Appendix 12

MFWP Comments on the Draft Mainstem Amendments Document 2002-16

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RE: Comments on the Draft Mainstem Amendments document 2002-16

Thank you for the opportunity to comment on the proposed Mainstem Amendments. We generally agree with the Council's strategies to balance the needs of fish and wildlife, flood control and power generation. Flood control drafting of the reservoirs should be accomplished using the variable flow, or VARQ strategy, developed by the US Army Corps of Engineers. Reservoirs refill should follow the Integrated Rule Curves developed by Montana Fish, Wildlife & Parks. Summertime flow augmentation for anadromous fish recovery should be released at a constant flow rate over the months of July through September to protect resident fish immediately downstream of the headwater storage reservoirs.

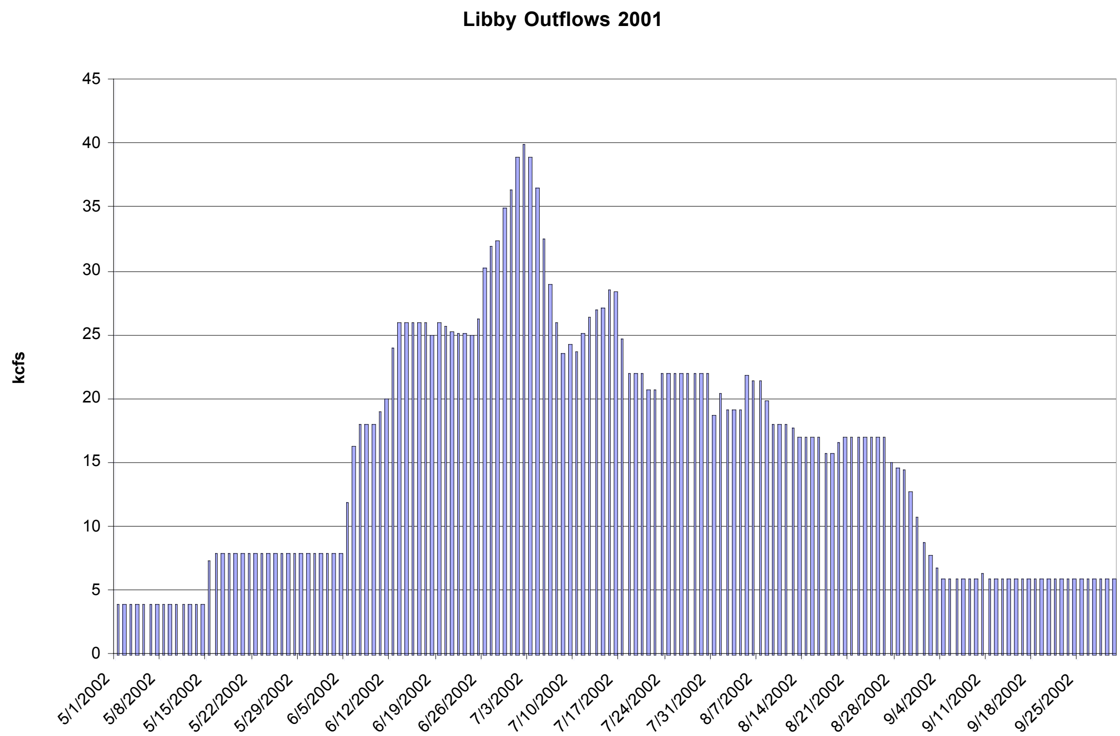
Our comments are arranged in response to the specific questions asked by the Council. Detailed comments are preceded by an executive summary. Literature referenced in the text provides additional detail and supporting information.

BACKGROUND

During August of 2002, the State of Montana recommended to reduce and stabilize the flows out of Libby dam through the end of September. The flows out of Libby Dam were greater than 20 kcfs during the first portion of August, which was far in excess of the optimum bull trout flows of 9 kcfs. The State of Montana filed a System Operations Request with the other states and federal agencies in the Technical Management Team (TMT) process. The biological objective of Montana was to provide a better balance between the needs of resident fish in Montana with the demands for additional flows for anadromous fish recovery in the lower Columbia River.

Montana's request was included in SOR 2002-MT1. We requested reduced, stabilized flows out of Libby Dam to improve habitat conditions for bull trout and resident fish in the Kootenai River and Libby Reservoir by creating a relatively constant outflow from Libby Dam. Our requested flow strategy was identical to that proposed in the Council's draft Mainstem Amendment, which Montana believes can be accomplished without significantly impacting anadromous fish in the lower Columbia River.

The Montana request to the TMT was to reduce flows out of Libby dam to 11 kcfs and to maintain this flow until the end of September. Montana recommended a flow of 11 kcfs from Libby Dam based on the inflow forecasts at the time, which would have drafted Libby Reservoir to elevation 2449 feet by the end of September. Montana further recommended that any flow changes should follow the flow ramp rates in the Biological Opinion for the threatened bull trout. The following graph illustrates the actual flows out of Libby dam during the period from May through September 2002.



Montana recognizes that 2002 was a difficult hydrologic year and that there were impacts on resident fish above and below Libby Dam that were difficult to prevent. However, the summer began with a forecast of average flow volumes and after only a few days of testing of the effects of spill on resident fish, rapid runoff necessitated massive spills to maintain a controlled rate of refill. Outflows peaked at 40 kcfs with almost 16 kcfs of this flow being spilled. These spills created gas supersaturation conditions in the river that exceeded Montana's water quality standard of 110 percent saturation and harmed fish and habitat conditions far downstream of the dam. Immediately following this event the fish in the Kootenai River were further impacted because the TMT began large drafts of Libby Dam in an attempt to remove the full 20 feet of storage called for by the NMFS 2000 Biological Opinion.

The State of Montana's request for the salmon managers to reduce and stabilize the flows out of Libby Dam would have helped to reestablish bull trout habitat downstream of the dam. This operation would also have reduced the rapid drawdown of Libby Reservoir to below the Integrated Rule Curves, designed by Montana Fish Wildlife & Parks to Balance the requirements of resident fish in Montana with the needs of anadromous fish downstream. However, the TMT salmon managers rejected Montana's request.

The resulting dam operation in 2002 maintained abnormally high flows during August and then suddenly dropped the flows out of Libby Dam to 6 kcfs during September. This created additional impacts on bull trout that could have been avoided by slowing the rate of draw down and extending the draft to the end of September.

The optimal habitat conditions as measured by Montana Fish Wildlife & Parks in the Kootenay are approximately 9 kcfs. Montana is sensitive to the tradeoffs between the flows out of Libby Dam and the needs of anadromous fish below McNary but the releases from Libby Dam do not translate into a one-for-one increase in McNary flows due to a number of factors. The first factor is the extended distance between Libby Dam and the lower Columbia River system. This distance and the intervening dams serve to attenuate the flows that will reach McNary. The most dramatic affect is the ability for Canada to store, in Kootenay Lake British Columbia, a portion of the water released from Libby Dam. In communications between the Corps and BC Hydro they estimated that approximately 35 percent of the flows out of Libby Dam during the summer of 2002 were captured in Kootenay Lake and not passed downstream.

In early August when Montana submitted its SOR, the average seasonal flow over the period from July 1 to the end of August was 197 kcfs at McNary. Montana's proposed reduction in Libby outflows of approximately 11 kcfs, after 35 percent of the flows are retained in Kootenay Lake, would have resulted in a flow reduction at McNary of a little more than 7 kcfs. However, even this change would have only affected the flows during the last three weeks of August. Taking this into account, the average McNary flow over the July – August period would have been 195 kcfs if Montana's recommendation had been implemented. This is a very small change in overall hydrologic conditions in the Lower Columbia River, yet the biological impacts on Montana's resident fish were very serious. Montana's proposed operation would have provided substantial biological benefits for Montana's resident fish while having no measurable impact on downstream salmon populations; however, this request was rejected by the salmon managers in the TMT.

The State of Montana supports the Council's proposed operations strategy for both Libby and Hungry Horse Reservoirs because it will help to avoid the same impacts that the resident fish in Montana experienced in 2002.

Comments on the Northwest Power Planning Council's Proposed Mainstem Amendment document 2002-16.
Montana Fish, Wildlife & Parks

Executive summary

The Council requested comment on the science surrounding the benefits to fish populations resulting from their proposed Mainstem Amendments. Specific comments were sought on the Council's hypothesis that their proposed operational strategies will have significant biological benefits to the fish species that live upstream and downstream of federal hydropower dams. This document describes the biological justification for Montana Fish, Wildlife & Park's preferred operating strategy, with attention to the Montana portion of the Federal Columbia River Power System. **We believe this strategy will restore normative functions in the Columbia River headwaters, consistent with dam operations called for in the NMFS and USFWS 2000 Biological Opinions**.

Our preferred strategy for operating Columbia River Dams generally agrees with the Council's proposed Mainstem Amendments. The strategy was designed to protect the threatened bull trout and the endangered Kootenai white sturgeon, as Mainstem Columbia River flows are augmented to recover anadromous stocks. The resulting operation will also benefit non-listed fish species that are directly influenced by the headwater storage projects. **Fish directly impacted by headwater dams should receive a high priority for protection, as reservoir operations are managed systemwide. The resulting flows coincide seasonally with flow requirements in the Mainstem Columbia River.**

Our findings suggest that recovery objectives for anadromous and resident fish can be achieved simultaneously by mimicking the natural spring runoff event, within flood constraints, then gradually reducing dam discharge toward stable flows during the biologically productive summer and fall period. We generally support the Council's strategies to balance the needs of fish and wildlife with flood control and power operations. **Flood control drafting of the reservoirs should be accomplished using the variable flow, or VARQ strategy, developed by the US Army Corps of Engineers. Reservoir refill should follow the Integrated Rule Curves developed by Montana Fish, Wildlife & Parks. Summertime flow augmentation for anadromous fish recovery should be released at a constant flow rate to protect resident fish immediately downstream of the headwater storage reservoirs. Flow augmentation during spring and summer must be proportional to water availability on an annual basis.**

Background

It is necessary to compare the proposed operating strategies with the river in its natural state to describe the biological effects of the Council's Mainstem Amendment. Prior to dam construction, the Columbia River and its tributaries flowed unimpeded. The annual hydraulic cycle included a high flow event during the spring melt (which peaked between late May through early June) and relatively constant low flows throughout the remainder of the year. Headwater storage projects, including Hungry Horse and Libby Dams, reversed this discharge pattern by storing water during the spring runoff to prevent flooding and releasing water to generate electricity, primarily during the fall and winter when flows were naturally low (Figure 1).

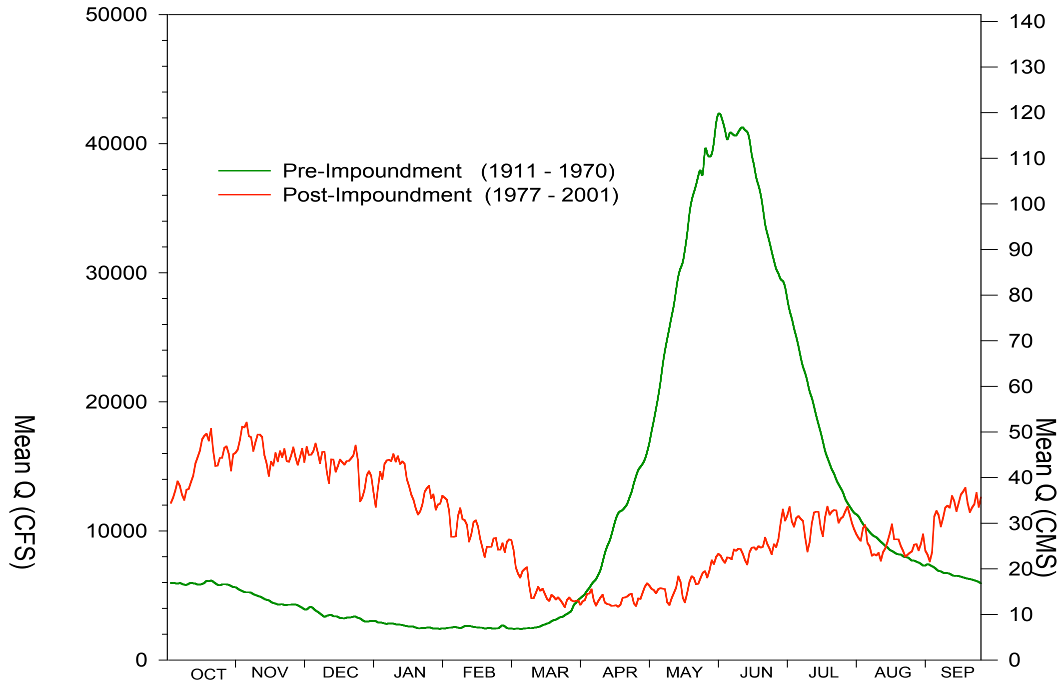


Figure 1. Example of flow regulation below headwater storage projects. These data compare the Kootenai River discharge prior to impoundment by Libby Dam (1911-1970) and regulated flows post-impoundment (1977-2001) in mean annual cubic feet per second (cfs) and cubic meters per second (cms). Spring flows were higher, and winter flows lower, prior to impoundment.

Under natural conditions, river flows during the low flow period were relatively stable and the portion of channel affected by flow fluctuation (called the "*varial zone*") was a narrow band along the shoreline. The nearshore habitat provides food and security cover for fish and wildlife. High springtime river flows flushed fine sediments from river gravels creating spaces between the stones (called "*interstitial habitat*") for insects and juvenile bull trout. High flows each spring defined the river channels and cleansed fine sediments from the riverbed gravels improving conditions for fish spawning.

Fine sediments flushed from the river bottom were deposited on the river margins providing a fertile medium for water tolerant plants. Spring scouring can provide the seedbed preparation necessary for plant reproduction, particularly for cottonwoods. Riparian vegetation withstood annual flooding or reestablished seasonally, providing secure habitat along river margins and reducing erosion of silt into the river. Deltas that form at the mouths of tributary streams were swept away annually, improving fish passage to critical spawning habitat in the headwaters.

Fluctuating or abnormally frequent high discharges disrupt this natural floodplain process. Unnaturally low spring water levels alter vegetation and habitats associated with riverine meanders and sloughs. High and variable winter flows scour recently established seedlings and limit the potential range of elevations for successful cottonwood and willow recruitment (Jamieson and Braatne 2001; Suchomel 1994).

Changes in storage reservoir operation

Mainstem Columbia River operations profoundly influence dam operations as far upstream as headwater reservoirs. Dam operations affect environmental conditions in the reservoirs upstream, and rivers downstream of the dams. The abundance, productivity and diversity of fish and wildlife species inhabiting the headwaters of the Columbia River are dependent on their immediate environment that ebbs and flows with river management.

Our comments related to reservoir biology are based on field sampling and quantitative biological modeling of Hungry Horse and Libby Reservoirs (Chisholm et al. 1989; May et al. 1988; Cavigli et al. 1998; Dalbey et al 1997; Zubik and Fraley 1987; Skaar et al 1996). Computer models were constructed using empirical field measurements of physical and biological parameters, as related to dam operations (Marotz et al. 1996). Conditions in the reservoirs resulting from various dam operation scenarios were assessed beginning with the hydrologic mass balance and thermal structure in the reservoir pool. The models calculate the biological response extending from primary producers (plants) through tertiary trophic levels (fish growth). Fish growth is correlated with survival, fecundity and reproductive success (Chapman and Bjornn 1969).

Headwater reservoirs fluctuate annually, reaching minimum pool during mid-April, refilling during the spring snow-melt, and increasing towards full pool in the summer. Water is then released for fish flow augmentation, flood control and power generation and the cycle continues. Since construction, Hungry Horse Reservoir has fluctuated as much as 189 feet and Libby Reservoir has been drafted as far as 152 feet (MFWP and CSKT 1997; Marotz and DosSantos 1993). Extreme reservoir drawdowns result in the desiccation of vast expanses of lake bottom, which become biologically unproductive (Figure 2).

Nearly all biological production in the reservoir pool occurs during the warm months (Chisholm et al. 1989; May et al. 1988; Marotz et al. 1996) (Figures 3-7). Failure to refill the reservoir each summer impacts reservoir productivity. At full pool, the reservoir presents a large volume and surface area. The sunlit surface layer of the reservoirs produces food (*zooplankton*, a microscopic crustacean that grazes on suspended algae called *phytoplankton*) that forms the base of the food web. The large flooded area produces aquatic insects and the large surface area traps insects from the surrounding landscape. Insects provide the primary food source for westslope cutthroat trout and juvenile bull trout during summer and fall (May et al. 1988). Biological production generally increases with reservoir elevation (Figures 8-11). The term *flatline* in the figures refers to the data presented, which assume that the surface was stable yearlong. Biological production increases when the annual fluctuation of the reservoir pool is minimized (Figures 8-11).

Reducing reservoir drawdown (duration and frequency), especially during summer, protects aquatic insect production in remaining wet portions of the reservoirs, assuring an ample food supply for fish. During winter, fish (kokanee, westslope cutthroat and rainbow trout, whitefish, chubs, and suckers) eat mainly *zooplankton*, a microscopic crustacean that grazes on *phytoplankton,* suspended algae. **We support the Council's proposal to restrict summertime reservoir drawdown to 10 feet from full pool during the highest 80th percentile water years and 20 feet from full pool during the driest 20th percentile water years**.

The Variable flow, or VARQ flood control strategy developed by the Army Corps of Engineers (ACOE 1999), improves reservoir refill probability. Improved reservoir refill increases the frequency of years in which water is available for spring and summer flow augmentation. NMFS 2000 states that "VARQ reduces system flood control drafts at Libby and Hungry Horse Reservoirs in years when flood control risks are moderate (average to below average water years) and adds about 10,000 cfs to summer flows at McNary Dam without increasing flood risks". VARQ supplies additional water for the endangered Kootenai white sturgeon by April, 30-90 percent of the time, and provides additional water 30-60 percent more often for bull trout and salmon (BPA model runs Dec. 2000).

Improved reservoir refill assures that passage into spawning tributaries is maintained for bull trout that begin their fall spawning run in July. Another species of special concern in Montana, the westslope cutthroat trout, ascends the spawning streams during April and May when the reservoirs are near the annual minimum elevation. Figure 12 shows an example of a complete fish barrier when Hungry Horse Reservoir is approximately 50 feet below full pool.

Our operating strategy was designed for use with monthly water supply forecasts beginning in January each year, and updated each month as forecasts become available. Monthly adjustments accommodate forecasting error and unpredictable precipitation events. For example, the Integrated Rule Curves (IRCs) developed for Hungry Horse and Libby Reservoirs categorize the inflow volume into five categories (from drought to flood) based on the historic record. Each category corresponds with a draw down and refill curve for reservoir operation (Marotz et al. 1996 and 1999; Fraley 1989). Reservoir elevations can also be calculated mathematically for the entire year (See attached IRC instructions). Adjustments are made mathematically when actual water supplies differ from the forecast. **Reservoir operations should be based on local inflows to each storage project. Reservoir fisheries benefit by operating the dams consistent with the variable flood control strategy (ACOE 1999), Integrated Rule Curves (IRC) during reservoir refill and a gradual reservoir draft during summer and fall as flows are augmented for anadromous fish recovery (NMFS 2000).**

Changes in river operations – summer flows.

Our comments on riverine biology are based on field sampling (Fraley and Graham 1982) and quantitative computer models that were designed using a modified form of the Instream Flow Incremental Methodology (IFIM). River models quantify the total availability of various habitats for selected life stages of native fishes (i.e. bull trout and westslope cutthroat trout) under different dam operation scenarios. The IFIM models were developed based on site-specific habitat suitability data collected from the Flathead and Kootenai Rivers downstream of the dams. IFIM studies have provided empirical evidence for seasonal flow limitations and ramping rates (Hoffman et al. 2002; Marotz and Muhlfeld 2000; Muhlfeld et al. 2003). Tiered flows for Kootenai River white sturgeon and allowable ramping rates for bull trout are specified by the USFWS 2000 BiOp and Recovery Plan (USFWS 2000; USFWS 1999).

River fisheries benefit when dams are operated consistent with normative hydrologic conditions (Muhlfeld et al. 2003; Paragamian 2000; Independent Scientific Group 1999; ISAB 1997 and 1997b; Hauer and Potter 1986). Normative hydrologic conditions mimic natural processes and minimize impacts on fish and wildlife (Ward and Stanford 1979). For example, Muhlfeld et al. (2003) found that subadult bull trout moved from deep, mid-channel areas during the day, to shallow low-velocity areas along the channel margins without overhead cover at night in the partially regulated reaches of the Flathead River. The authors recommended that restoration of the most natural and stable flow regime possible under the current management constraints will protect key ecosystem processes and maintain or restore bull trout populations in the Flathead and elsewhere in the Pacific Northwest (Independent Scientific Group 1999). Conversely, fluctuating stream flows resulting from dam operation directly affect the aquatic environment and associated riparian and wetland habitats downstream of headwater reservoirs. Figure 13 shows the influence of dam regulation on daily flow fluctuation downstream of a storage project. Flow fluctuation increases the width of the varial zone that becomes biologically unproductive (Perry et al 1986; Hauer et al. 1997; Hauer et al. 1974).

Normalized river flows benefit all fish species of special concern in Montana, then flows continue downstream to aid anadromous salmon smolt migration in the mainstem Columbia River. The naturalized spring freshet resorts and cleans river sediments and helps restore nutrient cycles and floodplain function (Shepard et al. 1984). Once the spring runoff ends, river flows should gradually decline toward stable summer flows to protect biological production in the rivers downstream of the dams, especially during the productive warm months. The IRCs for reservoir operation provide seasonality of flow in downstream reaches that are consistent with the Normative River Concept (ISAB 1997, 1997b).

Springtime dam operations at Hungry Horse and Libby Dams should avoid uncontrolled spills. Instituting a “sliding scale” for the refill date, based on reservoir inflow forecasts, can mitigate the potential for uncontrolled spill at Hungry Horse and Libby Dams (Marotz et al. 1999). The reservoirs can safely refill earlier during dry water years, but should

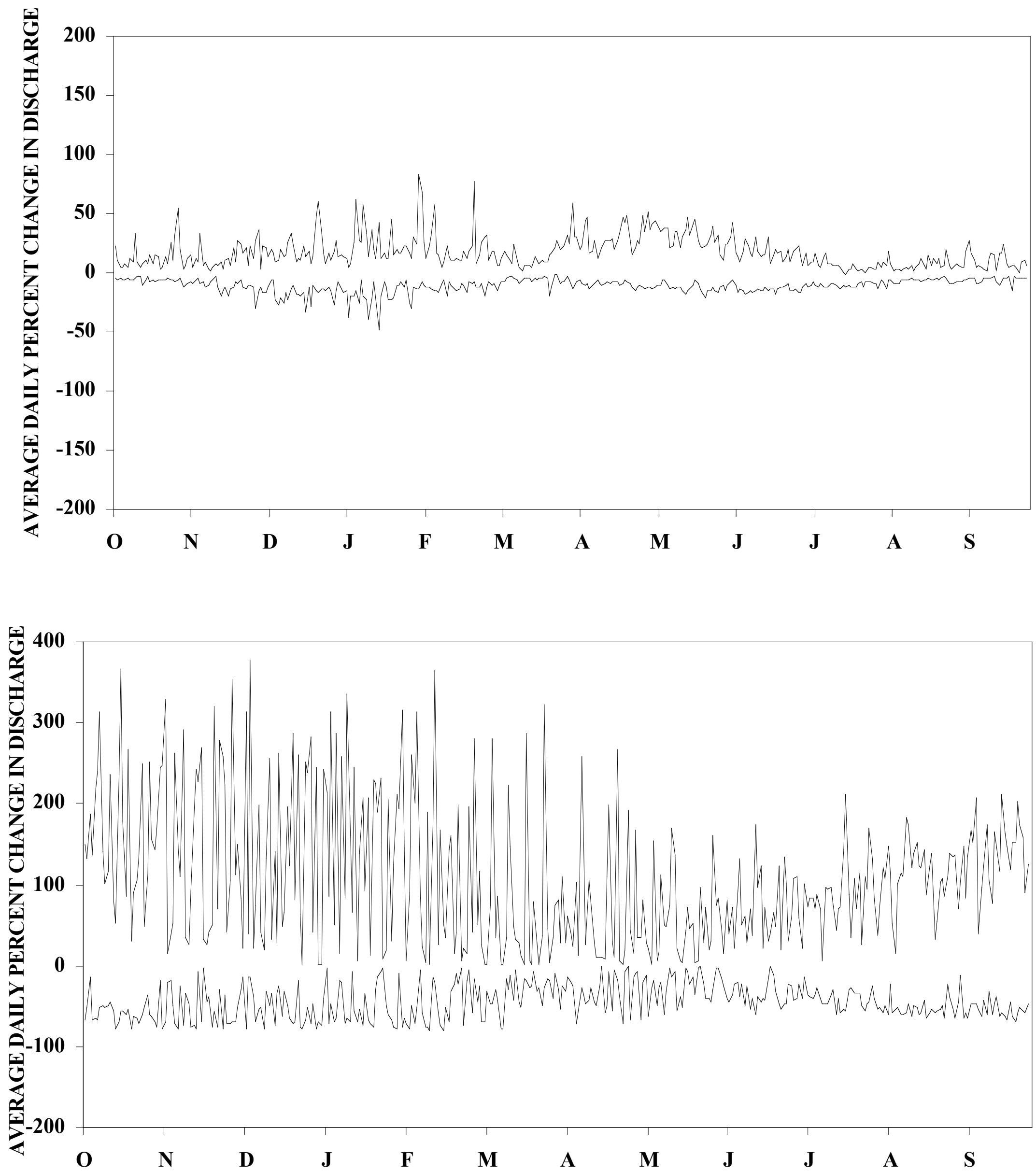


Figure 13. Range in daily change in discharge of the Kootenai River from water year 1952 through 1971 (top) and below Libby Dam from water years 1975 through 1995 (bottom) *in* Hauer 1996.

refill later during high water years to avoid the use of the spillways, which cause biological damage associated with gas supersaturation and abrupt changes in water temperature. Reservoir refill should be achieved by slowing the rate of refill as the reservoir approaches full pool. This allows operational flexibility to respond to inflow volumes and smooth the discharge prior to and after refill. The goal should be to fill the reservoir as soon as inflows decline to turbine capacity so that discharge after refill approximates the discharge prior to refill. **The Council should adjust the refill date to reduce the potential for uncontrolled spill and associated gas supersaturation problems downstream of headwater storage projects. Smoothing the discharge benefits river productivity because the width of the unproductive varial zone is reduced.**

To avoid unnecessary impacts in Montana, Hungry Horse and Libby Reservoirs should be operated conservatively, releasing stored water gradually over the summer to avoid unnatural flow fluctuations. The primary objective for summer operations should be to maximize habitat for optimal biological production in the rivers downstream of storage reservoirs during the period of July through September. Preliminary results of the IFIM models show that the availability of critical riffle habitat (e.g. wetted perimeter) sharply declines below 6,000 cfs in the Flathead River (Figure 14) and 9,000 cfs in the Kootenai River (Figure 15). These data suggest that dam operations that stabilize river discharge at or above these inflection points (up to 10,000 cfs) will optimize aquatic insect production. The ongoing IFIM research will quantify the total usable area for each target fish species and life stage at various flows of interest. The combination of the wetted perimeter and total usable area relationships will allow resource managers to identify flows that will maximize both aquatic invertebrate and fish production using a comprehensive ecosystem approach.

We support the Council's strategy to extend dam discharges from Libby and Hungry Horse Reservoirs for summer flow augmentation through the end of September, and to require that the water be released in a stable way that minimizes or eliminates fluctuations. Further, we recommend that the Council use recommendations from the ongoing IFIM studies in the Kootenai and Flathead Rivers to refine flow ramping rates and flow windows for each project.

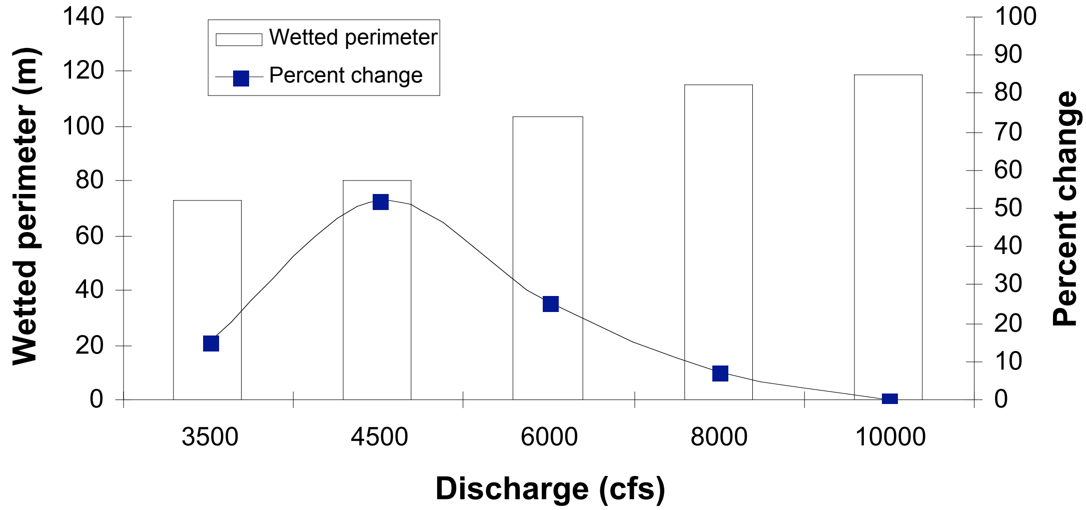


Figure 14. The wetted perimeter-discharge relationship for 2 riffle sections in the mainstem Flathead River near Columbia Falls, Montana. Note that at 6,000 cfs most of the wetted perimeter remains biologically productive and losses increase at lower flows.

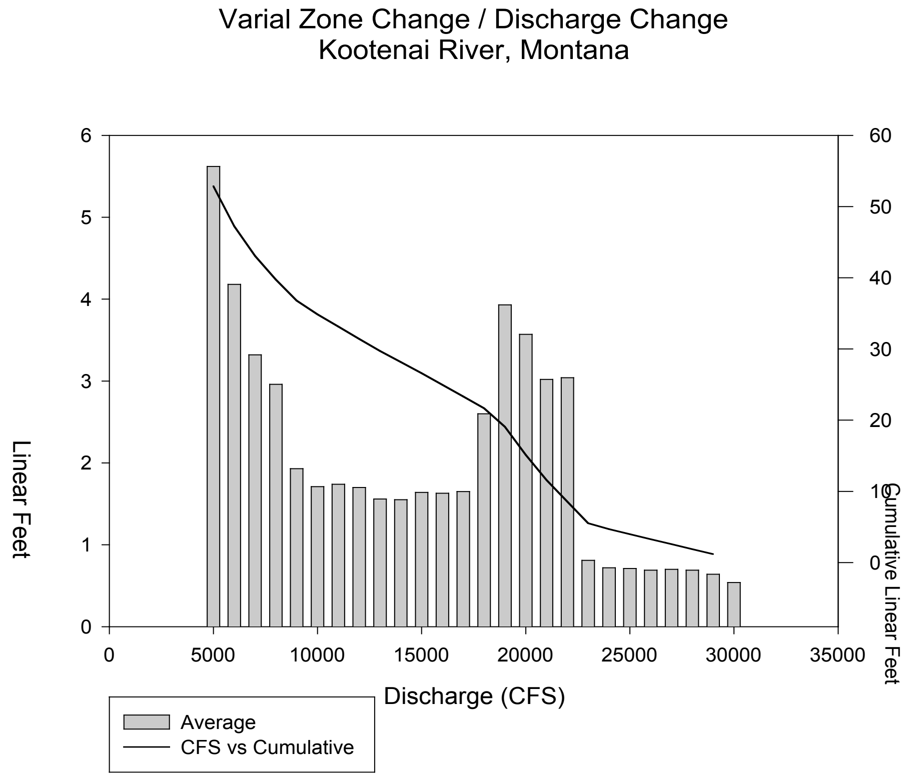


Figure 15. Varial zone exposed in the Kootenai River, Montana, below Libby Dam per mile for each 1,000 cfs drop in discharge. Note that at 9,000 cfs, most of the wetted perimeter remains biologically productive and losses increase rapidly at lower flows.

We concur with the mathematical technique developed by the Council for calculating stable summer flows (John Fazio, model runs and personal communication). Specifically, the reservoir volume above the summer reservoir draft limit plus a conservative estimate if inflow volume, spread equally each day throughout the July through September period. Flow management during the summer should be based on the volume of water in storage behind Libby Dam available for salmon augmentation down to elevation 2449 feet, and Hungry Horse to elevation 3550 feet. During the driest 20 percent of water years, these draft limits can be adjusted 10 feet lower, to 20 feet from full pool. This is consistent with the USFWS 2000 BiOp, which specifies higher flows during the summer for bull trout downstream of Libby Dam. **We concur with this sliding-scale flow strategy for bull trout as specified (USFWS 2000). Further, we urge the Council to implement a similar sliding-scale minimum flow target for bull trout downstream of Hungry Horse Reservoir.**

The USFWS BiOp stated that the white sturgeon tiered flows should be refined by developing a mathematical formula, based on water availability, to define the required volume to be released from storage at Libby Dam to meet flow targets at Bonners Ferry, Idaho (USFWS 1999, 2000). **We support the new formula for sturgeon flows, which is in the Council's preferred alternative.**

The USFWS and NMFS 2000 Biological Opinions on the operation of the FCRPS called for the variable flow, flood control strategy (VARQ). VARQ allows dam operators to store more water prior to runoff during less than average water years (years with low flood potential) to create a naturalized spring runoff (within flood constraints) without compromising the probability of reservoir refill. This limits the duration and frequency of deep reservoir drawdowns and improves the likelihood of reservoir refill. River flows can be augmented while protecting resident fish in and below Hungry Horse and Libby Reservoirs (ACOE 1999, Marotz et al. 1999). VARQ flood control should be implemented within the flood stage requirement at the nearest downstream flood control centers. **We support VARQ flood control at Hungry Horse and Libby Dams** (ACOE 1999; Complete data set received by MFWP from ACOE December 2002).

The minimum flow during the remainder of the year should remain at 3,500 in the Flathead River at Columbia Falls and 4,000 cfs discharge from Libby Dam.

The minimum flow in the South Fork Flathead River immediately downstream of Hungry Horse Dam should continue to follow the "sliding scale" adjustment based dependant on water availability. The existing 900 cfs minimum flow downstream of Hungry Horse Dam benefits riffle and shallow run habitats in the affected 8.4-km reach. However, reservoir refill failure would affect the entire shoreline of the 42-km long reservoir. Hungry Horse Reservoir contains one of the few remaining native species assemblages and one of the strongest metapopulations of bull trout in existence. To avoid impacts to reservoir productivity, the minimum flow shall be determined based on the January final volume runoff forecast for Hungry Horse Reservoir for the period of April 1 to August 31. When the April through August forecast is greater than 1,790 thousand acre feet (KAF), the minimum flow shall be 900 cfs. When the forecast is less than 1,190 KAF, the minimum flow may be reduced to 400 cfs. When the forecast is between 1,190 and 1,790 KAF, the minimum flow shall be linearly interpolated between 400 and 900 cfs. Hungry Horse Dam discharge must maintain the established minimum flow of 3,500 cfs at Columbia Falls. However, in the event of a flood emergency (when river stage at Columbia Falls reaches 13 feet) the minimum flow in the South Fork can be reduced to the physical minimum (approximately 145 cfs) (Marotz and Muhlfeld 2000).

Riparian and wetland areas have the greatest influence over the biological health of the watershed (Bissell 1996; Bayley 1995; Naiman et al. 1993). Small changes in the structure and composition of riparian habitats can adversely affect populations of riparian dependant species. For example, riparian habitats support more priority avian species than any other habitat (Casey 2000). They provide security cover for fish and terrestrial wildlife, habitat and food for insect production, and woody debris that creates channel diversity and pocket water for spawning gravel deposition. Ground cover vegetation and riparian canopy in the riparian zone traps sediments produced from adjacent land areas. Cottonwood recruitment generally requires a decline in river stage immediately following the spring peak in the order of 2.5 cm/day. However, in cases of reaches dominated by fine substrates, seedlings may survive stage declines of up to 3 to 5 cm/day (Rood and Mahoney 2000). Stable or slowly declining summer flows help maintain cottonwood and willow seedlings established earlier in the year (Jamieson and Braatne 2001). **The Council's program should identify and protect the best available remaining**

riparian and wetland habitats through the use of conservation agreements and land acquisitions and modify the activities that are causing the degradation of impacted areas or that are preventing the ecosystem from recovering.

Action vs. Status Quo

The preferred alternative selected by the Council in the draft amendment is generally consistent with our biological goals. During review of flow augmentation, we urge that the Council implement these strategies immediately, rather than maintain Status Quo operations.

Elimination of April 10 flood control elevation target.

The Council proposed to remove the April 10 flood control target specified by NMFS and replace it with a 95% refill probability by June. The Council hypothesizes that this reduction in spring flows would be muted by the 95% priority refill requirement at the end of June. The assumption is that the reservoirs could never be drafted too deeply in winter or refill probability would be reduced below 95 percent. Therefore any reductions in spring flows would be relatively minor and would not have significant adverse effects on the survival of spring-migrating anadromous fish.

We reviewed the Council's model simulations that indicate that this strategy would allow dam operators, in many years, to draft the reservoirs somewhat deeper in winter to provide additional flexibility for power generation at peak winter times as needed. This is consistent with the flexibility designed into the IRCs. However, because model simulations are unable to mimic the real-time decision space available to human operators (e.g. short-term weather forecasting, precipitation records etc.) it remains uncertain how operations would occur in reality. **We therefore recommend that provisional and firm power drafting be conservative to prioritize reservoir refill.**

Increasing the frequency of deep reservoir drafts and/or refill failure impacts biological productivity. In the reservoirs, the depth of drawdown is more biologically important than the number of days the reservoir remains at each elevation. Once the substrate desiccates and/or freezes (for roughly one week), aquatic production ceases at that elevation until the following spring when the substrate is re-flooded for approximately five weeks and aquatic life recolonizes. Biological modeling indicates that annual biological production changes very little if the reservoir is drafted to the same minimum elevation, during winter or later during spring. However, once the reservoir refills and becomes biologically productive, annual production is increased the longer the pool remains at or near full. **If the Council's proposed operation indeed implements IRCs and VARQ, the question of removing the April 10 flood control limit becomes moot. VARQ and IRCs will ensure that the reservoirs are not drafted so deeply in the winter to impact on refilling all of the reservoirs.**

River productivity is similarly impacted by low river stage and intermittent fluctuations (Perry 1984; Hauer and Stanford 1982). Once the substrate desiccates and/or freezes (for roughly one week), aquatic production ceases at that elevation until the substrate is re-flooded and aquatic life recolonizes (Gersich and Brusven 1981). **River productivity is enhanced when flow fluctuation is reduced and the varial zone minimized.**

The above operational strategies represent actions related to mainstem operations that will create desirable habitat and help recover fish and wildlife populations in the headwaters while recovery actions for anadromous fish continue in the lower Columbia River. These operations are consistent with established mitigation plans in the Flathead and Kootenai subbasins (Fraley et al. 1989; MFWP and CSKT 1991,1993; MFWP, CSKT and KTOI 1998).

Criteria and procedures for emergency operations.

The Council sought comment on provisions for when and how it would be permissible to declare a power system emergency and reduce or eliminate operations for fish. Montana's recommendations for operating the FCRPS were designed to meet the needs of fish and wildlife with minimal impacts to power supply needs and system flood control in the northwest region. Power analyses have been completed by BPA (Wright 1996; Also see model simulations by Roger Schiewe BPA).

We believe hydrologic calculations in the Columbia Watershed should begin with water availability in the headwaters and work downstream. Monthly inflow forecasts for each headwater reservoir should be used to calculate reservoir drawdown and refill targets, and/or dam discharge schedules (SOR EIS 1995). Water availability in the Flathead and Kootenai subbasins varies somewhat independently from the main stem Columbia River; the subbasins might be wet or dry compared to the whole Columbia Watershed. Dam discharge is regulated by the physical characteristics of catchments/dams and downstream flood constraints. River friction and downstream catchments, water travel times and hyporheic interactions, dampen flow peaks. Flows from unregulated sources are added enroute downstream. These variables must be considered for system operation. **The Council should request the Action Agencies to develop a weekly time-step system operation model capable of simulating water routing strategies. This tool would allow for greater efficiency to maximize benefits from the Columbia River.**

The Council should consider more inter-regional energy transfers, energy conservation, and alternative energy technologies to resolve the region's power supply problems. Additional transmission associated with Hungry Horse and Libby Dams would have the added fisheries benefit of stabilizing river flows when electrical storms cause grid interruptions.

The Council should incorporate costs associated with damages to fish and wildlife resources and losses to past mitigation investments when the power supply impacts of proposed operations are evaluated. Economic analyses should not externalize costs associated with losses to ecosystem health.

We urge the Council to have project sponsors develop loss statements associated with each dam in the FCRPS and ultimately develop a measurable system for evaluating progress toward mitigating those losses. The Council previously approved the loss statement for Hungry Horse Reservoir (MFWP and CSKT 1991, and 1993), and the loss statement for Libby Reservoir was submitted to the Council in 1998 (MFWP, CSKT and KTOI 1998).

The construction and operation of **Libby Dam** caused the following fisheries losses that must be mitigated (MFWP, CSKT and KTOI 1998):

- Replace the annual loss of 15,000 trout and 377,000 mountain whitefish from the river inundated by Libby Reservoir.
- Replace the annual loss of 57,000 juvenile *Oncorhynchus spp* from inundated tributaries.
- Replace the annual loss of 5,990 juvenile *Oncorhynchus spp* from tributaries blocked by new road construction to accommodate the reservoir.
- Replace the annual loss of 2,100 juvenile westslope cutthroat trout from the Kootenai River downstream of Libby Dam.
- Increase burbot in the Kootenai River to replace a loss of an approximate 90 percent reduction in the burbot fishery.
- White sturgeon are now endangered and bull trout are designated threatened under the Endangered Species Act (ESA). These populations need to be restored to sustainable numbers to allow delisting these species.
- Replace 175 km of the Kootenai River and 134 km of tributary stream habitat lost to inundation by Libby Reservoir.
- Replace 25 km of adfluvial trout habitat was blocked by road construction when new roads were built around the reservoir to accommodate filling the pool.

The construction and operation of **Hungry Horse Dam** resulted in the following fisheries losses that must be mitigated (Zubic and Fraley 1987; MFWP and CSKT 1991):

- Replace a minimum annual loss of 65,000 juvenile westslope cutthroat trout.
- Replace an annual loss of 250,000 juvenile bull trout
- The loss statement also identifies the loss of 100,000 adult kokanee. Since experimental stocking could not restore the kokanee population, the implementation plan calls for replacing this loss using native trout species.
- Replace the loss of 78 miles of river and tributary habitat lost due to inundation by Hungry Horse Reservoir.

Only when fish and wildlife populations show positive trend can the Council conclude that it is adopting a fish and wildlife program that truly does protect, mitigate and enhance fish and wildlife, while continuing to assure the region an adequate, efficient, economical and reliable power supply.

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Integrated Rule Curves
Operating Instructions

Background

The Integrated Rule Curves (IRCs) were developed by Montana Fish, Wildlife & Parks and the Confederated Salish and Kootenai Tribes as a tool to balance the requirements of hydropower generation and flood control with resident and anadromous fish. They are the result of over 17 years of field and laboratory research to assess the effects of hydropower operations on the aquatic resources in the Columbia River watershed in northwestern Montana.

The IRCs were designed to limit the duration and frequency of deep reservoir drawdowns, improve reservoir refill probability and produce a more naturally shaped dam discharge hydrograph. All of these actions are necessary to partially mitigate fisheries losses attributable to the construction and operation of Hungry Horse (MFWP and CSKT 1991,1993) and Libby Dams (MFWP, CSKT and KTOI 1999). Reduced drawdown protects aquatic food production in the reservoirs, assuring an ample springtime food supply for fish. Increased refill frequency improves biological production during the warm months. At full pool, the reservoir contains the maximum volume and biological productivity for fish growth and a large surface area for the deposition of terrestrial insects, an important summer fish food component, from the surrounding landscape. Refill timing also assures that passage into spawning and rearing habitats in tributaries is maintained for the threatened bull trout that begins its fall spawning run in July. Another species of special concern in Montana, the westslope cutthroat trout, ascends the spawning streams during April and May when the reservoirs are near the annual minimum elevation. Downstream of the dams, biological production in the river is protected by the more naturally shaped hydrograph. The naturalized spring freshet resorts and cleans river sediments and helps restore nutrient cycles and floodplain function. Normalized river flows benefit all species of special concern, including the endangered Kootenai white sturgeon and interior redband trout. In Montana, these species occur only in the Kootenai River below Libby Dam. River discharges from both projects then continue downstream to aid anadromous salmon smolt migration.

The IRC elevational targets published by Marotz et al. (1996) have been revised for compatibility with the various system models, and to improve conditions for the Kootenai white sturgeon and other resident and anadromous fish species. For example, the four-year "critical period" method for dam operation was abandoned due to fishery-related changes in the operation of Columbia River dams. The IRC operations now assume that every year is designated "critical year one" to better mimic current operations. This revision was consistent with Montana's recommended operation because of the improved reservoir refill probability resulting from the IRC operation. However, the system will continue to experience refill failures, but to a lesser degree, even if IRCs are applied to other storage projects. The Columbia watershed naturally experiences wet and dry periods. The elevational targets published in 1996 have also been revised for use in the monthly system models to better mimic the results of our daily models.

Lastly, Montana revised the IRCs to accommodate a 10 foot summer drawdown from full pool at both reservoirs to aide in the recovery of anadromous fish stocks, and shaped the discharge to benefit listed and petitioned fish and wildlife species in the Flathead and Kootenai systems. The 10 foot draft limit can be adjusted to 20 feet from full pool during the lowest 20th percentile water years.

The reservoir models (HRMOD and LRMOD) and an earlier draft of the IRC (Biological Rule Curves or BRCs) were critically examined during the period 1991-1995, in the Columbia River System Operation Review (SOR) conducted by Bonneville Power Administration (BPA), U.S. Bureau of Reclamation (BOR), and U.S. Army Corps of Engineers (ACOE). State, tribes, and agencies represented on the SOR Resident Fish Workgroup assessed analytical tools available for biological assessments of various reservoir operation strategies. Our methodology was deemed appropriate for use in the SOR process. A simplified version of the Montana models was modified for use on the other storage reservoirs in the U.S. portion of the Columbia River System. Results were published in Appendix K of the Final Environmental Impact Statement (SOR EIS 1995). This "screening model" enabled researchers to evaluate compromises between resident fish species in the headwaters and salmon and steelhead in the lower Columbia. The IRCs and similar resident fish constraints at other storage projects formed the basis of SOS #4 which met the requirements of more work groups than the preferred alternative. Alternatives designed to improve anadromous fish survival with increased instream flow had a negative effect on the reservoirs fisheries (Geist et al. 1996).

Although the IRCs were adopted by the Northwest Power Planning Council in its1994 Fish and Wildlife Program ,they were not implemented in 1995 because of conflicting requirements in the NMFS 1995 Biological Opinion (BiOp). In general, the original IRC and BiOp were similar throughout the operating year but differ substantially during the summer. Whereas the IRCs attempted to fill the reservoirs in July and maintain elevations near full pool, the Biological Opinion attempts to fill the projects by June 30, then drafts the projects 20 feet by the end of August. The BiOp operation results in a failure to refill the projects by up to 20 feet in some years (Data provided by NMFS, and Roger Schiewe BPA). Reservoir refill failure impacts biological production in the reservoirs during the productive warm months and causes unnatural flow fluctuations in the Kootenai and Flathead rivers below the dams. The IRCs delay the refill date during high water years to avoid forced spill and associated gas supersaturation in the Kootenai and Flathead rivers

Flow augmentation NMFS 2000 Biological Opinion should be released at a constant rate over the July through September period to avoid creating a second flow peak following the naturally-timed spring freshet for white sturgeon. Reservoir discharge should mimic the natural hydrograph which historically declined gradually from a peak flow in early June to basal low flows by late July. Rapid flow fluctuation is biologically damaging because a large portion of the river margins become dewatered, stranding insects, zooplankton, and potentially fish and fish eggs (Hauer 1994, 1997). This could directly impact young white sturgeon if they use backwater areas (information on habitat requirements of sturgeon during their first year of life is sparse) or flow fluctuation could impact sturgeon prey production (sturgeon food habits during their first year includes insects and other invertebrates and small fish).

Juvenile bull trout can also be harmed when flows first decline in July, then increase in August. Upon emigrating from their natal tributaries, young bull trout reside in shallow river margins (< 1 m depth), often associated with unimbedded cobble. Insects are an important food component as juvenile shift from insects to fish prey. As flows increase, much of the habitat in the river margins includes the portion of channel that was recently dewatered and killed, essentially moving the bull trout into the unproductive varial zone. Conversely, the IRCs gradually reduce flows after the spring runoff peak and moderate flow fluctuations, thus avoiding this riverine impact.

The IRC concept was compared to the Biological Opinion and two other alternatives (Wright et al. 1996). This analysis did not address incremental tradeoffs between anadromous and resident fish species resulting from the alternatives. The process did, however, focus the debate by identifying similarities and differences. Results of the Wright analysis also showed that the enhanced reservoir operation (IRC concept) was the least expensive of the alternatives analyzed, saving the power system an incremental average of $27 million per year as compared to the Biological Opinion.

Scientific and policy guidance is needed to resolve the obvious potential for conflicting direction for salmon steelhead, white sturgeon and bull trout recovery. The Independent Scientific Group (ISG 1996) noted that the IRCs provide seasonality of flow in downstream reaches that are consistent with the Normative River Concept (ISAB 1997). The Group also noted "that an incremental, empirical relation between flow [in the lower Columbia] and survival [of anadromous smolts] has not been demonstrated, even though it is likely that survival is higher on high runoff (wet) years," and that non-seasonal flow augmentation [summer releases] to aid summer smolt migration in the lower Columbia River may do more harm than good because the smolts may not have accumulated necessary growth and energy reserves for successful migration. The Independent Scientific Advisory Board (ISAB 1997a) also reported that the operations called for by the BiOp cause harm to resident fish species in the Montana reservoirs and rivers downstream. Given these uncertainties, we have focused our biological research on reservoir and riverine effects and have tailored the IRCs to balance the potentially conflicting needs of various native species. Fortunately, the NMFS Biological Opinion contains language that allows for operational changes when new information becomes available.

A multi-species watershed approach can be used to balance actions for white sturgeon and bull trout with actions for anadromous salmon and steelhead. Recovery efforts throughout the basin can also be balanced with important non-listed species. The IRCs strive to benefit fish throughout the Columbia Basin by coordinating water flows from the headwaters to produce a protracted flow event in the main stem. By implementing operating curves similar to the IRCs at other storage projects, sub-basins experiencing wet conditions can supply the bulk of salmon flow augmentation. Dry sub-basins provide less flow, protecting important reservoir and riverine stocks.

Operations

The IRCs are a family of reservoir elevation targets for dam operation that incorporate incremental adjustments to allow for uncertainties in water availability. IRCs delimit five categories, or *Quintiles*, of water availability and are intended for use similar to power and flood control rule curves. In real time, the dam operator would receive an inflow forecast in early January and interpolate the corresponding reservoir elevational target. Elevation targets are derived by first comparing the most accurate inflow forecast to four inflow thresholds to determine the corresponding quintile. Next, a coefficient is derived through linear interpolation by using the two curves that bracket the most recent inflow forecast. An equation described below is used to calculate the end of month elevational target.

The models, HRMOD and LRMOD, run on the water year October 1 through September 30, and use the April 1 through August 31 inflow forecast (water year day 183 - 335). We can also set up the model to run on forecasts for any other period (e.g. April through July or April through September).

At Libby Dam (LRMOD) the inflow volume thresholds (that designate which IRC elevational targets) are equally spaced as follows:

Vol1 = 4214.52 (KAF April 1 to Aug 31);
Vol2 = 5481.60;
Vol3 = 6748.68;
Vol4 = 8015.76. Each increment is 1267.08 KAF.

At Hungry Horse Dam (HRMOD) the thresholds are equally spaced as follows:

Vol1 = 1192.34 (KAF April 1 to Aug 31);
Vol2 = 1590.37;
Vol3 = 1988.40;
Vol4 = 2386.43. Each increment is 398.03 KAF

These thresholds have not changed since 4/23/96 (Version IRC-v96). The curves representing the IRC targets (LMATRIX and HMATRIX) have changed very little since 1996, but have varied only subtly, to smooth the curves and to make them function better in the system models.

The inflow thresholds (Vol1 through Vol4) define the divisions of the five quintiles of inflow volumes. Inflow forecasts should be compared to the threshold values and an elevational target should be interpolated from the MATRIX for each project (IRC curves, Tables 1 and 2). For example, if the January inflow forecast for Libby Reservoir for the period April 1 through August 31 is 7000 KAF, the forecast would be intermediate between Vol3 and Vol4, or quintile 4. The coefficient would be .1983 (the difference between 7000 – 6748.68 = 251.32 divided by the total range of the quintile 8015.76 - 6748.68 = 1267.08, or 251.32 / 1267.08 = .1983). If the inflow was extremely high, say 9000, the quintile would be 5 and the coefficient would be .777 (or difference 984.25 / difference 1267.08). Next, we would refer to LMATRIX and find the corresponding elevational targets for the end of January. The deepest end of January elevation is curve F = 2378, the next deepest is E= 2383 and the next is D=2390. The first volume would yield 2390' + .1983(2383'-2390') = 2388.61 feet. The second volume would yield 2383' + .777(2378-2383) = 2379.12 feet. A new end-of-month elevational target should be interpolated from the IRC curves as each consecutive inflow forecast become available. These represent minimum elevational targets. The reservoirs can be operated at elevations higher than the IRCs (e.g. operated to VARQ) if required for other system needs. This causes the actual operation to be flexible and variable over time. Actual operations will vary somewhat from the target elevations due to inflow forecasting error. Negative deviations from the targets caused by forecasting error can be verified mathematically.

The Endangered White Sturgeons Recovery Team's Kootenai River IRCs (KIRC) and "tiered flow approach" for white sturgeon recovery is consistent with the Montana state and tribe's preferred operation plan for other non-listed stocks and recreational fisheries in the Flathead and Kootenai drainages. It is important that Libby Reservoir be operated to or above the IRC to balance the sturgeon release with reservoir refill. If the reservoir elevation is below the IRC on May 1 (as in 1999), release of the sturgeon volume will result in reservoir refill failure and difficulty shaping flows for sturgeon, bull trout and anadromous species. During sturgeon flow augmentation, Libby discharge should be held to the minimum needed to achieve the minimum flow target. However, if more water must be released to avoid overfill and spill, the minimum Bonners Ferry targets can be exceeded up to (but not beyond) flood stage at Bonners Ferry. Daily simulations have shown that flows at Bonners Ferry seldom exceed 50 kcfs when the IRC and tiered flows are used in concert. The portion of the target contributed from Libby Dam is somewhat flexible for inseason management to achieve the greatest benefit for sturgeon and other listed or petitioned fish stocks.

For modeling purposes, the unregulated flows below Libby Dam were calculated using concurrent daily data as the difference between Libby Dam discharge and the river gauge at Port Hill. The unregulated flow component was then regressed on the daily inflow to Libby Reservoir. We then used a time series regression to predict the magnitude and duration of the low elevation runoff between Libby Dam and Bonners ferry as a function of reservoir inflow (which includes high elevation runoff that typically occurs a week or two later). The model output was designed to be constrained by operating rules provided by the International Joint Commission (IJC 1938; data were provided by BC Hydro), but we would like to reexamine this model component with flood control experts.

Under the IRC operation, pass-through flows from Libby Reservoir are enhanced for the endangered white sturgeon and both Montana projects contribute spring and summer flows to enhance salmon migrations. A gradual ramp down from the spring runoff normalizes the river hydrograph while simultaneously increasing flows in August. This reduces the area of the river varial zone, improving biological production for riverine species including bull trout. Pass- through flows, augmented with conservative storage release, can be shaped to achieve the greatest benefit for sturgeon, salmon, and non-listed stocks. This can typically be achieved by providing an 9 kcfs minimum flow from Libby Dam for bull trout. Flows should remain stable through September. Similar protection in the Flathead River below Hungry Horse Dam by providing 6 kcfs minimum flow at Columbia Falls for bull trout. Flows should remain stable until flows increase for electrical generation when cold weather increases load (circa late September). The actual volume released should be calculated based on reservoir elevation and water availability.

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