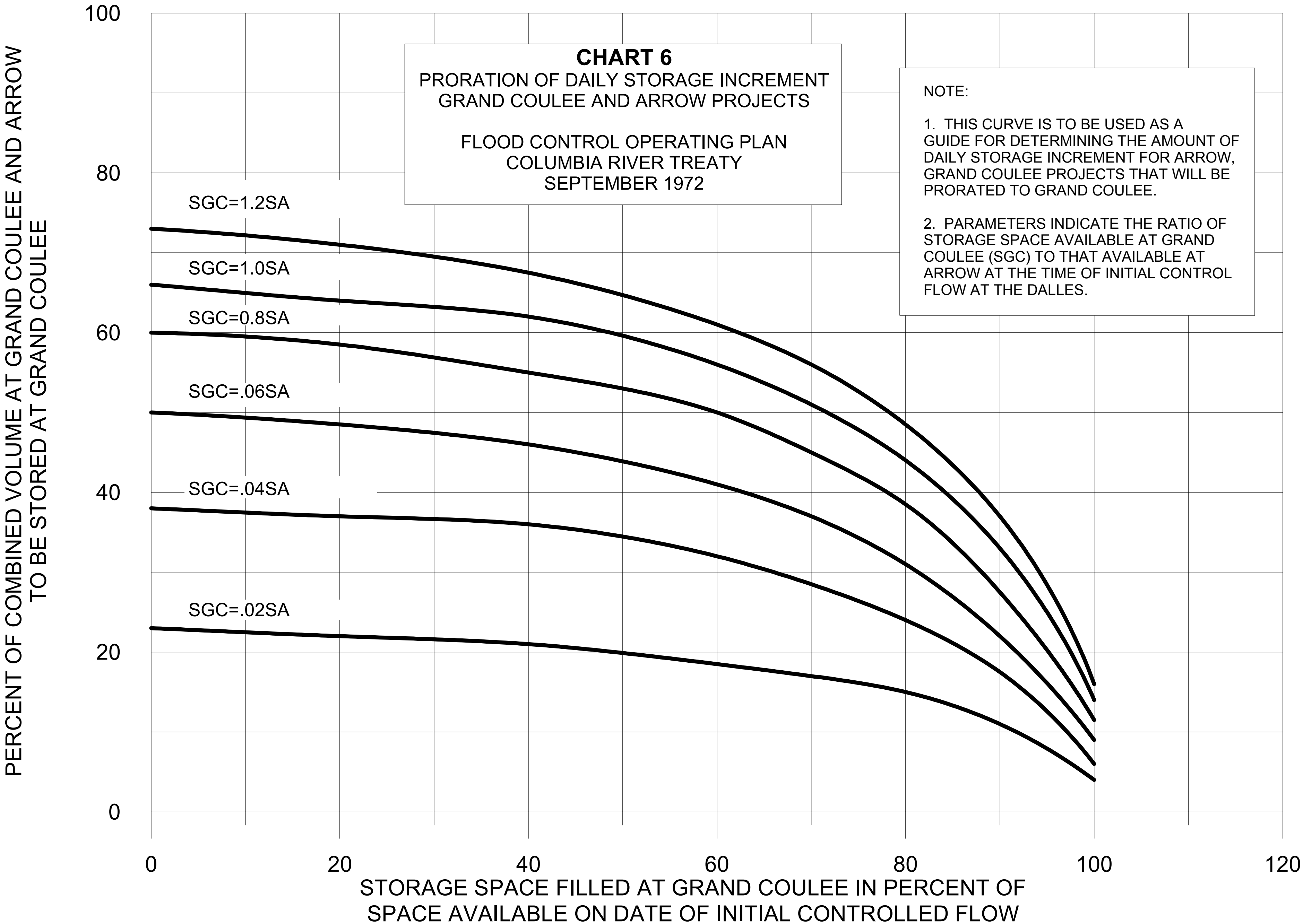
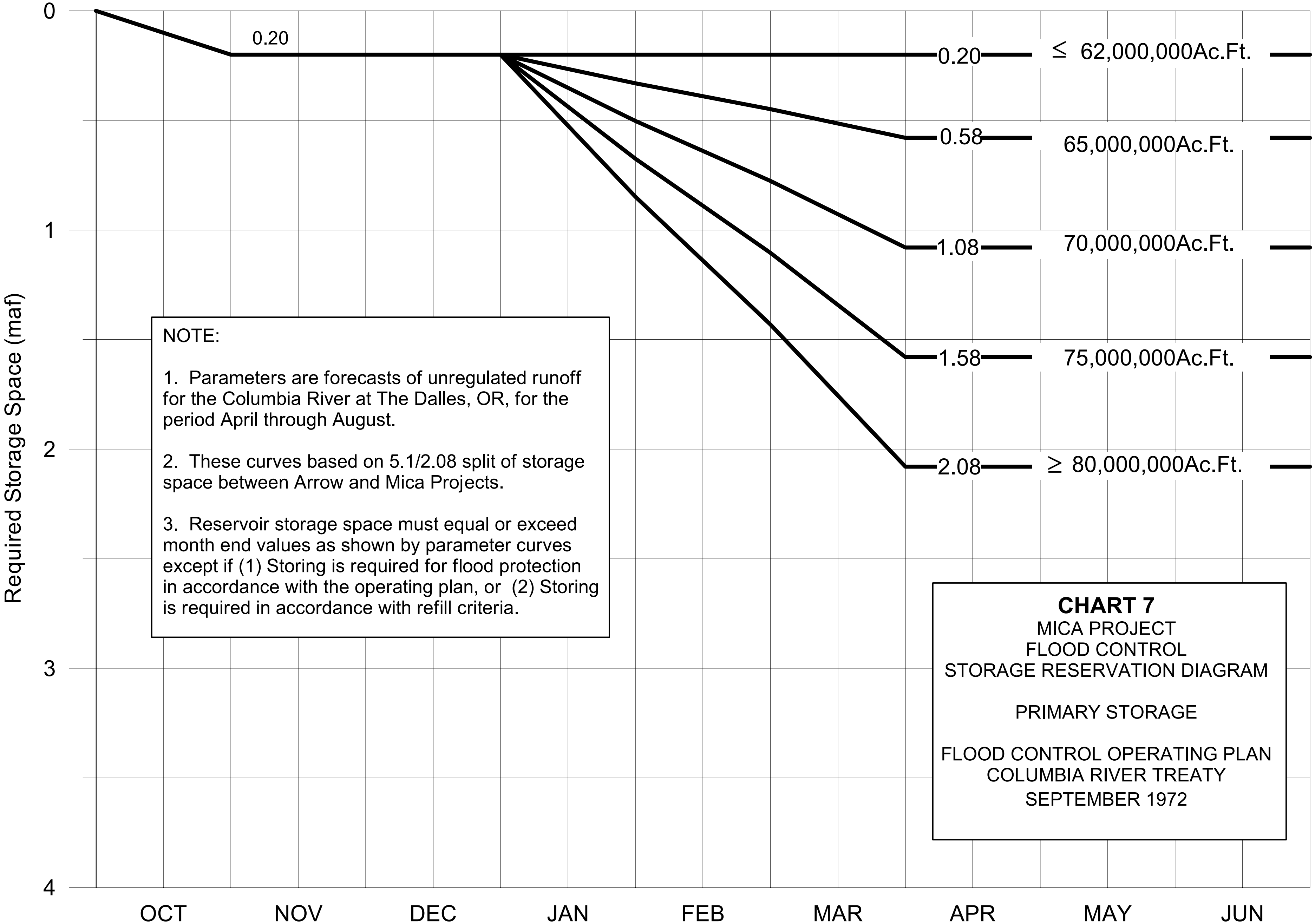


CHART 6
PRORATION OF DAILY STORAGE INCREMENT
GRAND COULEE AND ARROW PROJECTS
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972
NOTE:
1. THIS CURVE IS TO BE USED AS A GUIDE FOR DETERMINING THE AMOUNT OF DAILY STORAGE INCREMENT FOR ARROW, GRAND COULEE PROJECTS THAT WILL BE PRORATED TO GRAND COULEE.
2. PARAMETERS INDICATE THE RATIO OF STORAGE SPACE AVAILABLE AT GRAND COULEE (SGC) TO THAT AVAILABLE AT ARROW AT THE TIME OF INITIAL CONTROL FLOW AT THE DALLES.
SGC=1.2SA
SGC=1.0SA
SGC=0.8SA
SGC=.06SA
SGC=.04SA
SGC=.02SA
PERCENT OF COMBINED VOLUME AT GRAND COULEE AND ARROW TO BE STORED AT GRAND COULEE
STORAGE SPACE FILLED AT GRAND COULEE IN PERCENT OF SPACE AVAILABLE ON DATE OF INITIAL CONTROLLED FLOW
0
20
40
60
80
100
120


Required Storage Space (maf)
0
1
2
3
4
0.20
0.20
≤ 62,000,000Ac.Ft.
0.58
65,000,000Ac.Ft.
1.08
70,000,000Ac.Ft.
1.58
75,000,000Ac.Ft.
2.08
≥ 80,000,000Ac.Ft.
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
NOTE:
1. Parameters are forecasts of unregulated runoff for the Columbia River at The Dalles, OR, for the period April through August.
2. These curves based on 5.1/2.08 split of storage space between Arrow and Mica Projects.
3. Reservoir storage space must equal or exceed month end values as shown by parameter curves except if (1) Storing is required for flood protection in accordance with the operating plan, or (2) Storing is required in accordance with refill criteria.
CHART 7
MICA PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
PRIMARY STORAGE
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972

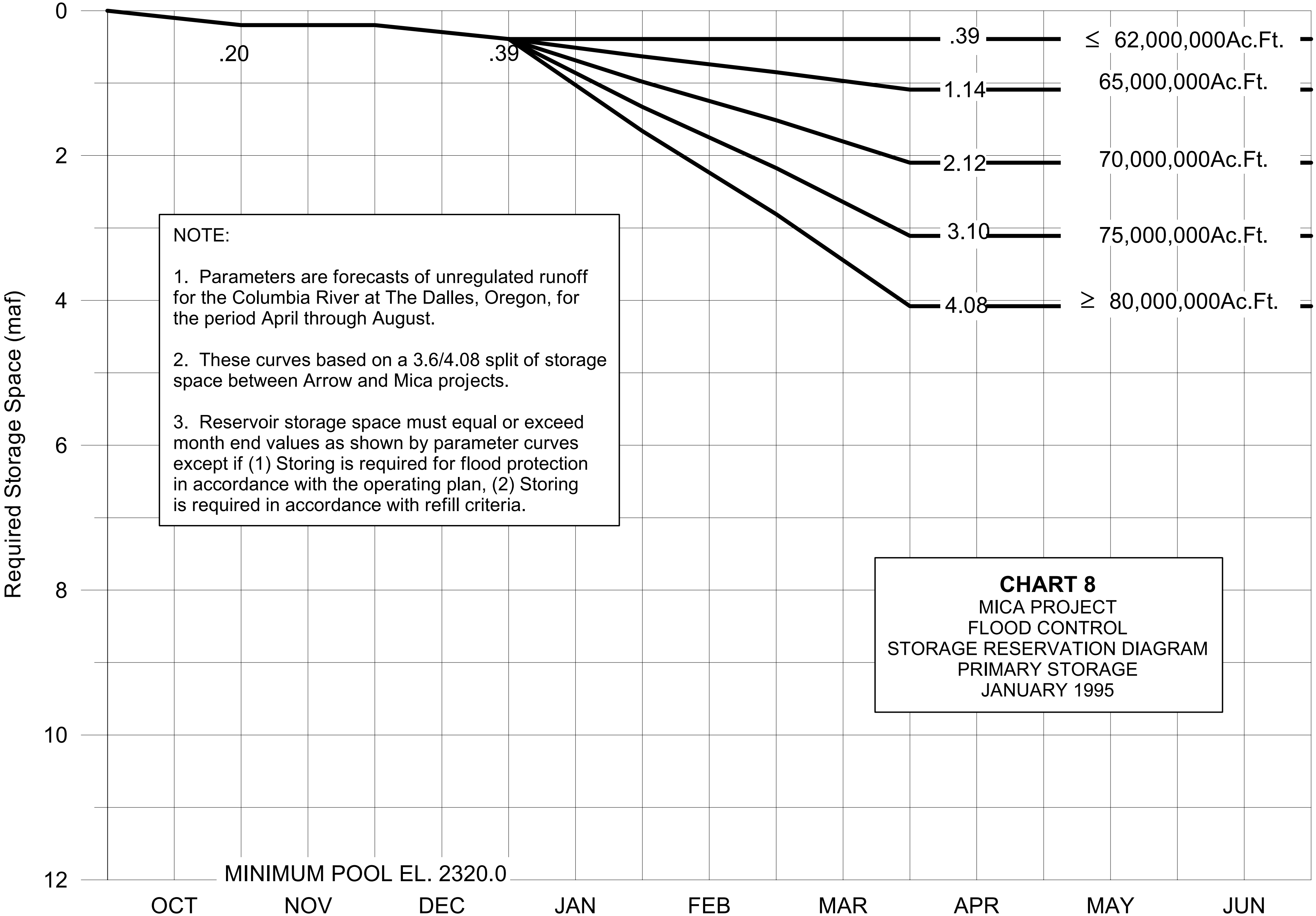


CHART 8
MICA PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
PRIMARY STORAGE
JANUARY 1995

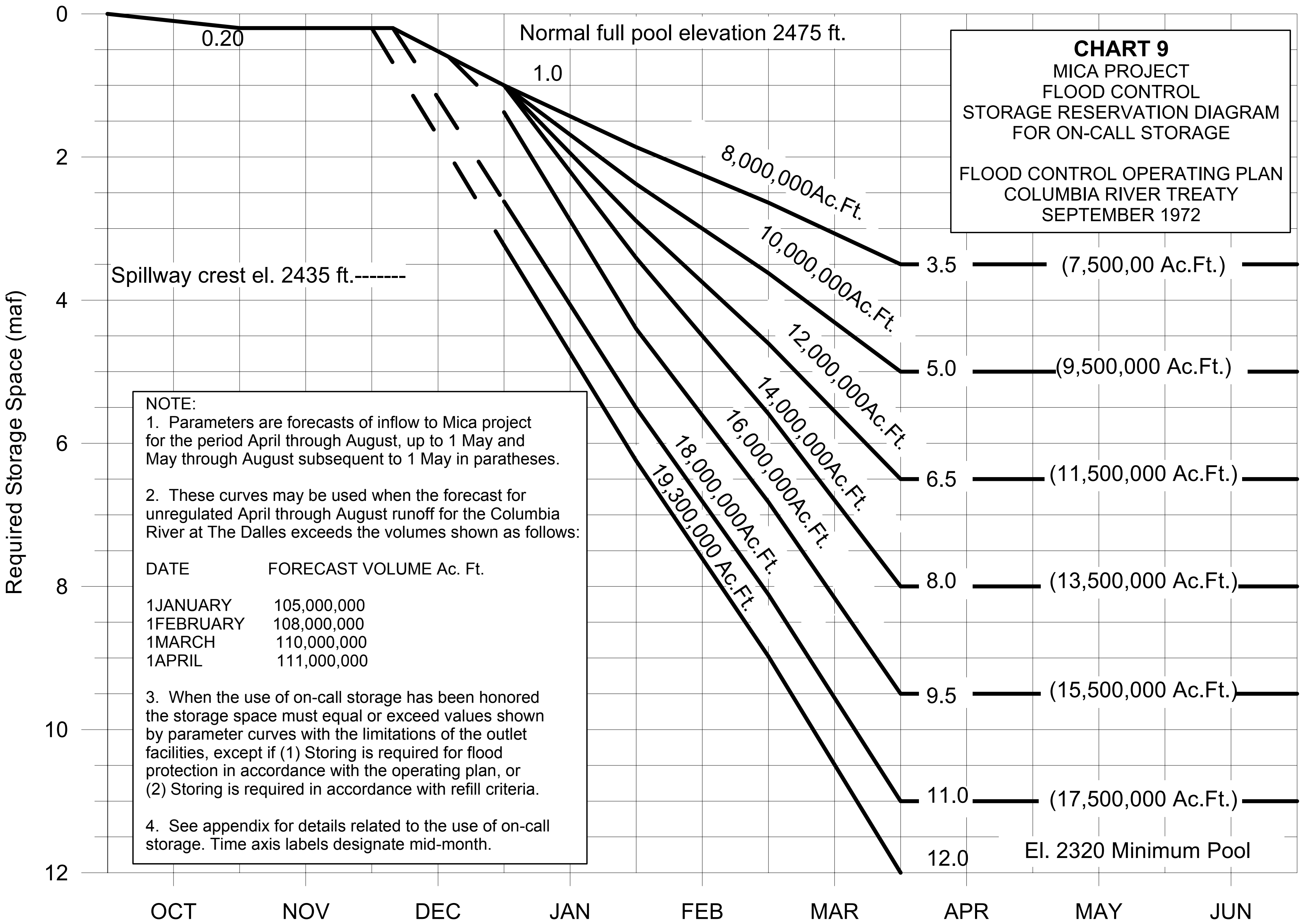
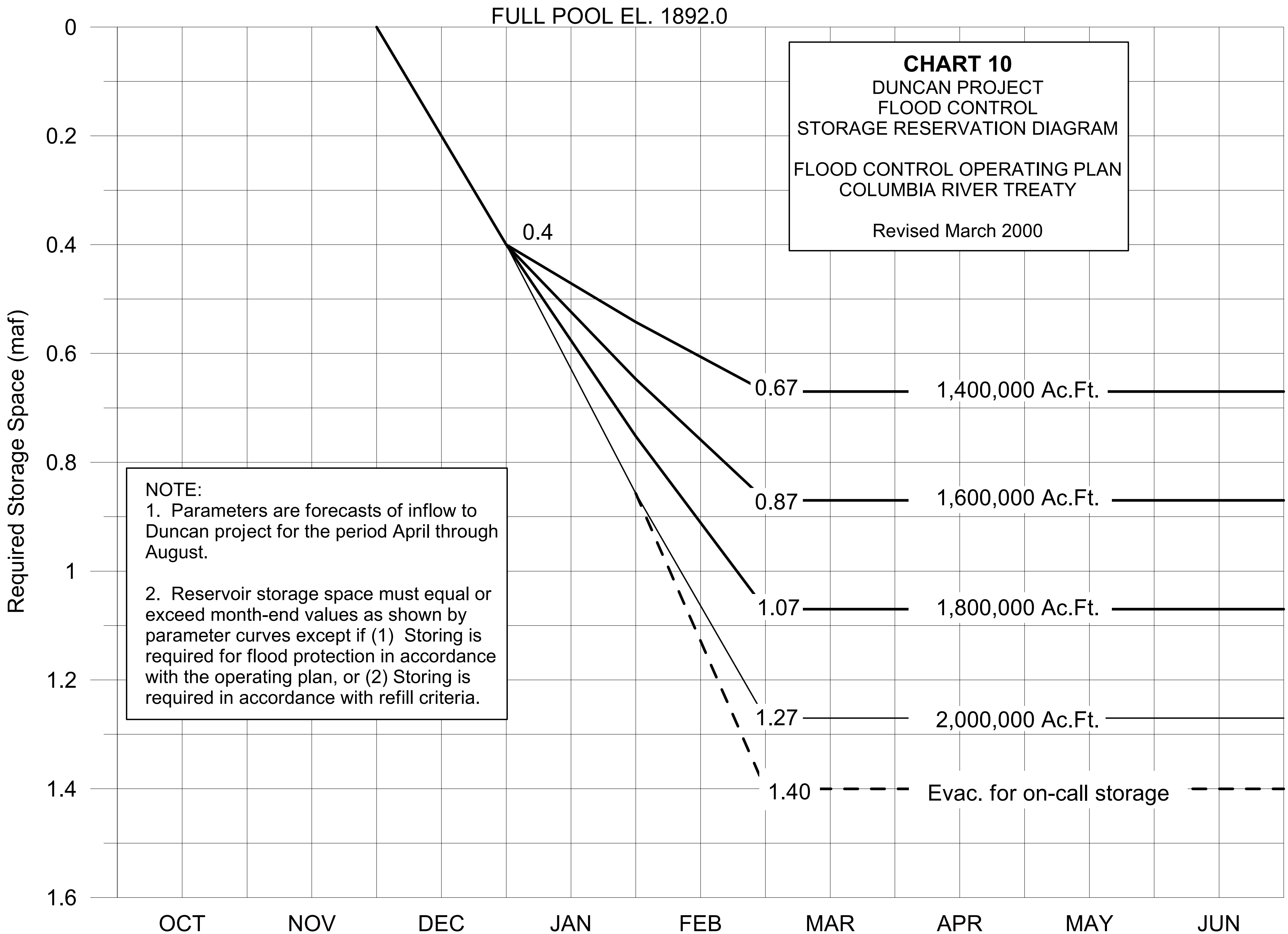
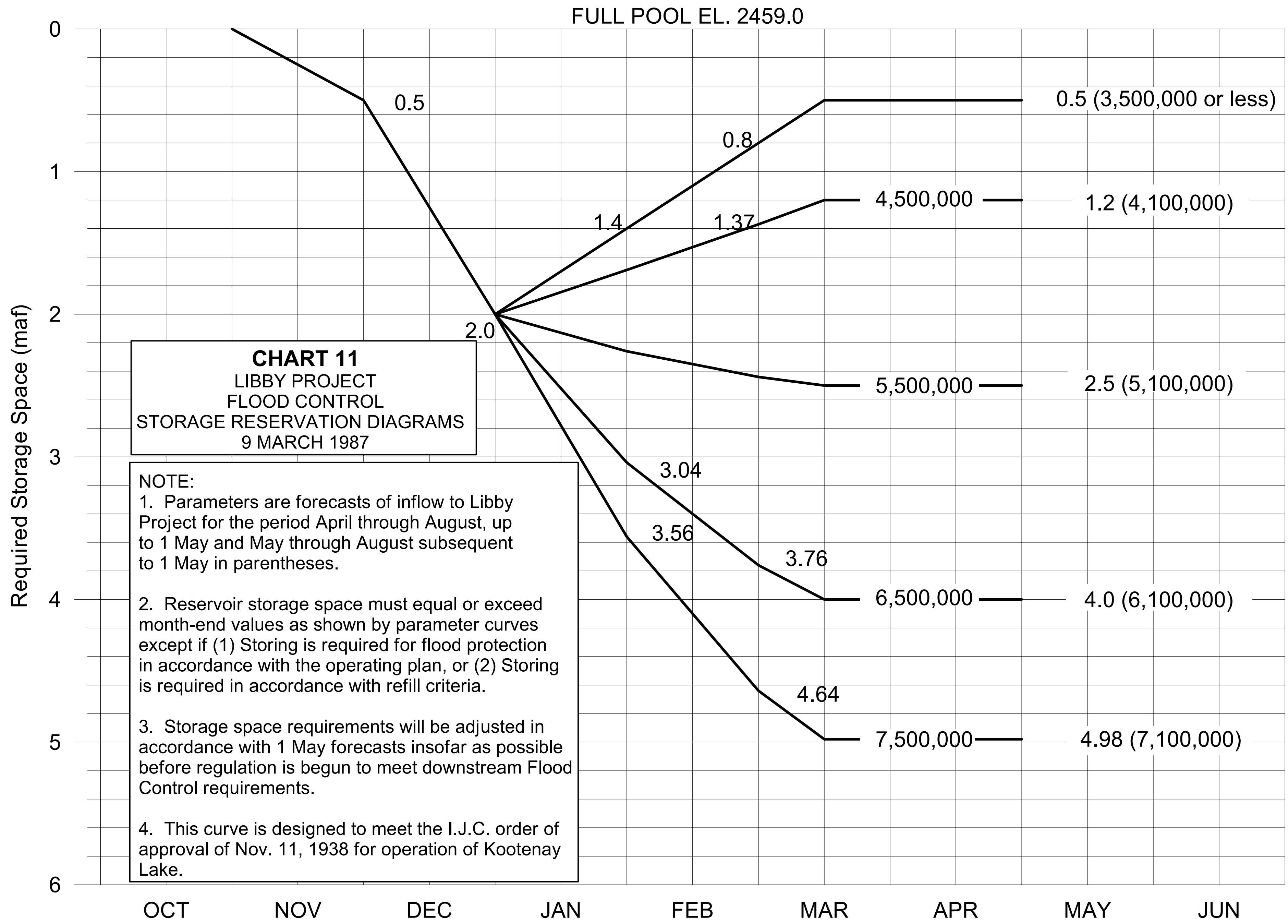
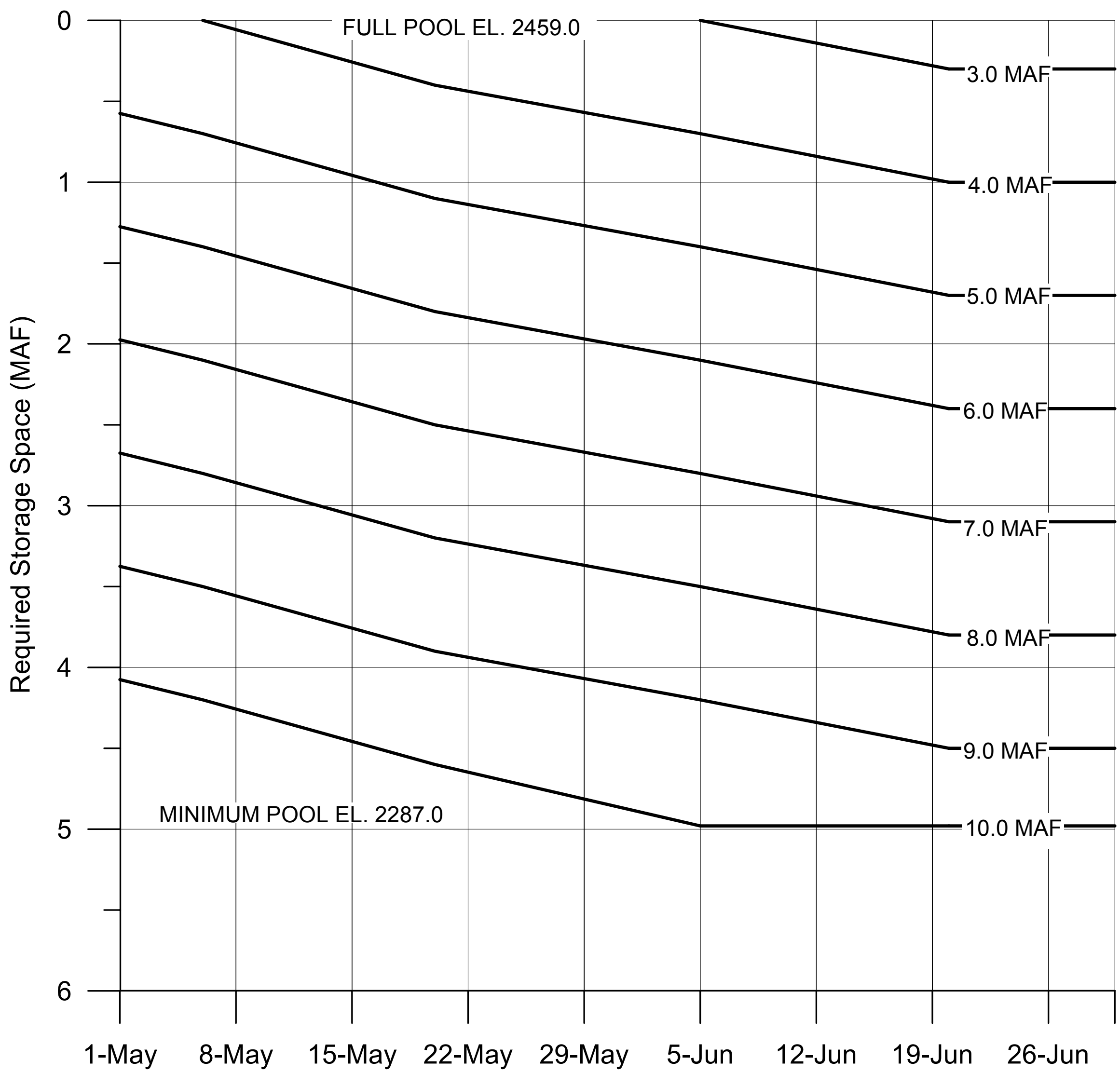


CHART 9
MICA PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
FOR ON-CALL STORAGE
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972
Normal full pool elevation 2475 ft.
0.20
1.0
Spillway crest el. 2435 ft.-------
8,000,000Ac.Ft.
10,000,000Ac.Ft.
12,000,000Ac.Ft.
14,000,000Ac.Ft.
16,000,000Ac.Ft.
18,000,000Ac.Ft.
19,300,000 Ac.Ft.
3.5
(7,500,00 Ac.Ft.)
5.0
(9,500,000 Ac.Ft.)
6.5
(11,500,000 Ac.Ft.)
8.0
(13,500,000 Ac.Ft.)
9.5
(15,500,000 Ac.Ft.)
11.0
(17,500,000 Ac.Ft.)
12.0
El. 2320 Minimum Pool
Required Storage Space (maf)
0
2
4
6
8
10
12
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
NOTE:
1. Parameters are forecasts of inflow to Mica project for the period April through August, up to 1 May and May through August subsequent to 1 May in paratheses.
2. These curves may be used when the forecast for unregulated April through August runoff for the Columbia River at The Dalles exceeds the volumes shown as follows:
DATE FORECAST VOLUME Ac. Ft.
1JANUARY 105,000,000
1FEBRUARY 108,000,000
1MARCH 110,000,000
1APRIL 111,000,000
3. When the use of on-call storage has been honored the storage space must equal or exceed values shown by parameter curves with the limitations of the outlet facilities, except if (1) Storing is required for flood protection in accordance with the operating plan, or (2) Storing is required in accordance with refill criteria.
4. See appendix for details related to the use of on-call storage. Time axis labels designate mid-month.



FULL POOL EL. 1892.0
CHART 10
DUNCAN PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
Revised March 2000
0.4
0.67
1,400,000 Ac.Ft.
0.87
1,600,000 Ac.Ft.
1.07
1,800,000 Ac.Ft.
1.27
2,000,000 Ac.Ft.
1.40
Evac. for on-call storage
Required Storage Space (maf)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
NOTE:
1. Parameters are forecasts of inflow to Duncan project for the period April through August.
2. Reservoir storage space must equal or exceed month-end values as shown by parameter curves except if (1) Storing is required for flood protection in accordance with the operating plan, or (2) Storing is required in accordance with refill criteria.


FULL POOL EL. 2459.0
0
1
2
3
4
5
6
Required Storage Space (maf)
0.5
0.8
1.4
1.37
2.0
3.04
3.56
3.76
4.64
4,500,000
5,500,000
6,500,000
7,500,000
0.5 (3,500,000 or less)
1.2 (4,100,000)
2.5 (5,100,000)
4.0 (6,100,000)
4.98 (7,100,000)
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
CHART 11
LIBBY PROJECT
FLOOD CONTROL
STORAGE RESERVATION DIAGRAMS
9 MARCH 1987
NOTE:
1. Parameters are forecasts of inflow to Libby Project for the period April through August, up to 1 May and May through August subsequent to 1 May in parentheses.
2. Reservoir storage space must equal or exceed month-end values as shown by parameter curves except if (1) Storing is required for flood protection in accordance with the operating plan, or (2) Storing is required in accordance with refill criteria.
3. Storage space requirements will be adjusted in accordance with 1 May forecasts insofar as possible before regulation is begun to meet downstream Flood Control requirements.
4. This curve is designed to meet the I.J.C. order of approval of Nov. 11, 1938 for operation of Kootenay Lake.



NOTE:
1. PARAMETERS ARE FORECASTS OF INFLOW TO LIBBY PROJECT FROM DATE THROUGH AUGUST.

2. RESERVOIR STORAGE SPACE MUST EQUAL OR EXCEED VALUES AS SHOWN BY PARAMETER CURVES EXCEPT IF (1) STORING IS REQUIRED FOR FLOOD PROTECTION FOR KOOTENAI BASIN, OR (2) STORING IS REQUIRED IN ACCORDANCE WITH REFILL CRITERIA.

CHART 12

LIBBY PROJECT
LOCAL FLOOD CONTROL
STORAGE RESERVATION DIAGRAM
FLOOD CONTROL ON KOOTENAI RIVER

FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1972

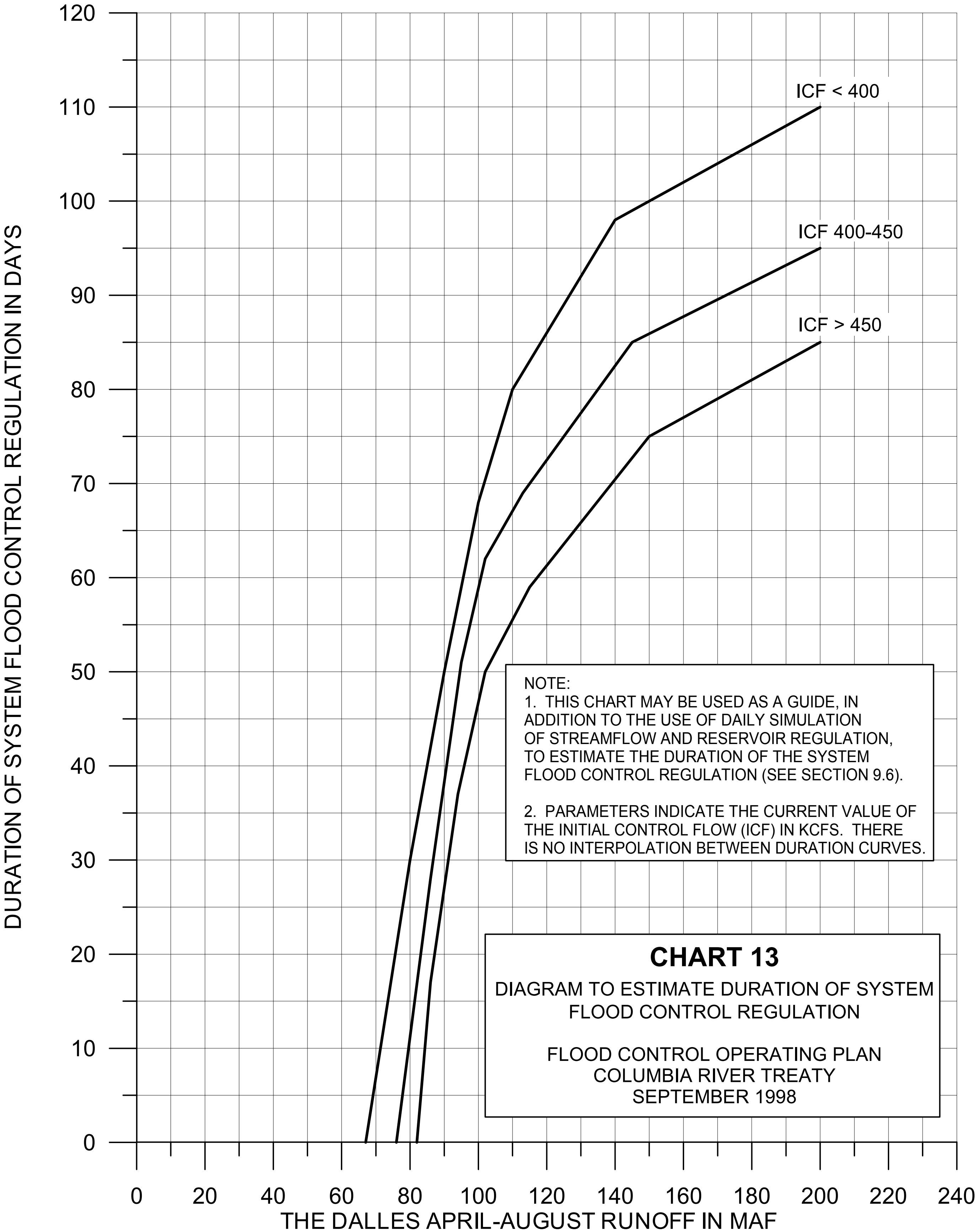


CHART 13

DIAGRAM TO ESTIMATE DURATION OF SYSTEM FLOOD CONTROL REGULATION

FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
SEPTEMBER 1998

APPENDIX A
ON-CALL STORAGE USE

Article IV, Paragraph 2(b) of the Treaty states that any additional storage in the Columbia River basin in Canada will be operated within the limits of existing facilities as required to meet flood control needs for the duration of the flood period when called upon by the United States Entity. This “On-Call” storage, as defined under the terms of the Treaty, applies principally, but not exclusively, to the full use of Mica, Arrow and Duncan projects for control of major floods. The Primary Storage at the Canadian storage projects amounts to 8,450,000 acre-feet out of a total of 20,500,000 acre-feet of usable storage capacity. Thus, there is an additional 12,050,000 acre-feet of storage capacity in Mica, Arrow, and Duncan available for control of major floods, most of which is located at Mica.

A large part of this On-Call storage would normally be evacuated during the winter, but this is not assured. Under Paragraph 1.(3) of the Protocol to the Treaty, a delay of twenty days may be encountered before the request for On-Call storage use is honored. With consideration to the discharge limitations at each project, the time required to prepare forecasts, and the time to process a request, it will be necessary for consultations on the use of On-Call storage to commence in November in order to be assured that the storage space at each project can be made available by 1 April. The need for On-Call storage will be evident very early; usually manifested by extraordinarily high base flows and snowpack. Even though official forecasts which are used to prescribe the On-Call storage draft are not available until January, On-Call drafting may need to begin sooner with the mutual consent of both parties. Once the decision for use of On-Call storage has been made, Canadian storage will be operated to provide the amount of storage space required by each project’s Storage Reservation Diagram within the limitation of the outlet facilities. Payment for the use of On-Call storage will be in accordance with Article VI, Paragraph 3 of the Treaty.

As defined in Paragraph 1.(1) of the Protocol to the Treaty, On-Call storage may be requested only for potential floods which could result in a peak discharge in excess of 600,000 cfs at The Dalles, assuming storage regulation of United States projects existing or under construction in January 1961, together with the Primary Storage provided in Canadian

Treaty projects, plus storage in Libby project. This amount of storage will assure a reduction of about 300,000 cfs in the peak discharge of major floods at The Dalles. Accordingly, a natural flood peak of 900,000 cfs could be regulated to about 600,000 cfs.

As a basis for determining when a flood, so regulated, could exceed 600,000 cfs, the peak-to-volume relationship for Columbia River at The Dalles was plotted as shown on Chart 1A. The independent variable for this relationship is the April through August volume of runoff at The Dalles for the years 1879 through 2002. The dependent variable is the corresponding peak discharge. The data represents unregulated conditions; that is, observed peaks and volumes were adjusted to compensate for the storage regulation of upstream reservoirs. Eighty percent of the variability of the data is accounted for by the regression model (R squared equals 0.80). On the chart parallel to the line of best fit are lines representing plus or minus one standard error of the predicted peak discharge. Assuming the errors are normally distributed about the line of best fit, there is about a 65 percent probability that the predicted peak discharge will be within one standard error, plus or minus, of the best fit line. Further, there is about a 95 percent chance that the predicted peak discharge will be within two standard errors, plus or minus, of the best fit line.

Chart 1-A shows that unregulated peaks in excess of 900,000 cfs have occurred only when the April-August runoff exceeds 120 million acre-feet. There are, however, inherent errors in forecasting runoff volume, and the amount of these errors will vary with the date on which the forecasts are made. A reasonable measure of the expected error in any given forecast is considered to be one standard error. The following table lists the standard errors in forecasts for the April through August runoff volumes for the Columbia River at The Dalles, based on forecasts made from hydrometeorological conditions as known on specified dates:

Date of Forecast	Standard Error, in acre-feet
1 January	15,000,000
1 February	12,000,000
1 March	10,000,000
1 April	9,000,000

If the forecast of April through August runoff volume at The Dalles, on the various dates, exceeds the following values, the potential exists of a flood exceeding 900,000 cfs unregulated and 600,000 cfs regulated:

Date of Forecast	Forecast of Runoff Volume in acre-feet
1 January	105,000,000
1 February	108,000,000
1 March	110,000,000
1 April	111,000,000

The forecast runoff amounts listed above constitute the basis on which consultation on a call may be initiated by the United States. Consultation on the need for a call should begin as soon as conditions indicate a call may be necessary and the actual call may be made by the United States Entity as soon as possible thereafter to assure the evacuation from Mica, Arrow, and Duncan of as much stored water as possible. The call may be delayed to 1 February or 1 March, if partial evacuation has already been accomplished. If there should be a significant increase in the forecast runoff volume during the period 1 January to 1 April, consultation on the need for a call may be initiated at such time as the forecast exceeds the above values.

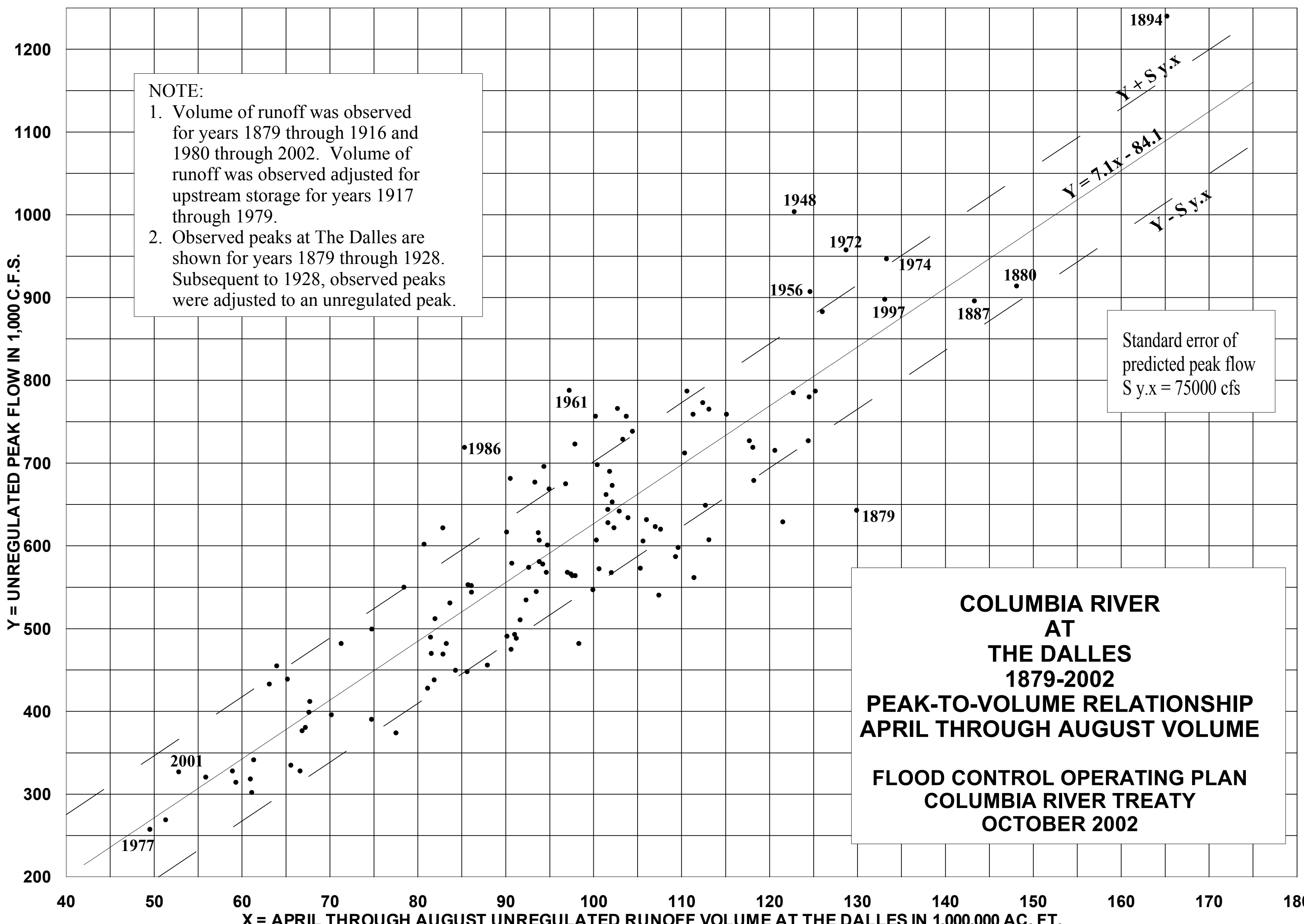

NOTE:
1. Volume of runoff was observed for years 1879 through 1916 and 1980 through 2002. Volume of runoff was observed adjusted for upstream storage for years 1917 through 1979.
2. Observed peaks at The Dalles are shown for years 1879 through 1928. Subsequent to 1928, observed peaks were adjusted to an unregulated peak.
Y + S y.x
Y = 7.1x - 84.1
Y - S y.x
Standard error of predicted peak flow S y.x = 75000 cfs
1894
1948
1972
1974
1956
1997
1887
1880
1961
1986
1879
2001
1977
Y = UNREGULATED PEAK FLOW IN 1,000 C.F.S.
X = APRIL THROUGH AUGUST UNREGULATED RUNOFF VOLUME AT THE DALLES IN 1,000,000 AC. FT.
200
300
400
500
600
700
800
900
1000
1100
1200
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
COLUMBIA RIVER
AT
THE DALLES
1879-2002
PEAK-TO-VOLUME RELATIONSHIP
APRIL THROUGH AUGUST VOLUME
FLOOD CONTROL OPERATING PLAN
COLUMBIA RIVER TREATY
OCTOBER 2002

CHART 1-A

APPENDIX B

GLOSSARY

CONTROLLED FLOW. The target flow for lower Columbia River flood control as measured at The Dalles, Oregon. Storage in reservoirs to meet the controlled flow will generally result in adequate control at other flood damage areas in Canada and the United States.

FLOOD CONTROL ARROW/MICA EXCHANGE. As designated by the Columbia River Treaty, the Canadian Entity may exchange flood control storage from Arrow to Mica if the entities agree that the exchange would provide the same effectiveness for control of floods on the Columbia River at The Dalles, Oregon.

FLOOD CONTROL REFILL CURVE (FCRC). Curves to help guide the refill of reservoirs and ensure the flood control regulation does not adversely affect refill insofar as possible. These curves define the lower limit of reservoir drawdown that can be filled with a 95 percent assurance. Their derivation is based on the current 95 percent exceedance volume runoff forecast corrected for refill of upstream storage and project outflows that are anticipated or projected to occur during the ensuing runoff season. They are updated daily, if necessary.

FLOOD CONTROL STORAGE EVACUATION PERIOD. Reservoir regulation period that begins when storage evacuation is required by the Flood Control Storage Reservation Diagrams contained in this plan and ends with the beginning of the Flood Control Refill Period.

FLOOD CONTROL REFILL PERIOD. Reservoir regulation period that begins 20 days prior to the date the unregulated mean daily discharge is forecast to exceed 450,000 cfs at The Dalles, Oregon. The end of the Flood Control Refill Period will be when no further flood potential exists at any of the damage areas in Canada and the United States as described in Section IV of this plan.

FLOOD CONTROL STORAGE RESERVATION DIAGRAM (SRD). Diagrams that define the flood control storage space required in each reservoir to provide flood protection for the Columbia River as measured at The Dalles, Oregon. Storage space required is a function of time of year and the seasonal runoff volume. The diagrams are designed to provide an orderly drawdown of each reservoir prior to the reservoir refill period with consideration to project and functional operating limits.

INITIAL CONTROLLED FLOW (ICF). The first, or initial, controlled flow of the runoff season to which control will be attempted for the Columbia River as measured at The Dalles, Oregon. The Initial Control Flow is used in conjunction with unregulated streamflow forecasts to guide the determination of when to begin refill of reservoirs.

LOCAL FLOOD CONTROL OPERATION. Regulation of reservoir storage projects to control flooding in damage areas immediately downstream. Releases specified for the system flood control operation may be temporarily suspended insofar as possible to provide better flood protection in these areas.

PRIMARY STORAGE. Storage space in Canada that is committed for the purpose of flood control for the Columbia River. The volumes are defined in the Columbia River Treaty as being 1,270,000 acre-feet at Duncan, 7,100,000 acre-feet at Arrow, and 80,000 acre-feet at Mica.

PRIORITY DRAFT. Draft priority for Libby or Duncan that is selected when outflows from Libby and Duncan are required to be reduced to preclude a violation of the 1938 International Joint Commission Order for Kootenay Lake. Selection of a specific draft priority will reduce, eliminate, or exacerbate trapped storage conditions at either Libby or Duncan.

ON-CALL STORAGE. As designated by the Columbia River Treaty, additional reservoir storage in the Columbia River basin in Canada (with respect to Primary Storage) that can be operated within the limits of existing facilities as required to meet flood control needs for the duration of the flood period when called upon by the United States Entity.

SYSTEM FLOOD CONTROL OPERATION. The regulation of reservoir storage projects in Canada and the United States as specified in the Flood Control Operating Plan to control flooding of the Columbia River. The main control point is the lower Columbia River as measured at The Dalles, Oregon. Meeting flood control objectives at this point generally will result in adequate control at other flood damage areas in Canada and the United States.

TRAPPED STORAGE. Reservoir condition where Libby, Duncan, or both, cannot be drafted in accordance with their Storage Reservation Diagrams, as in doing so would violate the 1938 International Joint Commission Order for Kootenay Lake. The trapped storage is the volume of water stored above the flood control rule curve at the end of the Flood Control Storage Evacuation Period.

UNREGULATED FLOW. The mean daily discharge that would occur without regulation of upstream storage reservoirs in the basin, and with the storage effects of natural lakes determined using existing outlet restrictions with control dams on freeflow.