APPENDIX A

Flood Control in the Columbia River Basin

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A.1 System Flood Control

On September 16, 1964, the United States and Canada ratified the Columbia River Treaty (CRT), which forms the basis for major hydropower and flood control related development on the Columbia River system. Under terms of the CRT, four major water storage projects were built: Mica, Arrow, and Duncan dams in Canada and Libby Dam in the U.S. The combined active storage of these treaty projects is about 25 MAF (13 MAF for primary flood control), more than double the storage capability of the system. In addition to the CRT projects, a number of other non-treaty storage projects in the basin, including Hungry Horse Dam on the South Fork Flathead River in Montana, also provide flood control storage that is managed for system and local flood control.

To manage system flood control operations, the U.S. and Canada developed of the Columbia River Treaty Flood Control Plan in 1972. "Standard" flood control (also named BASE CRT-63), completed June, 1991, updated the 1972 CRT Flood Control Plan. The basic objective of the Columbia River system flood control operations are to regulate the total reservoir system to minimize flooding at all potential flood-prone areas in Canada and the United States when possible, and, in years with very high runoff, to regulate flow at The Dalles, Oregon, to prevent storage reservoirs from filling too soon and causing the system to be in an uncontrolled situation. Flood control operations are managed to provide flood control while insuring with a high level of confidence that storage projects are refilled at the end of the spring runoff. Elements of development of annual flood control strategies include development of seasonal runoff forecasts, use of storage reservation diagrams, determination of the Initial Control Flow (which determines when system refill begins), regulation of projects to avoid jeopardizing refill, if possible, and local flood control operating criteria and project operating limits.

In the context of system flood control operations, storage reservoirs throughout the Columbia River Basin operate during January through April using guidance provided by a storage reservation diagram (SRD). A SRD shows how much water storage space is required for the current seasonal runoff forecast. In January, water supply forecasts are developed for each sub-basin and for the entire Columbia River system to The Dalles. Based on the water supply forecast, and using the SRD as guidance, the Corps will calculate the end of January through April upper storage limit at each reservoir that will provide for meeting flood control objectives at The Dalles. In February, a new water

supply forecast is used to develop updated end of February through April upper storage limits. The process repeats for each month through April.

In May through June, the refill of reservoirs is guided by upper flood control elevation limits, which vary each year. The May-June upper limits are dependent upon the natural flow at The Dalles, the amount of runoff that may remain in the system, the amount of storage available in the system, and the forecast of weather conditions.

A.2 Local Flood Control at Libby and Hungry Horse Dams

In addition to providing water storage for system flood control, water storage behind Libby and Hungry Horse Dams also provides local flood control for the river reaches closer to the projects. Each reservoir's fall and winter drawdown schedule is designed to provide space for storing both rainfall and snowmelt runoff. Storage of snowmelt runoff for system flood control provides protection for local areas as well. Operations for local flood protection occur on a real-time basis and are provided by individual project operations.

To the extent possible, Libby is operated to maintain flow in the Kootenai River below flood stage at Bonners Ferry, Idaho, of elevation 1764 feet.[1] Similarly Hungry Horse is operated to try to maintain the gage reading for the Flathead River at Columbia Falls, Montana, below 13 feet [2] (2977.67 feet msl) . In some cases when high volume inflow forecasts persist well into the spring season, it may be necessary to regulate dam releases in the interest of local flood control at high levels for extended periods of time. Although operators desire to maintain flow below flood stage at Bonners Ferry or Columbia Falls, there will be occasions when flood stage is exceeded with any flood control operation.

Additionally, there may be some occasions where the actual reservoir elevations may be higher than the maximum elevation targets defined flood control rule curve. For example, high runoff events during the winter due to rainfall or warm periods may require a dam to reduce outflows to moderate downstream river flows, resulting in an increase in reservoir elevation. After the end of the runoff event, the water that was stored during the runoff event would be released in an attempt to bring the reservoir back to the elevation defined by the flood control rule curve. In another example, the International Joint Commission (IJC) Order of 1938 requires lowering of Kootenay[3]

[1] Unless otherwise noted, all elevations in this document are referenced to the National Geodetic Vertical Datum of 1929 (mean sea level or msl).
[2] The flood stage at the Columbia Falls gage is 14.0 feet (2987.67 feet msl), but, when possible, Reclamation regulates to 13.0 feet (2986.67 feet msl).
[3] The American spelling is Kootenai. The Canadian spelling is Kootenay.

Lake in Canada to specific upper limit elevations during the winter months of January through March. Libby Dam releases flow into Kootenay Lake. There are times from January through March when releases from Corra Linn Dam (and the natural constriction at Grohman Narrows) at the outlet of Kootenay Lake are not enough to meet the upper limit elevation. When this occurs, the outflow from Libby Dam is reduced so that Kootenay Lake will not go above the upper limit elevation. The result is that Lake Koocanusa may be above its flood control rule curve by the end of March. The Columbia River Treaty (CRT) acknowledges the operation of the storage by the United States shall be consistent with the 1938 IJC Order on Kootenay Lake.

A.2.1 Standard and VARQ Flood Control

Prior to Endangered Species Act listings of a variety of fish species in the Columbia River Basin, Libby and Hungry Horse dams were operated primarily for flood control and hydropower using Standard Flood Control (FC). The Standard FC SRDs for Libby and Hungry Horse are shown in Figure A-1 and Figure A-2, respectively. Under Standard FC, the dams would generally draft deeply during the January-April period to provide water storage for flood control. Then, during refill, dam discharges would be held at minimum flows.

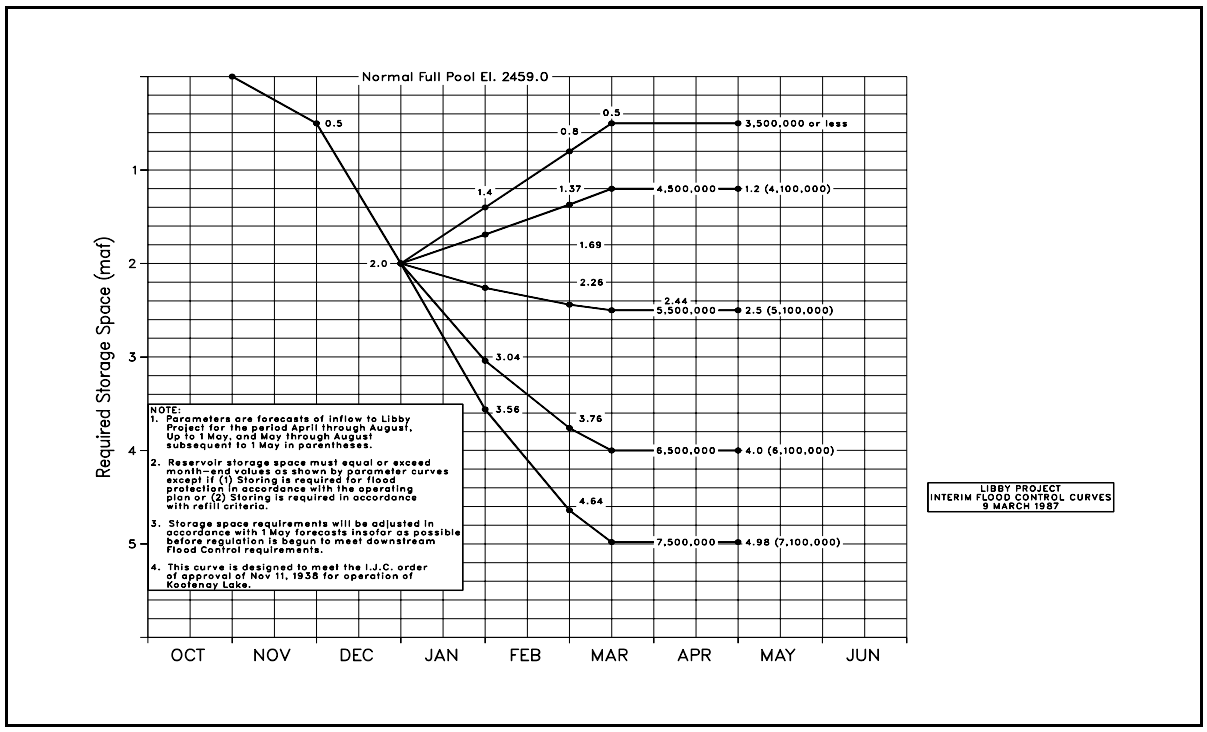

Figure A-1. Standard Flood Control Storage Reservation Diagram at Libby Dam.

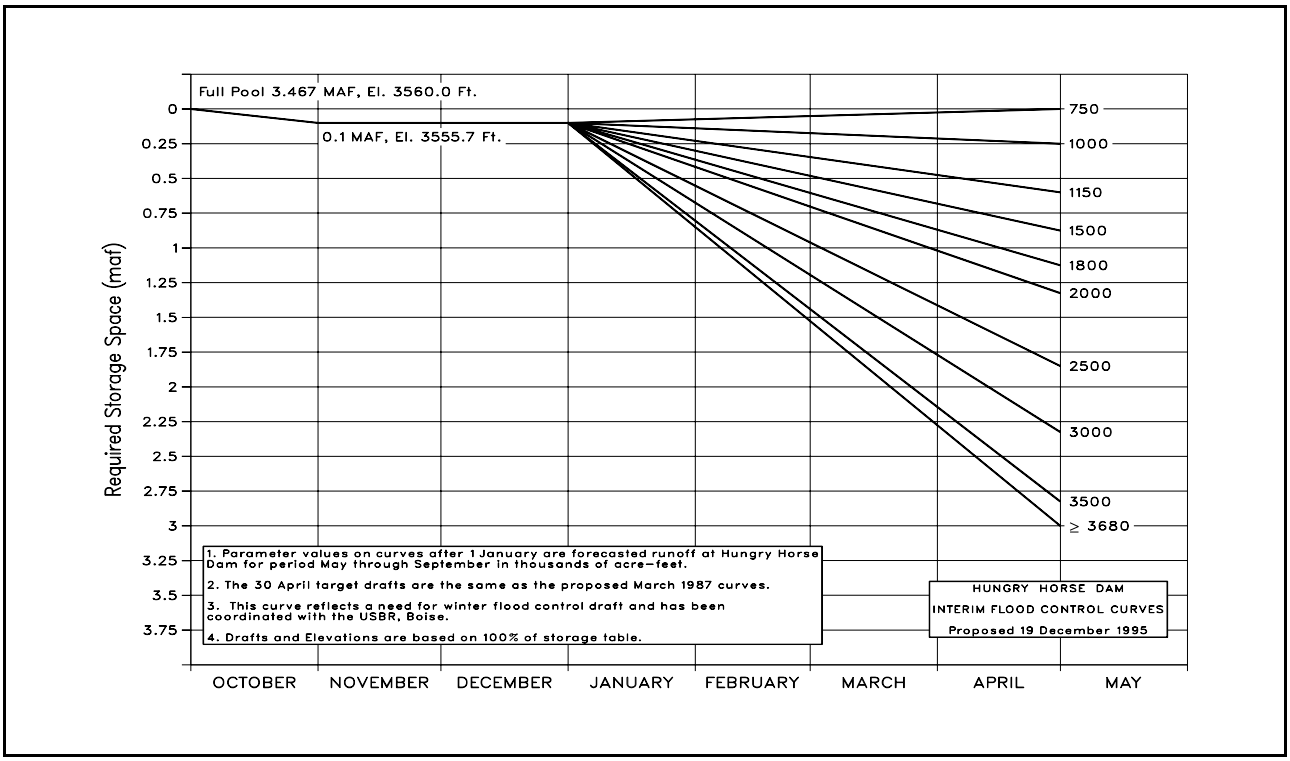

Figure A-2. Standard FC Storage Reservation Diagram, Hungry Horse Dam.

Since the early 1990s, Columbia River water management has changed due to the Endangered Species Act and the listing of various species of fish (Columbia and Snake River salmon, Kootenai River white sturgeon, and Columbia Basin bull trout) as threatened or endangered. As part of efforts to conserve and recover the listed fish species, the Corps and Reclamation release water from Columbia Basin dams for flow augmentation. At Hungry Horse Dam, these releases occur during the summer months primarily in the form of flow augmentation for salmon and during the fall and winter primarily in the form of maintenance of minimum flows for bull trout and. Libby Dam provides flows augmentation for white sturgeon in addition to summer bull trout minimum flows and salmon flow augmentation. These fish flow releases exceed those envisioned in the Standard FC plan and have adversely affected the likelihood and frequency of refill at each project.

With the objective of better assuring reservoir refill while providing fish flows, the Corps developed variable discharge (or VARQ, with Q representing engineering shorthand for discharge) FC. VARQ was first introduced as a possible alternative in the *Columbia River System Operation Review, November 1995 (SOR)*. The SOR was basically an EIS on operational actions recommended by the FCRPS Biological Opinions issued by the National Marine Fisheries Service (NMFS, now known as NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS) in the mid-1990s. A more detailed analysis of VARQ FC was conducted for the *Columbia River Basin System Flood Control Review,*

February 1997. Results of both these evaluations indicated that more work was needed to identify the impacts to providing local flood protection for the Kootenai River. This work was completed in *Kootenai River Flood Control Study, Analysis of Local Impacts of the Proposed VARQ Flood Control Plan, January 1998*. Additional analysis of VARQ FC is contained in the body of the EIS at hand.

In their 2000 FCRPS Biological Opinions, NOAA Fisheries USFWS recommended implementation of VARQ FC at Hungry Horse and Libby dams. Recently, the NOAA Fisheries 2000 FCRPS has been superseded, but implementation of VARQ FC was carried forward in the Action Agencies Updated Proposed Action (UPA) for the NOAA Fisheries 2004 FCRPS Biological Opinion.

VARQ procedures require less system flood control space be made available prior to spring runoff and allows outflows during refill to vary based on the water supply forecast. The SRDs for VARQ FC at Libby and Hungry Horse dams are shown in Figure A-3 and Figure A-4, respectively. Comparing the SRDs for VARQ FC and Standard FC for each project, note that reservoir draft targets for a given water supply forecast tend to be less under VARQ FC than Standard FC for all but very high runoff years. At Libby, reservoir levels during July through April would likely be higher with VARQ FC for years with water supply forecasts between about 80% and 120% of average.4 At Hungry Horse, reservoir elevations would be higher with VARQ FC for years with water supply forecasts between about 80% and 120%.

The basic premise of VARQ FC is that the outflows during the refill period can vary and be higher than minimum flows as based on the seasonal water supply forecast (hence the name VARQ). Accordingly, if the amount of water that is normally stored during the refill period is instead passed through the project, then the amount of storage space needed in the project for flood control is reduced without compromising system flood control. In years where the water supply forecasts at Libby and Hungry Horse are expected to be about 80% to 120% of average, the VARQ FC refill outflow may be greater than minimum flows during the refill period of May through July. Higher releases during refill are a result of higher elevations at the start of the refill period than would have been under the Standard FC SRD. In years where the seasonal runoff

[4] The SRDs for VARQ FC require less flood control storage for water supply forecasts between about 60% and 130%. However, due to physical constraints on dam operation, the volume of reservoir inflow, and limitations on Libby Dam outflows due to constraints of the International Joint Order of 1938 concerning Kootenay Lake levels, the actual flood control operations for years with water supply forecasts greater than about 120% of average or between 60% and 80% of average would be the essentially the same for both VARQ FC and Standard FC. For example, although the SRDs for VARQ FC and Standard FC are slightly different in years with water supply forecasts between 60% and 80% of average, maintaining minimum required outflows from the dam would likely result in the same end-of-month reservoir elevations under VARQ FC or Standard FC. In years with water supply forecasts higher than 120%, limitations on Libby Dam discharges necessary to comply with the IJC Order of 1938 would likely control reservoir elevations to levels above either VARQ or Standard FC rule curve targets (resulting in trapped storage).

forecast is high (above 120% of the average volume at both Libby and Hungry Horse), VARQ FC storage space for flood control and outflows during refill are the same as Standard FC.

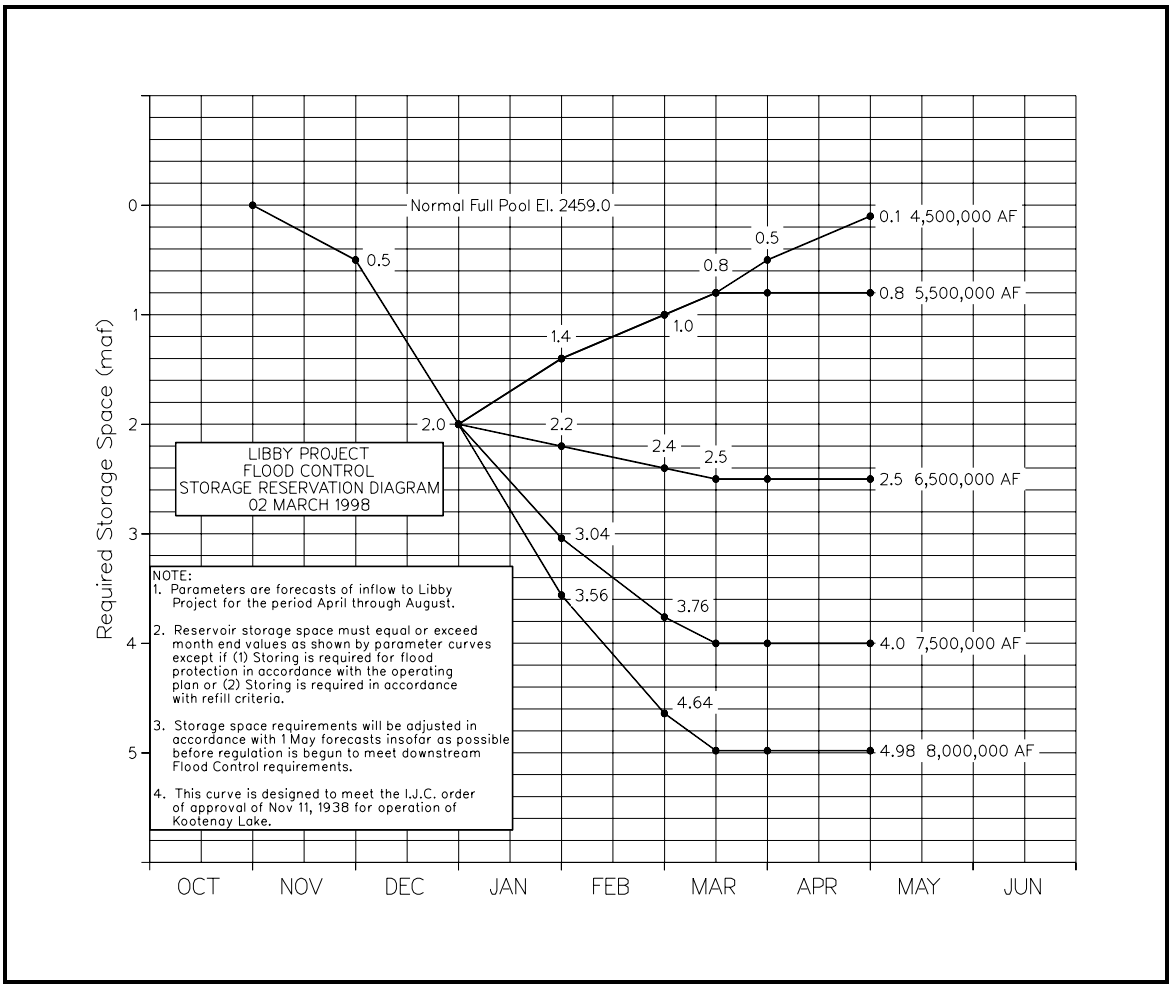

Figure A-3. VARQ FC Storage Reservation Diagram at Libby Dam.

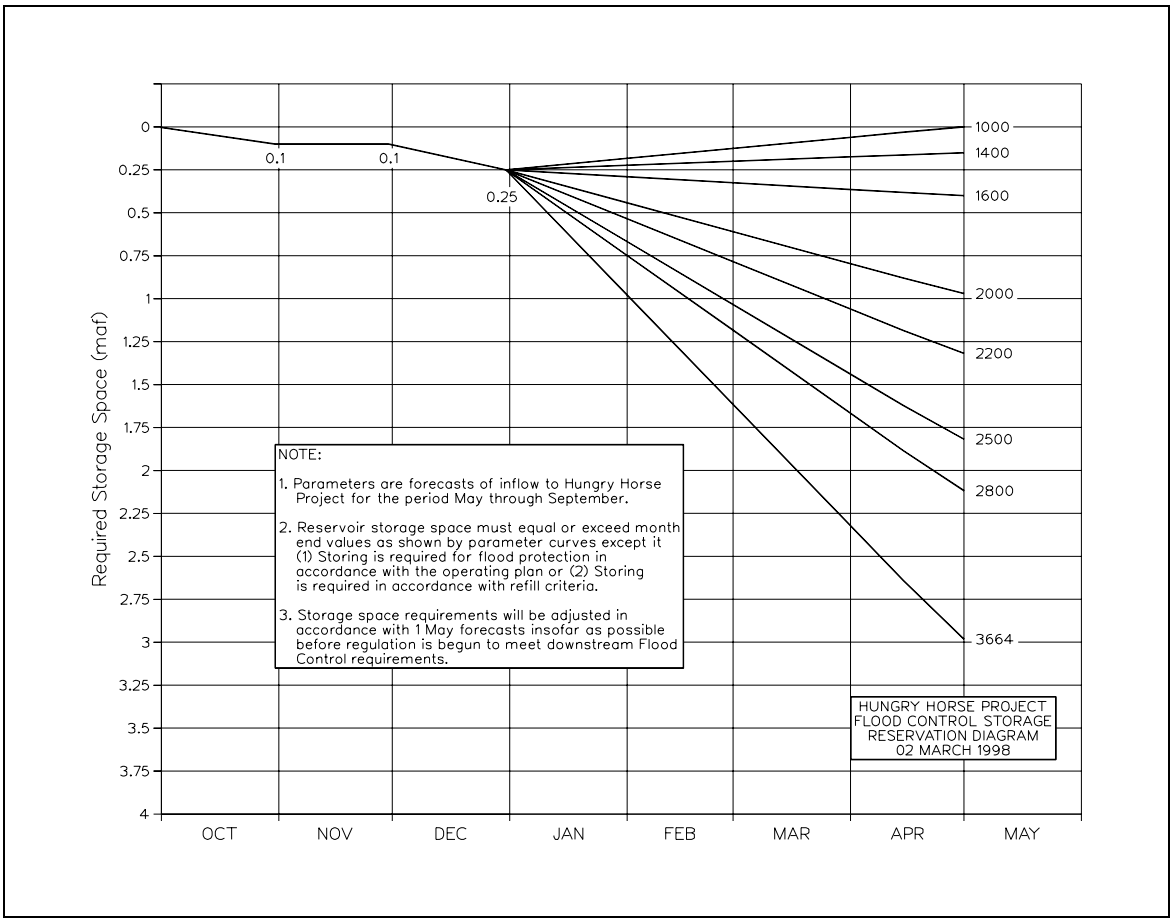

Figure A-4. VARQ FC Storage Reservation Diagram, Hungry Horse Dam

At Libby and Hungry Horse, a VARQ FC operation does not have any fish flow operations embedded in the operating strategy; however, VARQ FC does enable the operating agencies to more reliably supply spring flow for fish in the Kootenai River immediately downstream of the project. The assumption is that VARQ FC can provide higher dam discharges required for conservation and recovery of threatened and endangered species while maintaining flood protection and improving the chance of reservoir refill.

The Grand Coulee flood control draft requirement is a function of the expected April-August unregulated runoff at The Dalles and the available storage space upstream of The Dalles on May 1. Upstream space is available in Mica, Arrow, Libby, Duncan, Hungry Horse, Kerr, Noxon, Albeni Falls, Dworshak, Brownlee and John Day. The unregulated April-August runoff at The Dalles is adjusted downward for the total amount of upstream storage available on May 1 at these projects. The adjusted runoff is then used with the Grand Coulee SRD to determine the flood control draft requirement.

Under VARQ FC, Libby and Hungry Horse may be more full at the end of April, which reduces the amount of available upstream storage space on May 1. In order to maintain

flood protection at The Dalles, this requires an increased flood control draft at Grand Coulee in years with water supply forecasts between 86% and 100% of average. The difference in flood control draft at Grand Coulee does not equal the net change in draft at Libby and Hungry Horse caused by VARQ. The primary reason that Reclamation and the Corps are co-leads on this EIS is because impacts due to the change in flood control operations at both Libby (a Corps project) and Hungry Horse (Reclamation project) affect operations at Grand Coulee (Reclamation project).