COLUMBIA RIVER TREATY

Arrow 3.6 Million Acre-Feet

Flood Risk Operating Plan

U.S. Army Corps of Engineers,

Northwestern Division

26 June 2025

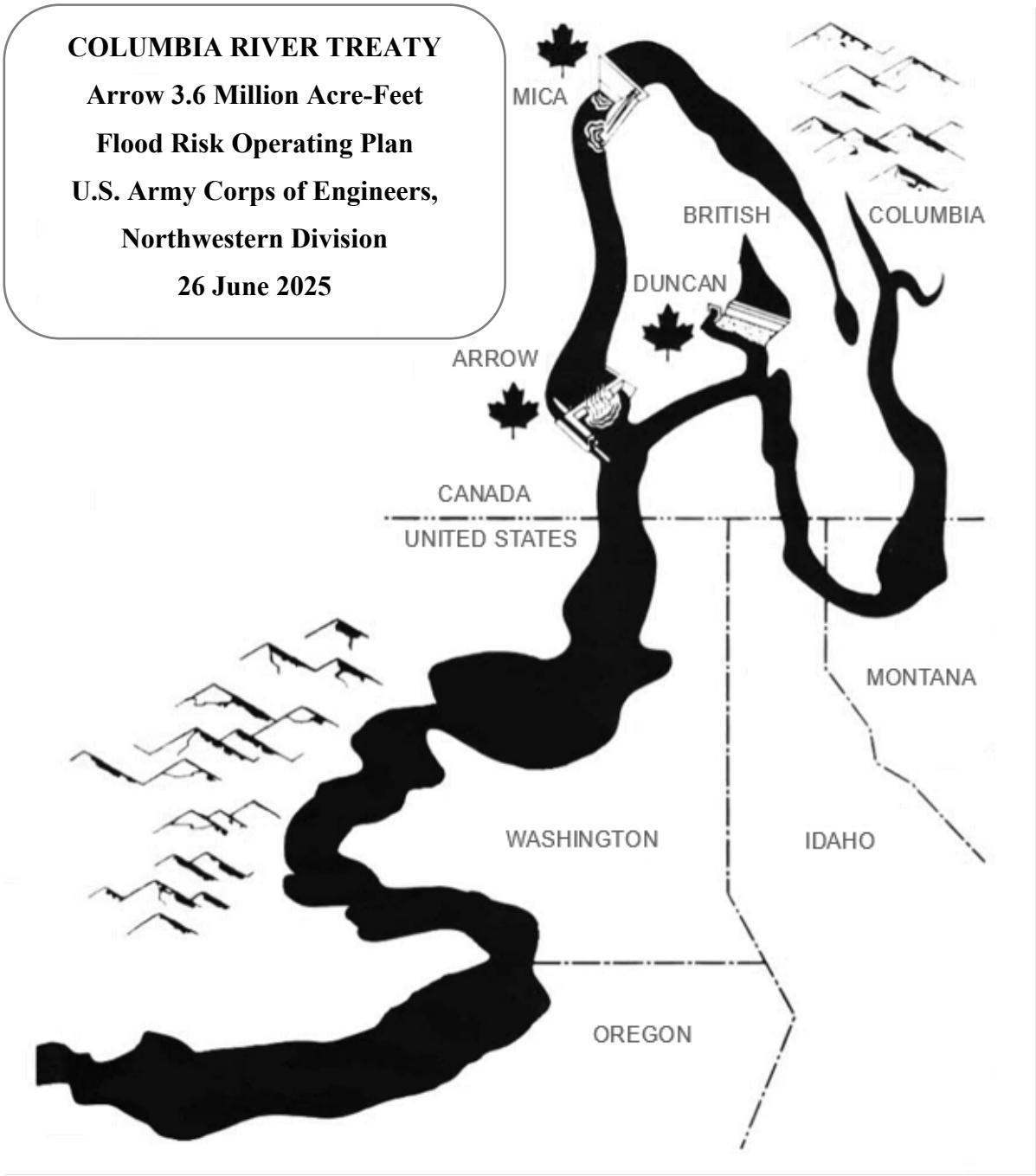

TABLE OF CONTENTS

1 INTRODUCTION 1
1-1 Purpose and Authority 1
1-2 Columbia River Flood Characteristics 2
1-3 Basic Flood Risk Management Objective 2
1-4 Flood Risk Management Objectives in the United States 2
1-5 Flood Risk Management Objectives in Canada 3
1-6 Seasonal Flood Risk Management 3
1-7 System FRM Evacuation Period 3
1-8 System FRM Fill Period 4
1-9 System FRM Coordination 4
2 PROJECT PERTINENT DATA 5
2-1 Naming Conventions 5
2-2 Vertical Datum 5
2-3 Sources of Operating Limits 5
2-4 Operating Limits of Arrow 6
3 OPERATIONAL DATA 6
3-1 Hydrometeorological Observations 6
3-2 Seasonal Runoff Volume Forecasts 6
3-3 Reservoir Operation Forecasts 7
4 OPERATIONS DURING SYSTEM FRM EVACUATION PERIOD 7
4-1 Storage Reservation Diagram 7
4-2 Fall and Winter Floods 7
5 OPERATIONS DURING SYSTEM FRM FILL PERIOD 9
5-1 System FRM Requirements 9
5-2 Minimum Space Requirement 9
5-3 Maximum Release Rate Requirement 9
5-4 Canadian Local FRM 10
Table 1: Arrow 3.6 MAF Storage Reservation Diagram 12
Chart 1: Arrow 3.6 MAF Storage Reservation Diagram 13

1 INTRODUCTION

1-1 Purpose and Authority

The purpose of the 3.6 million acre-feet (maf) pre-planned flood risk management[1] (FRM) operations is to achieve FRM objectives in the United States. The purpose of this Arrow 3.6 maf Flood Risk Operating Plan (FROP) is to describe the 3.6 maf pre-planned FRM operations at Arrow Lakes Reservoir including coordination with other operations under the Columbia River Treaty.

This FROP prescribes technical criteria and procedures that will be used in real-time operations and for inputs to system operational studies, such as assured operating plans and detailed operating plans. Technical criteria and procedures include "operating requirements".

This FROP was developed by the United States Army Corps of Engineers, Northwestern Division (Northwestern Division) on behalf of the United States Entity, pursuant to the *Columbia River Treaty Entity Agreement Regarding Pre-Planned Flood Risk Management Arrangements During the Interim FRM Period (*FRM Entity Agreement*).* The FRM Entity Agreement became effective on 22 November 2024, by the exchange of notes between Canada and the United States of America under Article XIV(4) of the Columbia River Treaty. The Canadian Entity accepted this FROP on 26 June 2025. This FROP is applicable to the operation of Canadian Treaty storage, in accordance with Section 2 of the FRM Entity Agreement, when the United States Entity "has made the election and corresponding payment as described in Section 3" of that agreement. In the event that the 3.6 maf pre-planned FRM operations are extended through future entity agreements, Treaty amendments, or otherwise, it is the intent of the entities that this FROP could continue to serve as the operating plan for the 3.6 maf pre-planned FRM operations, and that future agreements will address the applicability of the FROP to future operations.

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[1] Since the enactment of the Flood Control Act of 1917, the act of managing flood risk has been termed "flood control" in many historical documents including the Columbia River Treaty. However, the terminology used by the U.S. Army Corps of Engineers has evolved over time moving from flood control to flood damage reduction to flood risk management. For the purposes of this document, the term "flood control" is used when referring to authorizing or historical documents using that terminology. When referring to actions and activities in managing reservoirs for flood purposes, the term "flood risk management" (FRM) is used.

This FROP is distinct from and not related to Articles IV(3), VI(4), VI(5), XII of the Treaty and Articles 1, 2, and 5 of the Protocol and is "without prejudice" to the positions of the entities in relation to the aforementioned treaty provisions.

1-2 Columbia River Flood Characteristics

High flows on the Columbia River may be caused by melting snow, rainfall, or both occurring at the same time. Spring snowmelt (freshet) floods last for many days or weeks, as they are generated when a large snowpack melts rapidly. The most severe spring snowmelt floods occur when intense convective rainfall events occur during spring and early summer snowmelt. Flood stages in the Columbia River may also occur during winter atmospheric river storms when there are coincident high inflows from tributaries in the lower river. These atmospheric river storms may last several days and deliver a large amount of rain over their duration. Unless otherwise noted, the technical criteria and procedures in this FROP are focused on spring snowmelt floods.

1-3 Basic Flood Risk Management Objective

The basic objective for flood regulation is to operate reservoirs to reduce stages to non-damaging levels at all 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 have been established for this document considering the existing state of development.

1-4 Flood Risk Management Objectives in the United States

Flooding in the Lower Columbia River downstream of Bonneville Dam begins when the river reaches elevation 16 feet (Columbia River Datum) at Vancouver, Washington. The corresponding flow at The Dalles, Oregon is approximately 450,000 cubic feet per second (cfs), though this can vary widely depending on flows from tributaries downstream. Damage commences in the mid-Columbia area in the vicinity of Hanford, Washington, when flows reach 400,000 cfs at the Priest Rapids project. The regulation required for areas downstream of Bonneville Dam normally will achieve the desired flood risk management in the mid-Columbia area.

In this FROP, the term "System FRM" refers to the way the system of reservoirs upstream of the

control points described in the paragraph above are operated to achieve the FRM objectives in the United States along the Columbia River described in this section and Section 1-3.

This FROP describes how the 3.6 maf of pre-planned FRM storage at Arrow will be operated to achieve FRM objectives in the United States.

1-5 Flood Risk Management Objectives in Canada

Damage commences at Trail when flows exceed 180,000 cfs as measured at the gauge at Birchbank and major damage occurs when flows exceed 280,000 cfs. These flows correspond to elevations of approximately 1,360 ft and 1,370 ft respectively (GSC 1951 datum). Flood risk management objectives at Castlegar are normally met if the flood risk management objectives at Trail are met.

In this FROP, the term "Canadian Local FRM" refers to the way the system of reservoirs upstream of the control points described in the paragraph above are operated to achieve the FRM objectives in Canada along the Columbia River described in this section and in Section 1-3.

This FROP describes how "Canadian Local FRM" objectives are taken into account by the entities in relation to the operation of the 3.6 maf at Arrow to achieve FRM objectives in the United States.

1-6 Seasonal Flood Risk Management

The Columbia River is influenced by reservoir regulation, which reduces flooding through the redistribution of flows from periods with higher natural runoff to periods with lower natural runoff. The general nature of reservoir regulation for FRM in the Columbia River Basin involves two seasonal periods, (1) the reservoir evacuation period, when projects evacuate storage to create and maintain space to capture naturally high flow and (2) the reservoir fill period, when naturally high flow is captured in the reservoirs. The FRM regulation periods are termed the "System FRM Evacuation Period" and the "System FRM Fill Period".

1-7 System FRM Evacuation Period

During the System FRM Evacuation Period water is released from storage to achieve the reservoir space required to manage spring snowmelt flows. The required space varies annually

and is determined from forecasts of spring runoff. During the System FRM Evacuation Period, project outflows are managed to ensure that storage can be evacuated to the desired level before the arrival of spring flood flows, while limiting downstream flooding in both Canada and the United States.

The System FRM Evacuation Period begins on October 1. Transition from the System FRM Evacuation Period to the System FRM Fill Period occurs when forecasts of expected unregulated flows exceed desired flow thresholds and managed filling may be needed to reduce flood flows in the Lower Columbia River. The transition is termed the "Initiation of System FRM Fill", and the date of that transition is determined by Northwestern Division annually. Unregulated flows in this context include the following assumptions: 1) Initial reservoir levels throughout the system are set to their respective target FRM elevations for the end of the System FRM Evacuation Period; 2) to the extent possible these levels are held at that elevation while local inflows are routed through the system; and 3) flow routing takes into account travel time and the attenuation effects of natural lakes with existing outlet restrictions where appropriate.

When Arrow is evacuated to 3.6 maf, the outlet restrictions are generally not limiting.

1-8 System FRM Fill Period

During the System FRM Fill Period, when unregulated inflows are high, project outflows are regulated to limit flooding along the Columbia River thus filling the reservoirs. There are two objectives for System FRM during the System FRM Fill Period: (a) reducing downstream flood flows by reducing releases from upstream projects while (b) retaining reserved space to help manage future inflows. The constraints on operations during the System FRM Fill Period are designed in a manner that do not jeopardize refill of reservoirs insofar as possible.

The end of the System FRM Fill Period occurs when unregulated flows decrease and downstream flood risk is reduced. This end date is determined by Northwestern Division annually.

1-9 System FRM Coordination

Unless otherwise specified, references to the duties and actions of the entities described in the FROP (including those carried out on behalf of the United States Entity by the Northwestern

Division) may be accomplished by the respective section of the Columbia River Treaty Operating Committee, or as otherwise determined by mutual agreement of the entities.

A "System Flood Emergency" refers to the formal declaration by Northwestern Division of an active flood event in the United States. A System Flood Emergency declaration triggers increased communication and coordinated project operations and triggers specific operational requirements in Sections 4-2, 5-2, and 5-3. Project operations throughout the Columbia Basin will be led by Northwestern Division to manage flooding in the Lower Columbia River. A System Flood Emergency is declared when Northwestern Division forecasts that the Vancouver, Washington gauge will reach flood stage (16 ft). Northwestern Division contacts relevant project owners and operators when a System Flood Emergency has been declared and daily briefing calls commence.

2 PROJECT PERTINENT DATA

2-1 Naming Conventions

In this FROP, the terms Mica, Arrow, and Duncan are used to refer to Mica Dam, which forms Kinbasket Reservoir; Hugh Keenleyside Dam, which forms Arrow Lakes Reservoir; and Duncan Dam, which forms Duncan Lake, respectively.

2-2 Vertical Datum

Unless otherwise noted, elevations in this FROP are given in feet, in the project datums that were established when the reservoirs were constructed and have been used continuously since that time.

2-3 Sources of Operating Limits

Storage values and normal operating elevation limits are sourced from the Detailed Operating Plan for Operating Year 2023-2024 (June 2023). The Arrow storage-elevation table is dated 28 February 1974, updated 1 February 2013. Arrow discharge capacity is sourced from the Report on Arrow Project Discharge Capacity dated 25 August 1965, and the 2019 Pacific Northwest Coordination Agreement (PNCA) Data Submittal dated 31 January 2019. The Canadian Entity will provide up-to-date discharge capacity and storage-elevation tables when there are changes.

2-4 Operating Limits of Arrow

The normal full reservoir elevation is 1444.0 feet, and the normal minimum reservoir elevation is 1377.9 feet in Lower Arrow Lake. There is 7.1 maf of active storage between normal minimum and normal full pool. A surcharge elevation of 1446.0 feet provides approximately 0.25 maf of additional storage. The minimum average weekly outflow for Arrow is 5,000 cfs per the Treaty, Annex A. The maximum rate of change in outflow (ramp rate) is normally 15,000 cfs per day (for both increasing and decreasing flows) and best efforts are used to meet these ramp rates.

3 OPERATIONAL DATA

3-1 Hydrometeorological Observations

Annex A(2) of the Treaty states: "Hydrometeorological information will be made available to the entities in both countries for immediate and continuing use in flood control and power operations." As required in Annex A(2) of the Treaty, hydrometeorological information, including snow courses, precipitation stations, and stream flow gauges, are made available to the entities in both countries. The Columbia River Treaty Hydrometeorological Committee continues to be responsible for defining the required data, gathering it, and making it available to both entities.

3-2 Seasonal Runoff Volume Forecasts

Seasonal runoff volume forecasts indicate the amount of runoff expected during the spring snowmelt period based on available hydrometeorological information and weather forecasts. The seasonal runoff volume forecasts for the Columbia River at The Dalles are supplied by the United States Entity. The seasonal runoff forecasts for Mica, Arrow, and Duncan are supplied by the Canadian Entity.

These seasonal runoff volume forecasts will be made from available hydrometeorological data beginning 1 January and revised at the beginning of each month through June as the season advances. These forecasts will be made available by each entity, to the other entity, no later than the fourth working day of each month. If unusual hydrometeorological conditions prevail within the month, the entities may take action to obtain forecasts more frequently, such as at a mid-month date.

3-3 Reservoir Operation Forecasts

During the System FRM Evacuation Period and the System FRM Fill Period, the Canadian Entity will provide to the United States Entity short-term streamflow and operational forecasts to facilitate the planning of System FRM operations. Forecasts for the following week will be made available on a weekly basis. These forecasts will include weekly average releases and unregulated inflows at Arrow and Duncan.

It is understood that operational forecasts are provided on a good faith basis, but actual operations may differ.

4 OPERATIONS DURING SYSTEM FRM EVACUATION PERIOD

4-1 Storage Reservation Diagram

As noted in section 1-7, during the System FRM Evacuation Period water is released from storage to achieve the space required on the date of Initiation of System FRM Fill for management of spring snowmelt. Evacuating storage too rapidly can cause or worsen flooding downstream when downstream flows are high. In this situation, releases may be limited to avoid downstream flooding in Canada and the United States, which would prevent storage from being evacuated to the desired level to meet the United States FRM objectives described in section 1-3 and 1-4. Unevacuated storage above the FRM space requirements on the date of Initiation of System FRM Fill is termed “trapped storage”.

To reduce the risk of trapped storage, operating requirements during the System FRM Evacuation Period are defined by a Storage Reservation Diagram (SRD). The Arrow SRD in Chart 1 and Table 1 shows the required space at the end of each month, given the seasonal runoff volume forecast at The Dalles. In the month when the System FRM Evacuation Period ends, these operating requirements apply up to two days prior to the date of Initiation of System FRM Fill, or earlier at the discretion of the United States Entity.

4-2 Fall and Winter Floods

The Canadian Treaty storage is operated in accordance with the Columbia River Treaty. The Treaty Storage operations are specified in a monthly time step. To prevent Arrow outflows from exacerbating fall and winter flooding in the United States the entities may need to coordinate

daily operations during a System Flood Emergency. The operating requirements below, which are based on existing information, identify technical criteria and procedures designed to achieve United States FRM objectives during a System Flood Emergency.

In the event of a System Flood Emergency that occurs between September 30 and the start of the System FRM Refill Period, the United States Entity may specify a maximum release rate from Arrow Reservoir as low as 10,000 cfs.

System FRM forecasting and the declaration of a System Flood Emergency will be conducted by Northwestern Division. Major fall and winter runoff events in the Columbia River Basin are dominated by rainfall, rather than snowmelt-driven events during the spring. As a storm track passes over the Columbia River Basin, rainfall begins at different times, and each sub-basin has a unique response. This can make these events difficult to predict far in advance. In addition, there is an approximately two-day routing time for streamflow from Arrow to the Lower Columbia at Vancouver, Washington.

The maximum release rate from Arrow Reservoir may be specified two or more days in advance of reaching 16 ft at the Vancouver, Washington gauge to account for travel time. Sufficient notice will be provided to allow the Canadian Entity to plan an operation that follows the ramp rates for discharge from Arrow Reservoir.

Storage may be filled at Arrow to achieve the maximum release rate from Arrow Reservoir and no more than 0.25 maf of storage space in Arrow will be obligated for this operation. In the months of September and October the maximum obligation will be the lesser of 0.25 maf and the space available in Arrow Reservoir. The volume stored by this operation will be calculated relative to the total unregulated inflow to Arrow Reservoir. “Total Unregulated Inflow to Arrow Reservoir” means the sum of the local inflows to Mica Reservoir, Revelstoke Reservoir and Arrow Reservoir.

In extreme events, conditions could arise where BC Hydro cannot meet its Load Serving Obligations without impacting FRM operations at Arrow Reservoir. In advance of these extreme events, the entities will coordinate to determine any appropriate actions to avoid an Energy Emergency insofar as possible. **“**Energy Emergency” means a condition when BC Hydro has exhausted all its other resource options and can no longer meet its expected Load Serving

Obligations. “Load Serving Obligations” means the duty of BC Hydro to secure the necessary energy and transmission services to meet the electrical demand and energy needs of its customers to prevent blackouts.

As soon as the System Flood Emergency is over, or the storage obligated for this purpose is full, the maximum release rate from Arrow Reservoir will no longer apply, and the entities will decide on the timing of flow increases to return to the Treaty operation.

5 OPERATIONS DURING SYSTEM FRM FILL PERIOD

5-1 System FRM Requirements

In the System FRM Fill Period, System FRM operating requirements specified by the United States Entity for Arrow are defined as (1) minimum space and (2) maximum release rate. A proportional split between Canada and the US mainstem Columbia River projects will be used as a guide to operations for the System FRM Fill Period requirements at Arrow, but the actual operations are highly dependent on the specific conditions in the year. The System FRM operating requirements will be within the normal operating limits identified in Section 2.

5-2 Minimum Space Requirement

The first component of the System FRM operating requirements during the System FRM Fill Period is the minimum required space to be held vacant at Arrow to manage future inflows. The total amount of space to be held vacant in Arrow and all downstream projects generally depends on runoff forecasts, available reservoir storage space, and the flood regulation target in the Lower Columbia River. A portion of this space will be allocated to Arrow, using a proportional split between the United States and Canada as a guide to operations. Northwestern Division will provide the end-of-month System FRM space requirements on at least a monthly basis. As conditions warrant, Northwestern Division may issue these space requirements more frequently than monthly. During a System Flood Emergency, these space requirements may apply for shorter time periods, such as 1-week periods.

5-3 Maximum Release Rate Requirement

The second component of the System FRM operating requirements during the System FRM Fill

Period is the maximum release rate at Arrow. The maximum release rate is required to manage downstream flows only during a System Flood Emergency. When a maximum release rate is needed, Northwestern Division will provide the maximum weekly release rate once a week. During System Flood Emergencies, a maximum release rate from Arrow as low as 10,000 cfs may be specified by Northwestern Division as frequently as a daily basis to manage downstream flows under rapidly changing hydrologic conditions. When Northwestern Division forecasts that the Vancouver, Washington gauge will reach 20 ft (Columbia River Datum) a maximum release rate from Arrow as low as 5,000 cfs may be specified, and additional coordination will occur.

When implementing maximum release rates from Arrow, best efforts will be made to meet the ramp rates at Arrow as described in Section 2-4.

Northwestern Division will work to accommodate other objectives when issuing this maximum release rate at Arrow, including advance notice and coordination with BC Hydro to consider domestic Canadian operations. Proportional fill between Canada and the United States for the mainstem Columbia River projects can be used as a guide to operations, but in-season conditions will be evaluated to allow as much flexibility as possible without impacting System FRM. Typically, the maximum release rate may be higher when (1) there is ample storage space in the reservoirs or (2) the flood regulation target in the Lower Columbia River is lower. Conversely, the maximum release rate will be more constraining during large floods or when reservoirs are close to full.

In years when maximum release rates are specified from Arrow Reservoir the Entities will report the activities to the Permanent Engineering Board.

5-4 Canadian Local FRM

In coordinating the operations for System FRM at Arrow, every effort will be made to minimize flood damage in both Canada and the United States.

Flooding along the Columbia River in Canada occurs at the same time or later in the season than flooding in the Lower Columbia River, due to the higher basin elevations. There is no pre-planned reservoir storage (0 maf) for Canadian Local FRM but if the Canadian Entity requires dedicated space to meet Local FRM objectives, additional space beyond what is required for System FRM may be reserved during the System FRM Evacuation Period.

In coordination with the United States Entity the Canadian Entity may increase flows from Arrow in response to forecasted flooding and may reduce releases from Arrow to manage active local flooding as needed. Reducing reservoir releases for Canadian Local FRM objectives is generally compatible with System FRM objectives. However, no part of System FRM space in Arrow will be reserved in advance specifically to achieve Canadian Local FRM objectives.

The Canadian Entity may include a maximum elevation at Arrow Reservoir for Canadian Local FRM purposes provided that it is no higher than the System FRM elevation from Section 5-2. If a maximum release rate at Arrow is required for System FRM purposes, the maximum elevation at Arrow Reservoir for Canadian Local FRM purposes may be exceeded.

Surcharge storage identified in Section 2-4 may be used for Canadian Local FRM.

Table 1: Arrow 3.6 MAF Storage Reservation Diagram

The Dalles Apr-Aug Forecast (MAF)	End of OCT Required Storage Space (MAF)	End of NOV Required Storage Space (MAF)	End of DEC Required Storage Space (MAF)	End of JAN Required Storage Space (MAF)	End of FEB Required Storage Space (MAF)	End of MAR Required Storage Space (MAF)	End of APR Required Storage Space (MAF)	End of MAY Required Storage Space (MAF)	End of JUN Required Storage Space (MAF)
0	0.25	0.25	0.71	0.71	0.71	0.71	0.71	0.71	0.71
64	0.25	0.25	0.71	0.71	0.71	0.71	0.71	0.71	0.71
65	0.25	0.25	0.71	0.78	0.85	0.92	0.92	0.92	0.92
80	0.25	0.25	0.71	1.67	2.24	3.60	3.60	3.60	3.60
90	0.25	0.25	0.71	1.67	2.64	3.60	3.60	3.60	3.60

Chart 1: Arrow 3.6 MAF Storage Reservation Diagram