Columbia River Flood Control Using Treaty Storage

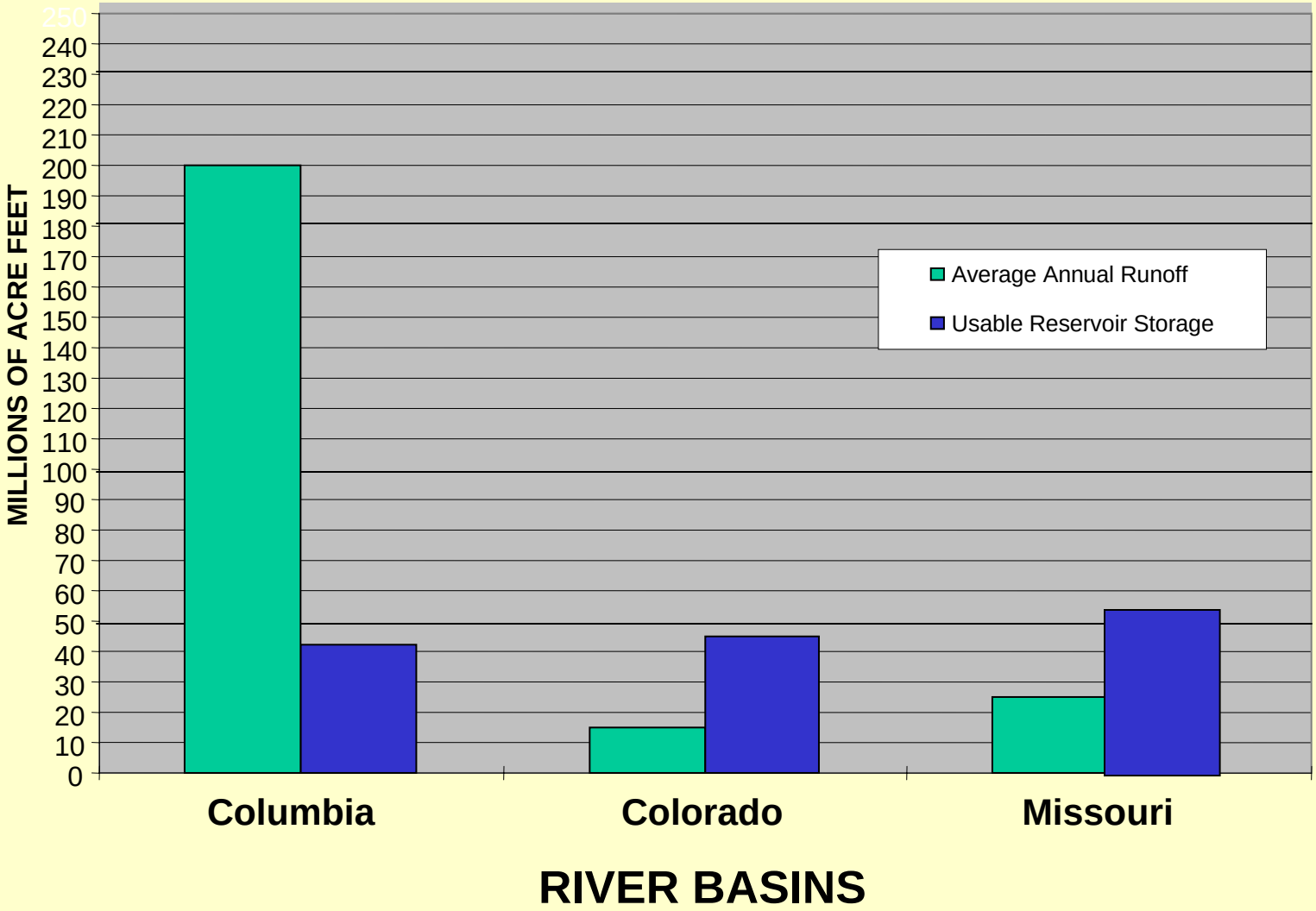
Mekong River Basin Commission Visit

April 2008

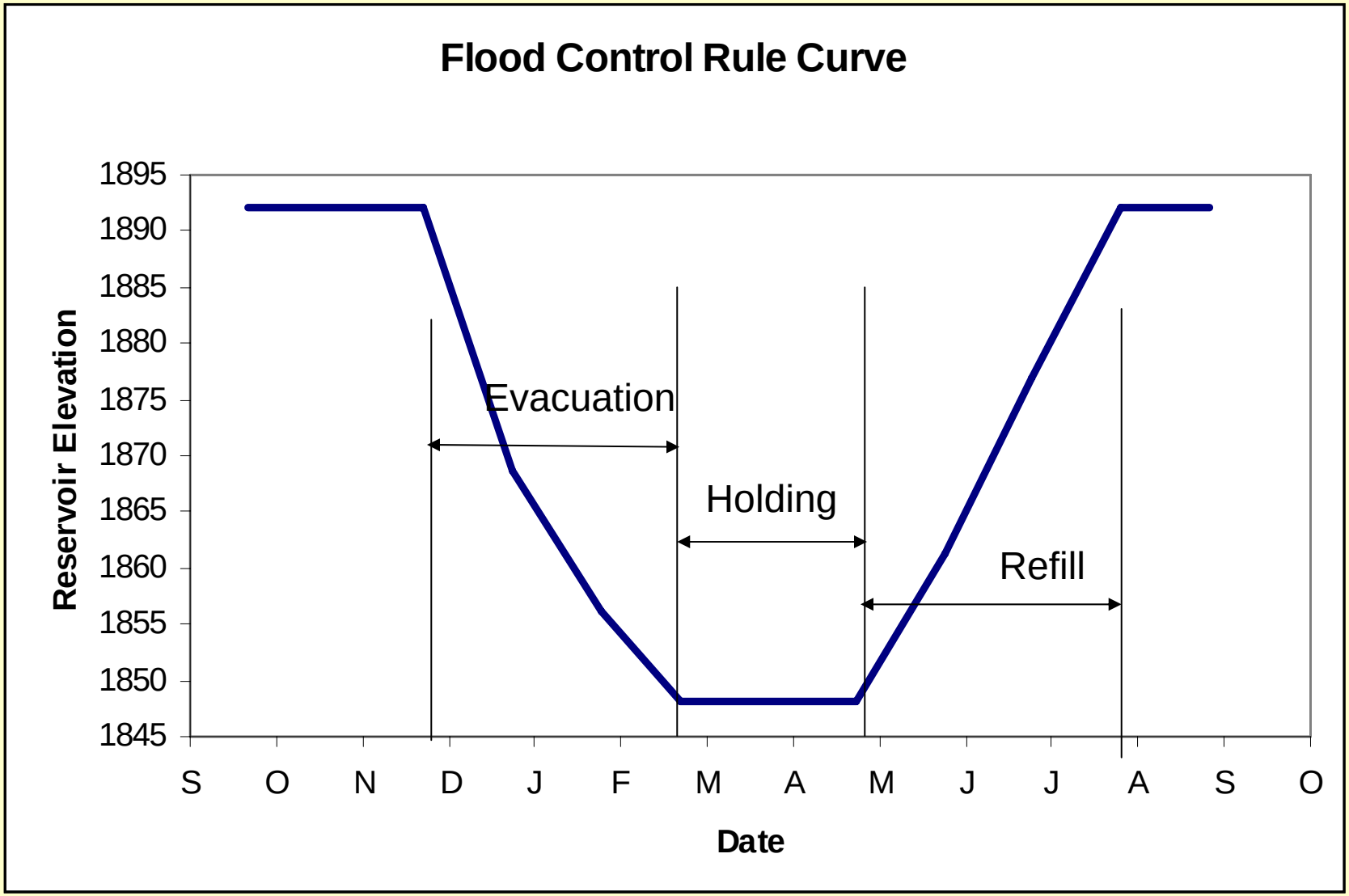
Flood Control Objective

- Corps of Engineers is in charge of Columbia River system flood control
- Objectives defined in FC Operating Plan (FCOP)
- Developed in consultation with Canadian Entity
- Address both system-wide and local flood control
- Use available reservoir storage space
- System designed to control a flood event similar to the 1894 flood event which reduces a peak flow of 1,240,000 cfs to 800,000 cfs at The Dalles
- Refill reservoirs

AVERAGE ANNUAL RUNOFF AND USABLE RESERVOIR STORAGE MAJOR WESTERN RIVER BASINS

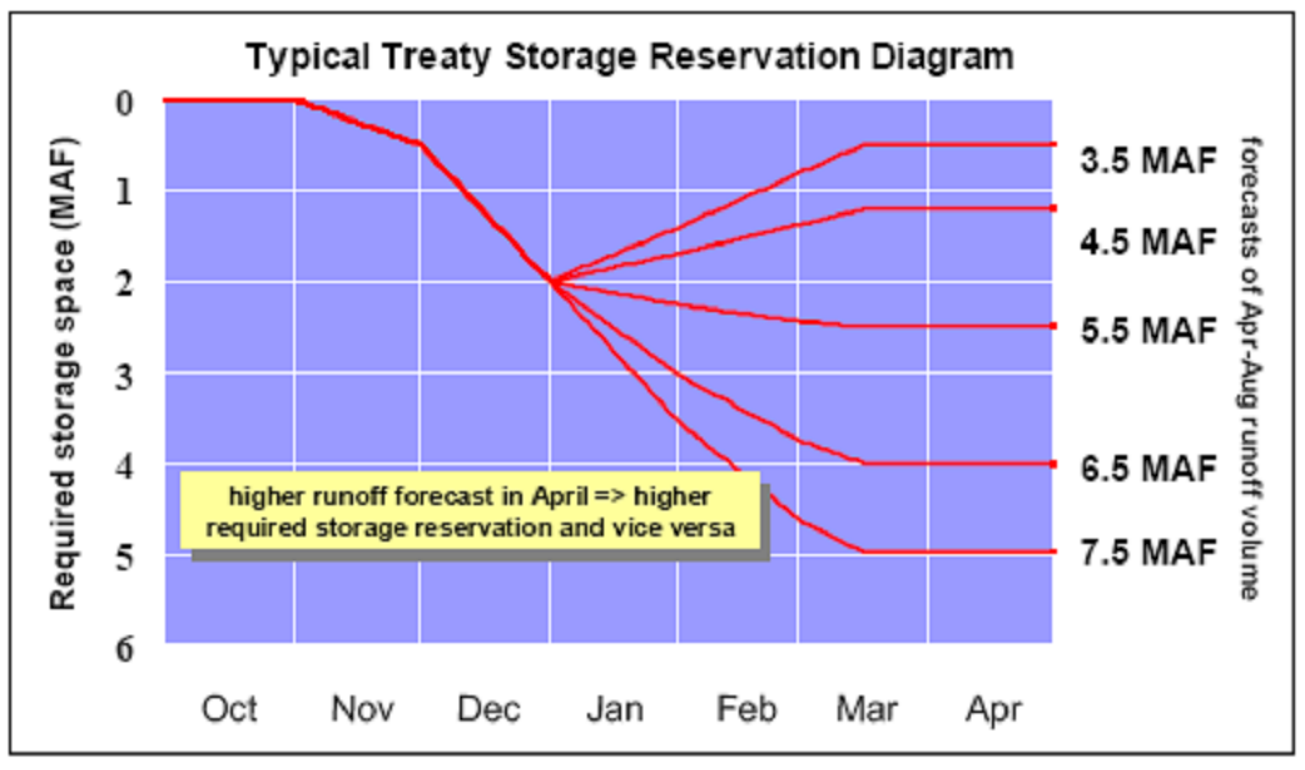


Columbia River Basin
Indicates primary flood control space available, in million acre-feet
Mica
4
Duncan
1.3
3.6
Libby
5
Hungry Horse
3.2
Grand Coulee
5
WA
Seattle
MT
Dworshak
.5
John Day
2
Portland
Brownlee
OR
1
ID
Jackson Lake


Flood Control Rule Curve
Reservoir Elevation
1895
1890
1885
1880
1875
1870
1865
1860
1855
1850
1845
Evacuation
Holding
Refill
S
O
N
D
J
F
M
A
M
J
J
A
S
O
Date

Flood Control Planning

- Use of Storage Reservation Diagrams (SRD) at each reservoir to ensure needed flood control storage is available before the flood event
- Volume to be evacuated depends on runoff forecast



Evacuation Period

- The evacuation period varies depending on project, but may begin as early as October and end as late as April 30
- Fall flood control space requirement is a fixed amount for rainfall events
- Evacuation for the spring freshet for a given project is based on a water supply forecast and a project's storage reservation diagram.

Water Supply Forecasts to Determine Project Flood Control Requirements

- Water Supply Forecasts are computed once a month and used to determine flood control space requirements

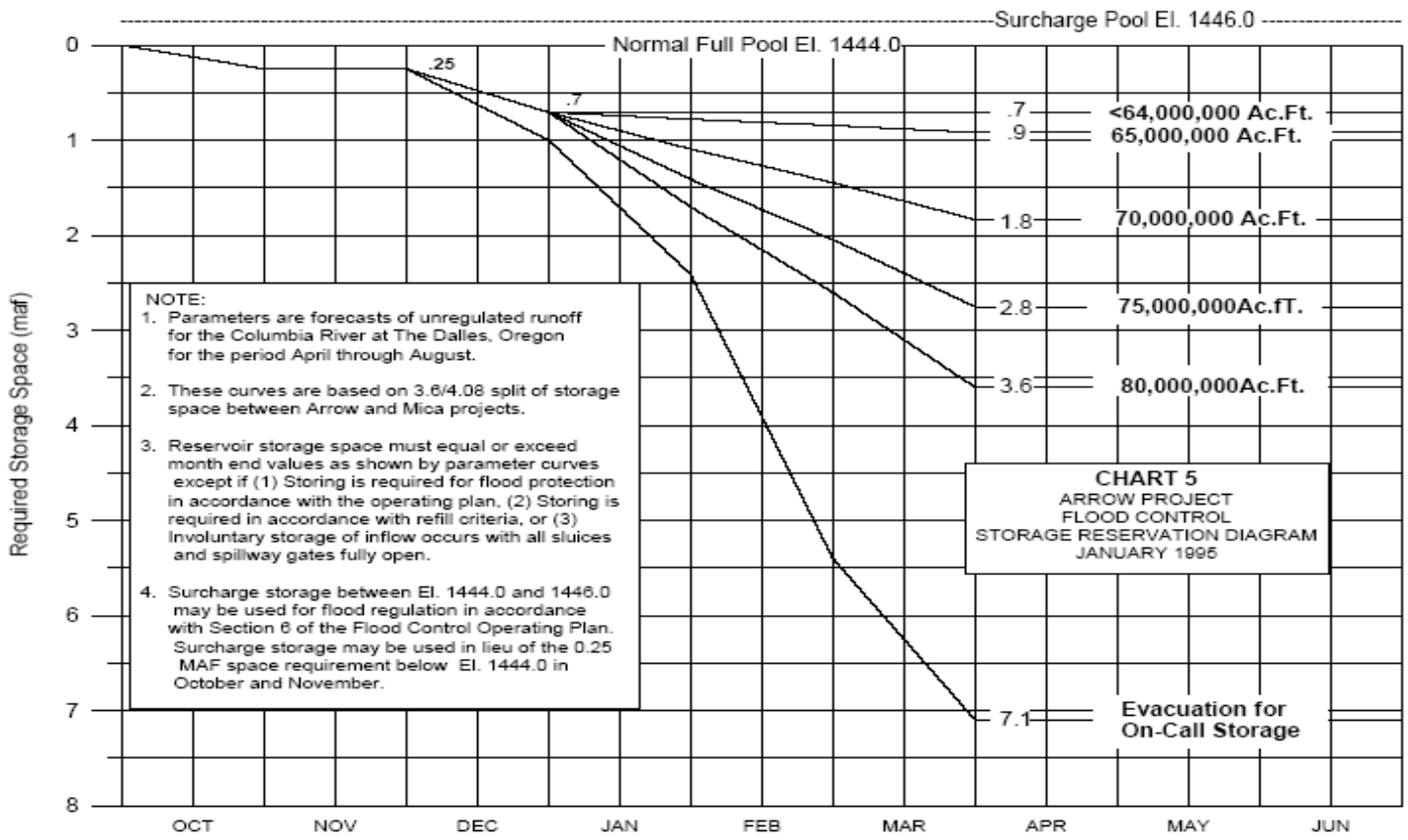
Project	**Forecast Location**	**Forecast Period**	**Forecast Issued by**
Mica, Arrow, Grand Coulee	The Dalles	Apr-Aug	NWRFC
Duncan	Duncan	Apr-Aug	BCHydro
Libby	Libby	Apr-Aug	Corps
Hungry Horse	Hungry Horse	May-Sep	Reclamation
Dworshak	Dworshak	Apr-Jul	Corps
Brownlee	Brownlee The Dalles	Apr-Jul Apr-Aug	NWRFC

Flood Control Operation

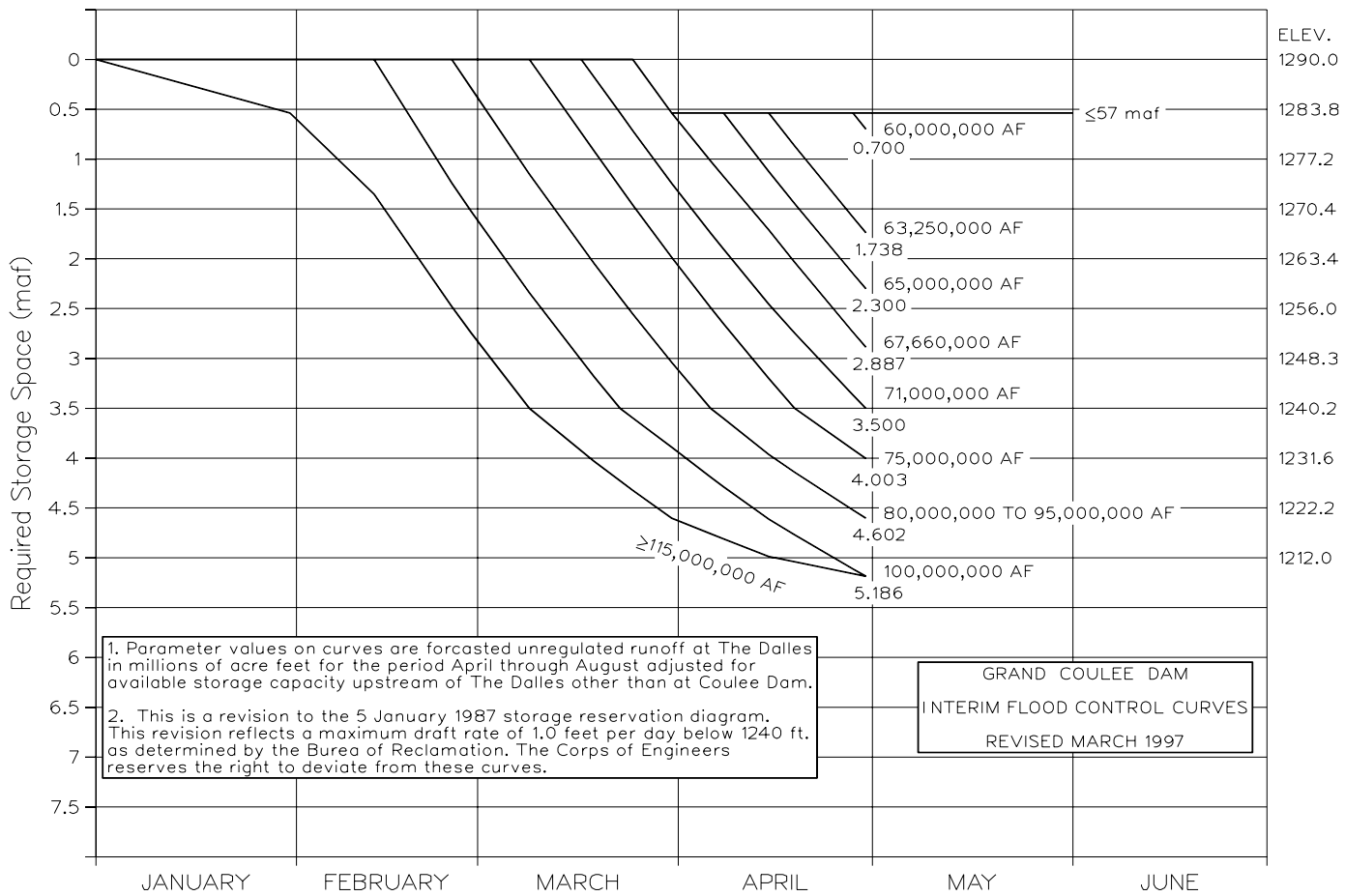
- October – December : draft reservoirs to control autumn and winter rainstorm floods
- January – April : when 1 January when (more reliable) runoff forecasts are available, draft reservoirs as defined by SRDs
- May – July: reservoir refill. Generally completed by 31 July
- In years of very high run-off, under certain conditions, Canada may be asked to evacuate additional “on-call” storage from CRT reservoirs (for a price). Never done.

- SRD for GCL needs adjustment to account for upstream storage

Arrow Storage Reservation Diagram (SRD)



Grand Coulee SRD



Using Grand Coulee SRD

- Compute Grand Coulee parameter = The Dalles Apr-Aug forecast – Upstream space adjustments
- Upstream space adjustments are computed for projects upstream of The Dalles except for Grand Coulee

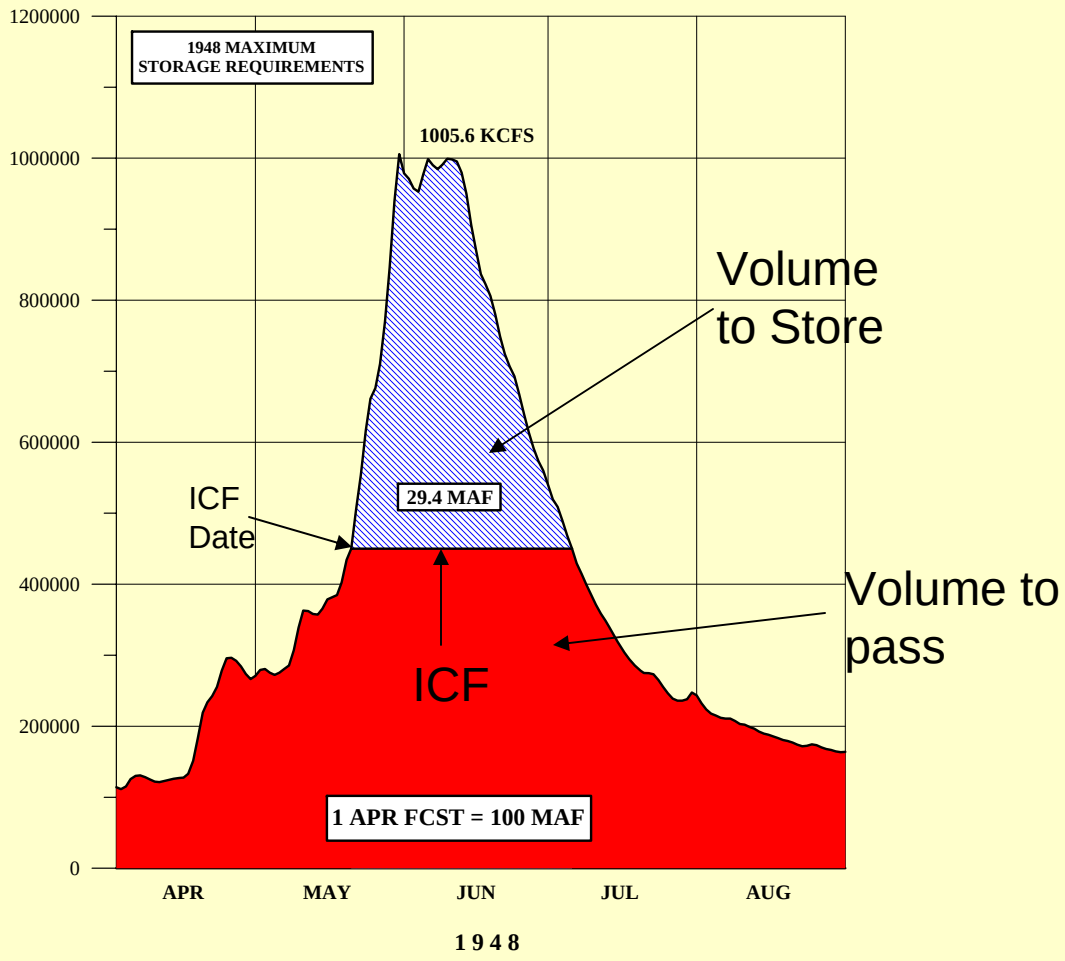
Holding Period

- When projects have evacuated to their full evacuation point, they may hold pool and pass inflow until refill is triggered.
- Holding pool may not be possible if the inflows are less than required minimum flows
- Full evacuation may occur as early as the end of February (Duncan) or as late as April 30 (Grand Coulee).

Refill Trigger

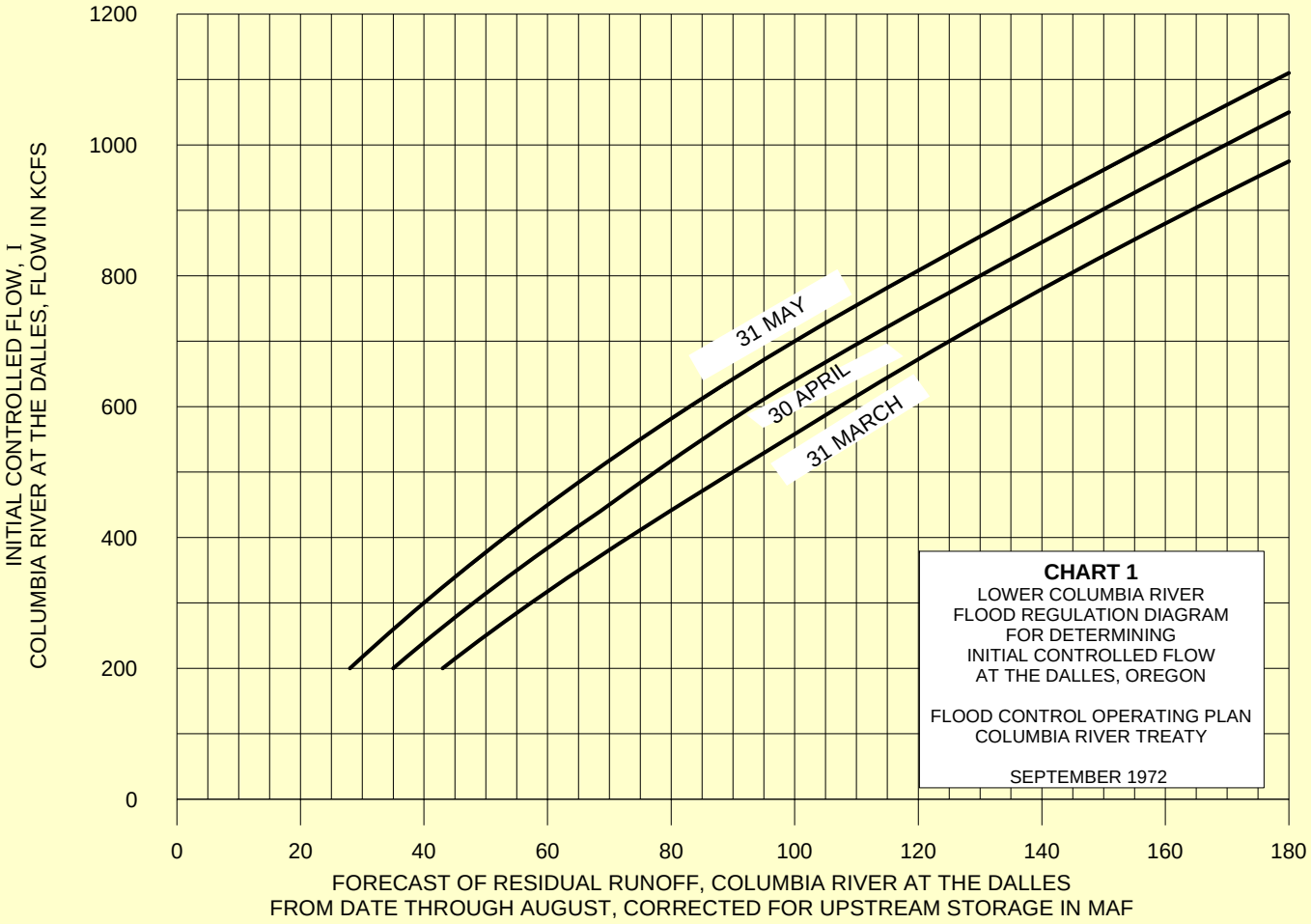
- Refill is triggered on the date that the forecasted unregulated flow at The Dalles is expected to exceed the Initial Controlled Flow (ICF). This date is called the “ICF Date”
- The ICF is determined using Chart 1 of the FCOP.
- Conceptually, the ICF is a volume converted to a flow rate and is a water balance reflecting reservoir space to refill and the seasonal volume to run off.

ICF Concept



The Dalles Unregulated Hydrograph

FCOP Chart 1
Determine the ICF



Initiation of Refill

- Headwater projects initiate refill up to 10 days before the forecasted ICF Date (the number of days is the assumed water travel time between each reservoir and The Dalles).
- Grand Coulee and Arrow begin refill one and two days, respectively, before the forecasted ICF Date.
- Mica may begin 5 days before the ICF Date

Refill Operations

- Headwater projects refill by reducing outflows to minimum flow.
- Local flood control objectives are always taken into consideration.
- Grand Coulee and Arrow are used to control flow at The Dalles. Arrow has a local flood control point at Trail.

Grand Coulee and Arrow Refill

- In addition to the headwater reservoirs filling and reducing flows for The Dalles, Grand Coulee and Arrow are used together (synthetic reservoir) to regulate to the controlled flow at The Dalles.
- Chart 6 of the FCOP is used to proportion the volume of water to be stored into Grand Coulee, while the remaining portion of the volume to be stored is filled into Arrow.

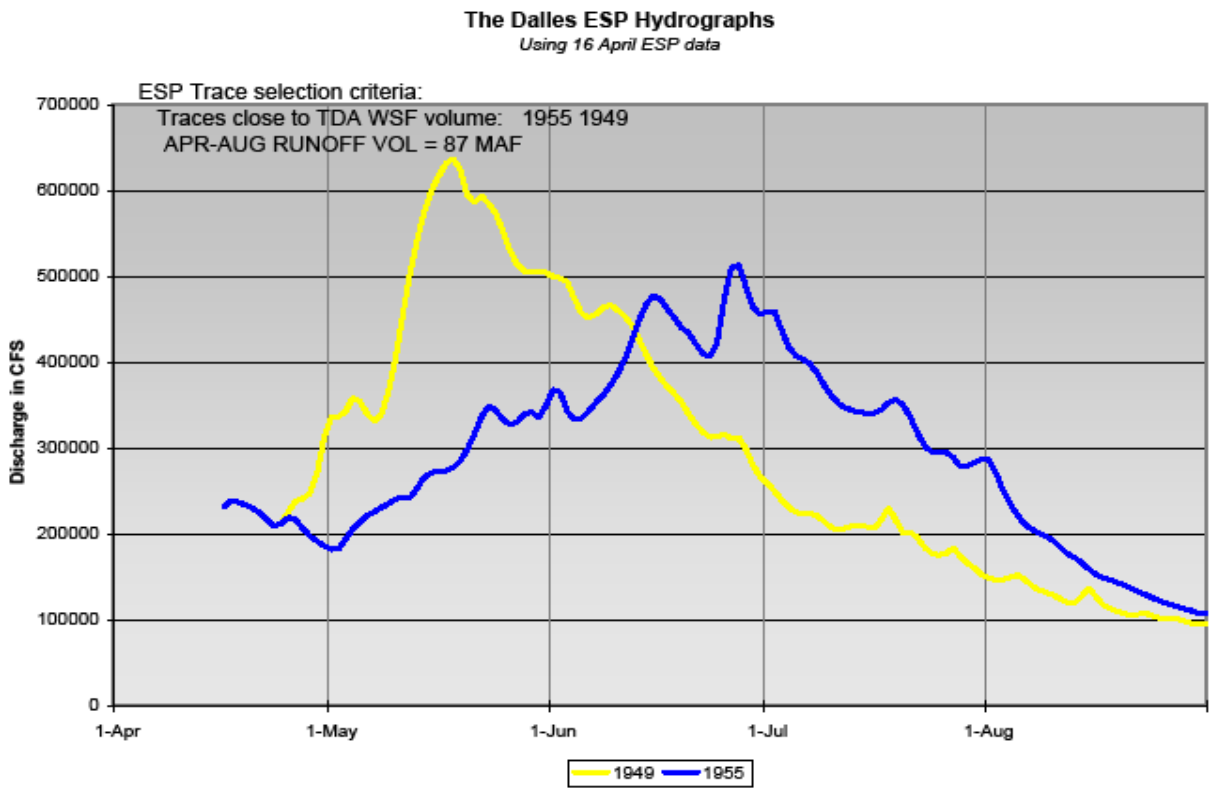
Synthetic Reservoir

- Consists of the combined reservoir space in Grand Coulee and Arrow
- “Virtually” located between McNary and John Day
- Inflows to the Synthetic Reservoir are from the Columbia above Arrow, Kootenai, Pend Oreille, Spokane, and Snake Rivers plus local inflows
- Charts 3 and 6 of the FCOP guide refill of the synthetic reservoir

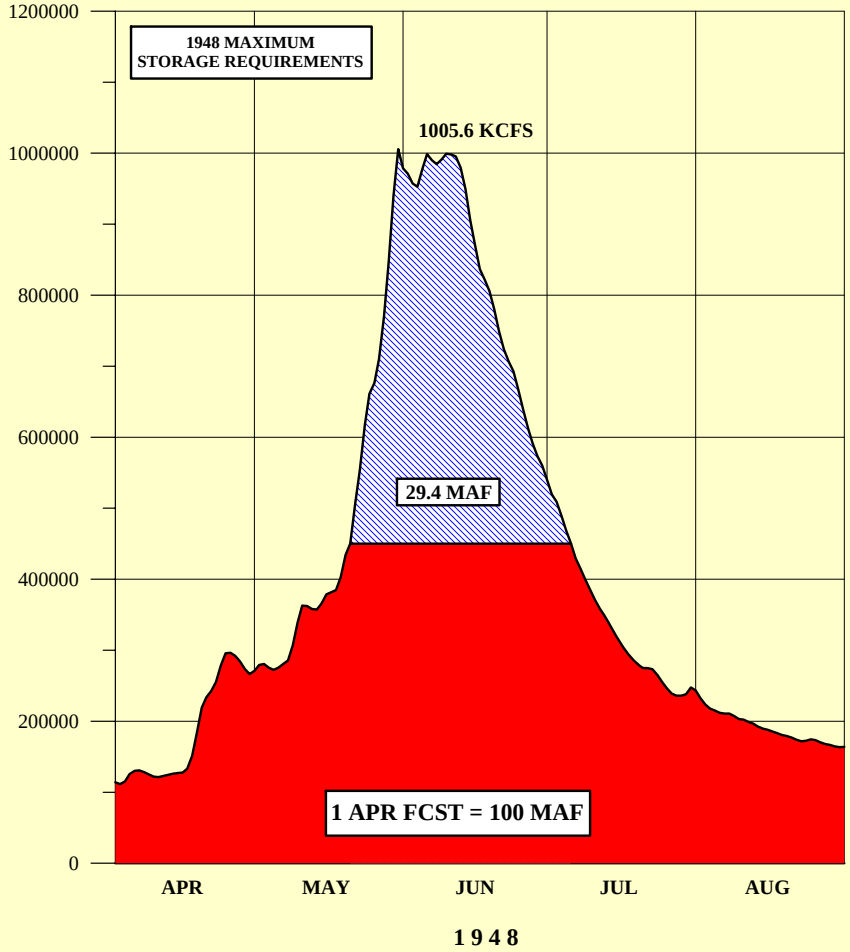
Varying the Controlled Flow

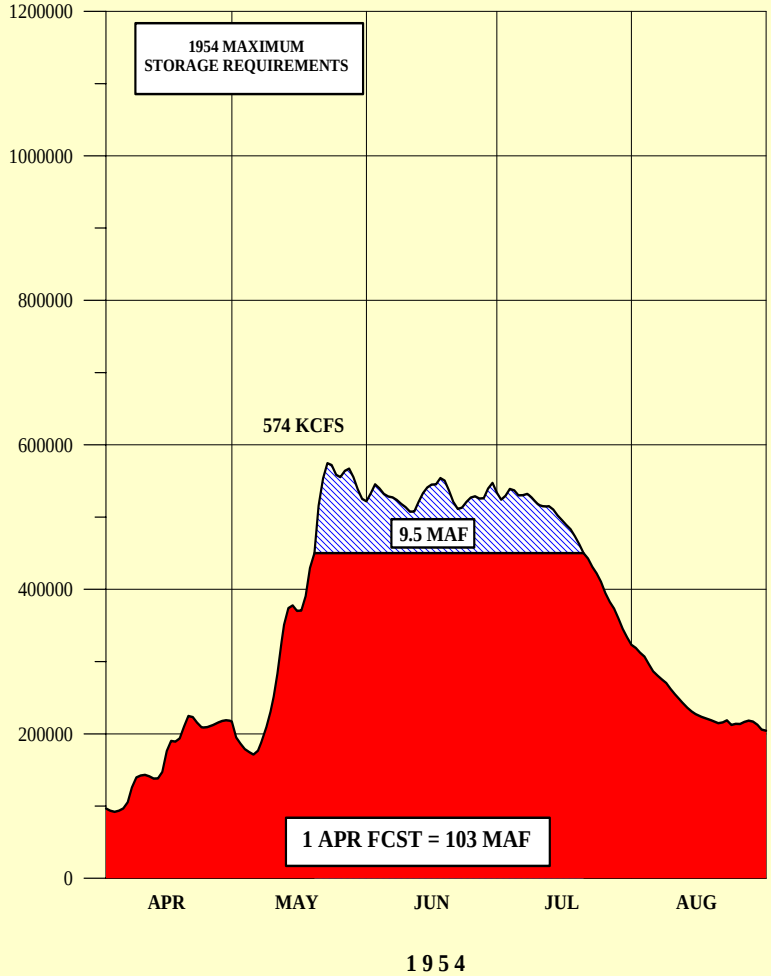
- The controlled flow at The Dalles <u>may</u> be increased to avoid an uncontrolled river (projects filling too soon resulting in involuntary spill). Some factors contributing to a need to increase the controlled flow are forecast error, unforeseen runoff events, or concentrated runoff shape.
- Chart 3 of the FCOP provides guidance to increase the controlled flow. It is a function of the space filled at Grand Coulee and Arrow since the ICF Date divided by the space on the ICF Date.

Variation in Forecasted Hydrographs



Need for Controlled Refill

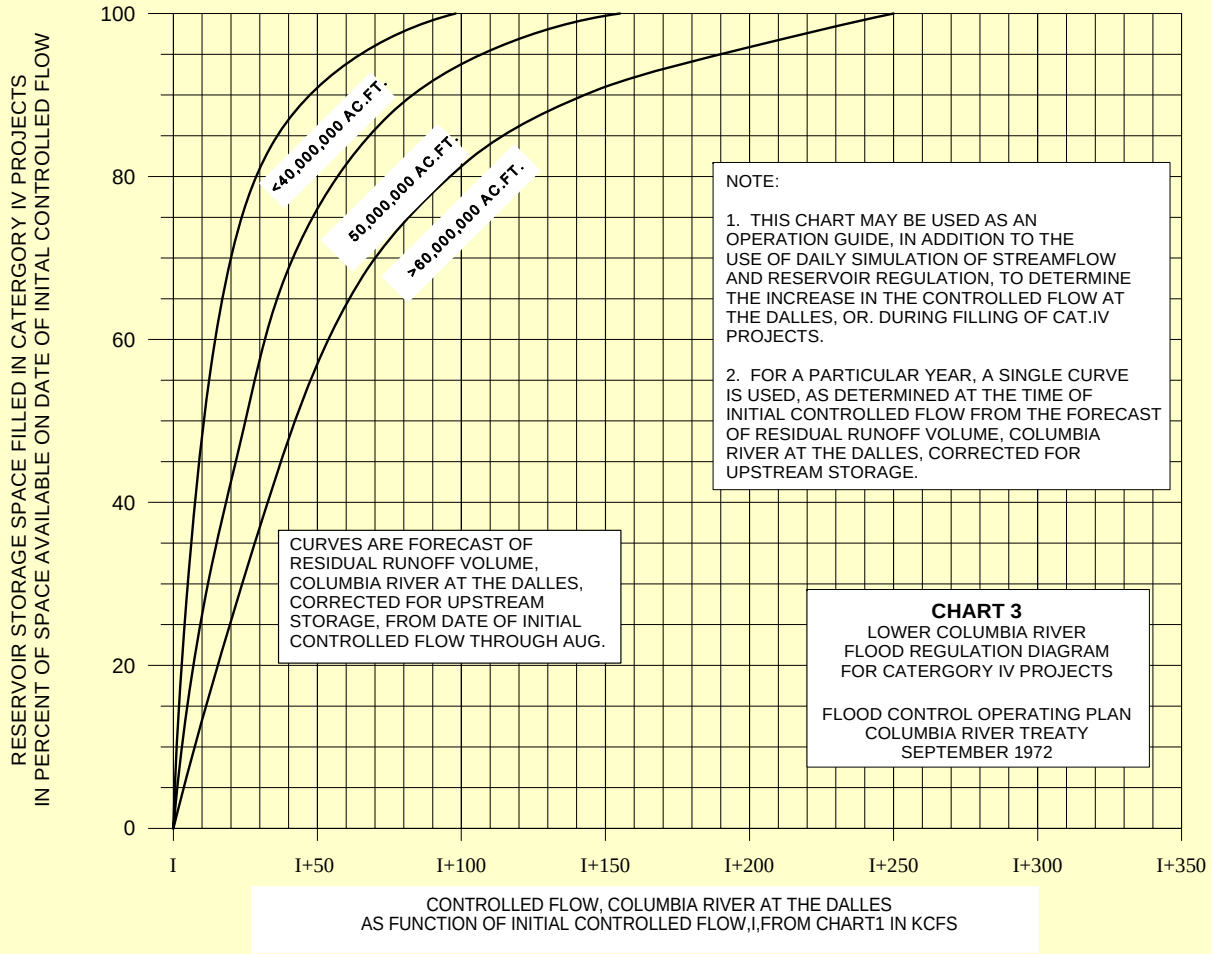




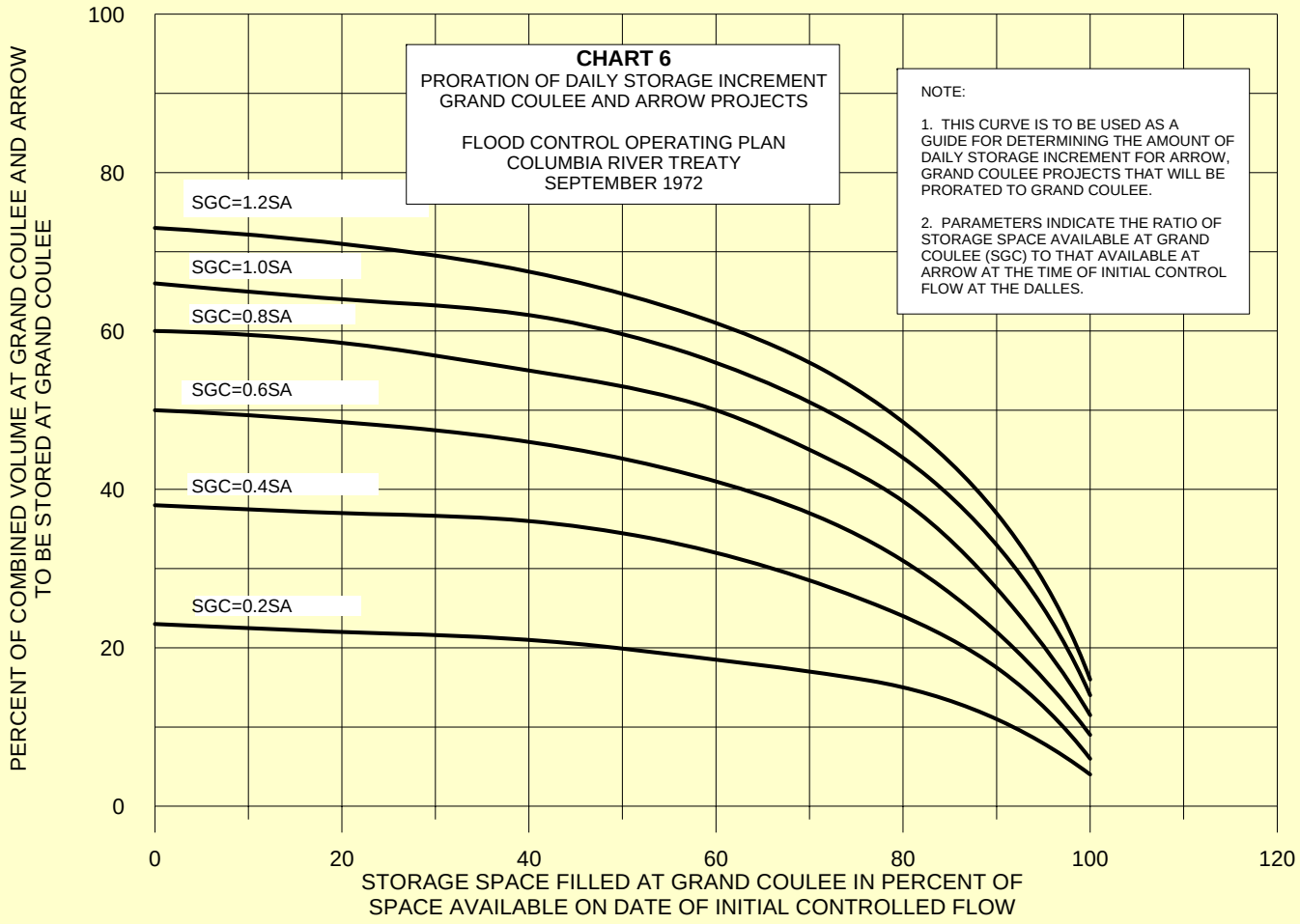
End of Controlled Flow Period

- Factors considered in determining the end of controlled flow period
  - **Flood control modeling-** when the flood control regulation hydrograph recedes below the initial or variable controlled flow, then the flood control period may be considered over.
  - **Regulated streamflow forecasts** –The end of the controlled flow period may be indicated by using a range of forecasted regulated streamflows that show low risk of future flows exceeding the controlled flow

Variable Controlled Flow
FCOP Chart 3



Proration of Daily Storage Increment Grand Coulee and Arrow Projects FCOP Chart 6



End of Controlled Flow Period
(factors cont.)

- **Residual volume** -A residual of 30% of The Dalles, Apr-Aug forecasted unregulated volume may be used as a guideline to end the controlled flow period, however each year is hydrologically different, and may range from 25-40% for The Dalles
- **Reservoir Space** - consider reservoir space vs. inflow volume
- **Shape of Runoff** - The inflow hydrograph should be receding prior to final refill.