Conservation of Columbia Basin Fish

Hydropower Appendix

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DRAFT

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The Federal Caucus

Army Corps of Engineers
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Bureau of Land Management
Bureau of Reclamation
Environmental Protection Agency
Fish and Wildlife Service
Forest Service
National Marine Fisheries Service

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SECTION I. SCOPE OF THE ANALYSIS

A. Geographic and Temporal

The geographic scope of this analysis is configuration and operations at hydroelectric dams and reservoirs in the Columbia River Basin. The hydro workgroup determined that any major project with a configuration or operation that affects the passage or lifecycle of Endangered Species Act-listed (ESA) or at-risk anadromous and resident fish could be considered in the analysis. The primary focus, however, is on the 14 Federal Columbia River Power System (FCRPS) projects on the mainstem of the Columbia River and its tributaries operated by the U.S. Army Corps of Engineers (COE) and the Bureau of Reclamation (Reclamation).

The hydro workgroup considered juvenile and adult passage at the Federal project sites, as well as conditions in other areas, such as in the Hanford Reach and below Bonneville Dam, where project configuration and operations affect fish spawning and rearing. Federal projects in the Yakima Basin in Washington and the Willamette Basin in Oregon are not considered in the analysis, but they are being considered in biological assessments and biological opinions under the ESA.

In addition to the FCRPS, the workgroup took into account configuration and operations at several non-Federal projects. Federal Energy Regulatory Commission (FERC) licensed projects, such as the Idaho Power Company's Hells Canyon Complex and Grant County Public Utility District's Priest Rapids Dam, are incorporated into the analysis where possible and practicable. While the focus was on projects in the United States, operations north of the border in British Columbia also have an impact, and Canadian operations that relate to non-Treaty storage and other storage agreements are included.

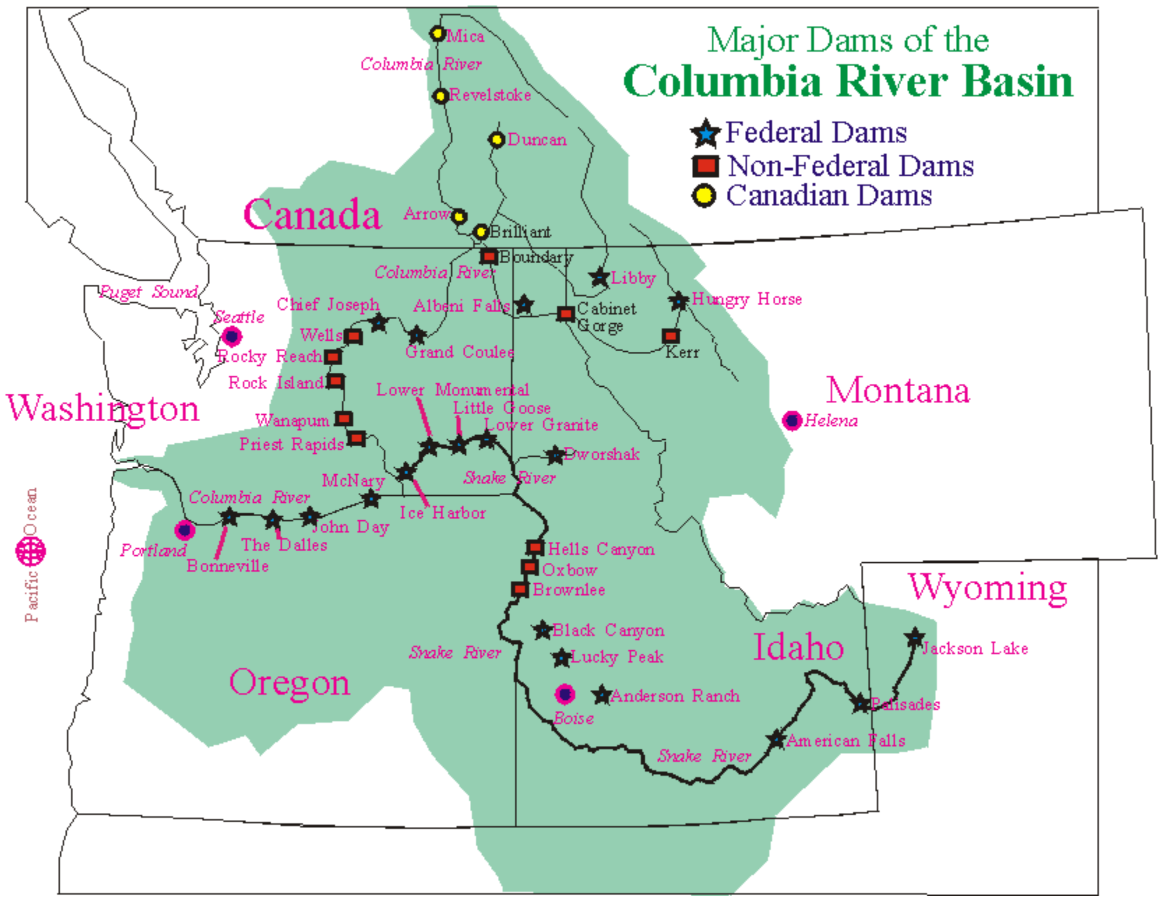
The following map, Figure 1-1, shows FCRPS projects and other major Federal and non-Federal dams that have been given consideration in this analysis.

The timeframe covered by the proposed configuration activities and operations extends into the foreseeable future, about 20 years.

B. Aquatic Species Considered

The hydro configuration and operations outlined here take into account multiple species of fish and other aquatic life that inhabit the Columbia River Basin. The workgroup addressed the aquatic species that have been listed as threatened or endangered under the ESA, as well as a number of species that are known or suspected to be at risk of extinction.

The following 12 Columbia River Basin anadromous fish species listed under the ESA are considered in the actions outlined in this report:



- Snake River fall Chinook
- Snake River spring/summer chinook
- Snake River sockeye
- Snake River steelhead
- Upper Columbia River spring chinook
- Upper Columbia River steelhead
- Middle Columbia River steelhead
- Lower Columbia River steelhead
- Lower Columbia River chinook
- Columbia River chum
- Upper Willamette River chinook
- Upper Willamette River steelhead

Three species of resident fish listed under the ESA are considered in the actions outlined in this report:

- Kootenai River white sturgeon
- Columbia River population of bull trout
- Oregon chub

Four species of mollusks listed under the ESA are considered in the actions outlined in this report:

- Idaho springsnail
- Snake River Physa snail
- Utah Valvata snail
- Bliss Rapids snail

There are several other aquatic species known or suspected to be at risk that have not been listed under the ESA. The following such species were also considered in the actions outlined in this report:

- Burbot (currently classified as a "state threatened species" by the Idaho Department of Fish and Game (IDFG))
- Pacific lamprey
- Westslope cutthroat trout.

C. Actions: Fish and Water Quality

In developing the configuration and operations for each of three scenarios, the workgroup considered a wide range of possible actions at both the system and project level. At the system level, the workgroup considered transportation, flow augmentation objectives and shaping, project breach and drawdown, changes in flood control, storage levels and location, dissolved gas abatement, and temperature control. At the project level, the workgroup looked at spill, reservoir draft and elevations, outflow, refill, passage improvements, and additional powerhouse capacity. There was also consideration of gas abatement and temperature control at specific locations.

The workgroup decided it could not reasonably analyze some actions, such as restoring passage above Chief Joseph and Grand Coulee Dams. While opportunities may exist to re-open blocked areas on the mainstem and tributaries; the workgroup did not include them in its analysis.

For the initial phase of a Department of Environmental Quality (DEQ) Water Quality Plan, actions from Grand Coulee on the Columbia River and Lower Granite in the Snake River to the tailrace of Bonneville Dam are being addressed. Future work may include considerations above the international boundary.

D. Constraints

The hydro workgroup recognized that nonpower requirements and operating criteria exist that will affect how and/or whether configuration or operations can be changed. This is particularly true with regard to eliminating or significantly reducing Congressionally authorized project purposes such as navigation, hydropower, and flood control. Breaching the Lower Snake River dams and John Day would require Congressional authorization, and the COE has breaching-related studies under way.

With respect to flood control, the group considered changes, including a regimen that may fall within the project authorizations. The regimen is referred to as VARQ. The analysis also considered constraints that the Federal transmission infrastructure imposes on power generation at projects in general and where additional turbines would prevent spill. The group recognized that improvements in the electric power transmission system could enable a broader range of operations.

The analysis gives consideration to limits posed by the logistical realities of implementing large-scale construction programs and significant changes in operations. For example, there would likely be manpower and budgetary constraints relative to the work that could be accomplished in the near-term.

E. Implementation Costs

Where possible, the hydro workgroup developed capital costs for implementing the configuration actions at each dam. Several configuration and operations measures that may be possible will require further analysis and subsequent decisions; most likely cost estimates or cost ranges are given in these cases. The process for developing the costs included laying out priorities for action, identifying realistic implementation schedules, and estimating implementation budgets. The cost information is presented in Section IV of this report.

F. Relationship to Other Regional Activities

The hydro workgroup considered proposals, concepts, analyses, and other information from many sources, and the group's activities were coordinated with other ongoing Federal and regional processes, including the following:

Lower Snake River Juvenile Fish Migration Feasibility Study – this feasibility study and Environmental Impact Statement (EIS) is addressing alternatives for improving salmon passage survival in the 140-mile river reach impounded by four COE dams in the Lower Snake River. The hydro workgroup has used the considerable engineering, economic, and biological information developed in this study.

Northwest Power Planning Council's (NWPPC) Multi-Species Framework Project – the Framework Project is developing visions, strategies, and alternatives for recovering fish and wildlife resources in the Columbia River Basin and analyzing the biological and social/human effects of the alternatives. The hydro workgroup and the Framework staff and constituents jointly evaluated alternative measures for system configuration and operations and agreed to the specifications of these measures in the seven Framework alternatives and three Federal scenarios. The joint group also coordinated the analysis of hydrosystem operations, the biological studies and evaluations, and other Federal and Framework tasks related to the hydrosystem.

Columbia River Fish Mitigation Project and System Configuration Team – this COE program for developing, evaluating, and implementing fish passage improvements at the eight COE mainstem dams is called the Columbia River Fish Mitigation Project (CRFM). Most of the information in this report relative to configuration measures was developed through the CRFM. The CRFM coordinates its work with the National Marine Fisheries Service (NMFS) regional forum System Configuration Team, which includes Federal agencies (COE, Bonneville Power Administration (BPA), Reclamation, U.S. Fish and Wildlife Service (USFWS), state agencies (Oregon Department of Fish and Wildlife, IIDFG, Washington Department of Fish and Wildlife), the NWPPC, and the Columbia River Inter-Tribal Fish Commission (CRITFC).

SECTION II. EXISTING CONDITIONS

A. Anadromous Fish

Beginning in the 1930s and continuing into the 1970s, numerous large dams were constructed on the mainstem Columbia and Snake Rivers and in headwater locations in both the United States and Canada. The dams were built for a number of purposes, including power generation, flood control, irrigation, and navigation, among others. As a result, their operations vary, as does their effect on fishery resources.

Dams created an impediment to fish passage by blocking access to the salmonids' historic range and creating passage conditions for both juveniles and adults that are detrimental to their survival during annual migrations. In addition to these passage impediments, headwater projects store water at certain times of the year for release at other times of the year to meet various public purposes. The regulated hydrograph that results from this operation differs from the natural hydrograph, reducing the magnitude of the spring freshet and increasing flow levels during the late fall/winter/early spring period. The operation of the dams also causes daily or hourly fluctuations in flow; affects water quality, causing turbidity and dissolved gas supersaturation; and modifies habitat and associated fauna and flora, including changes in community composition, invasion by exotic species, and increased predation.

Fish passage has been an issue since the mainstem dams were constructed. But since the establishment of the NWPPC's Fish and Wildlife Program under the 1980 Northwest Power Act and the listings under the ESA in the 1990s, there has been an extensive regional effort to increase survival of fish as they pass through the hydrosystem. Improvements have focused on both the operation and configuration of the FCRPS.

Information in the following section concerning current conditions in the hydro corridor is based in part on a series of "white papers" prepared in draft by NMFS in October 1999. (NMFS, 1999). NMFS distributed these papers in the region for review and comment. The papers address: passage of juvenile and adult salmonids, transportation of juveniles, effects of flow, and predation in the FCRPS. Because the white papers are a work in progress and subject to revision, the following section summarizes the current drafts and does not reflect a consensus among the members of the hydro workgroup with regard to the papers' contents.

1. *Current Configuration and Operations*

Reservoirs are characterized by wider cross-sectional areas than free-flowing rivers, which result in lower water velocity for any given flow level when compared to the unimpounded river. This wider cross-section, coupled with the storage of water within a year, reduces water velocities, particularly during periods when most juvenile salmonids outmigrate.

Flow augmentation, or use of water from storage reservoirs to augment natural streamflows, is one of the primary strategies to mitigate the effects of impoundments and the regulated hydrograph on juvenile passage. The general concept of flow augmentation is to increase flows and water velocities when most juvenile migrants are present.

In its biological opinions on operation of the FCRPS, NMFS has established spring flow targets of 220 to 260 kcfs, 135 kcfs, and 85 to 100 kcfs for McNary, Priest Rapids, and Lower Granite, respectively. Summer flow targets are 200 kcfs and 50 to 55 kcfs for McNary and Lower Granite, respectively. Water from key storage reservoirs – Grand Coulee, Dworshak, Hungry Horse, Libby, Snake River reservoirs, and Canadian reservoirs – is used to augment natural flows to meet these targets, to the extent possible. The probability of meeting these targets varies depending on snow pack and the runoff volume forecasts, shape of the runoff, and general weather patterns throughout the spring and summer flow augmentation period.

Prior to dams, spring migrants migrated from upper tributaries to the ocean in 15 to 30 days. With construction of dams, this migration was protracted to 30 to 50 days. Flow augmentation from storage reservoirs is intended to reduce the fishes' travel time to more closely approximate that of pre-dam conditions. The hypothesis is that increased water velocities resulting from higher flow rates will decrease juvenile fish travel time, resulting in reduced freshwater residence and earlier arrival at the estuary.

Research has shown that there is a strong relationship between river flow and fish travel time for spring migrants (e.g., yearling chinook and steelhead). Generally, spring migrants' rate of travel increases with increasing flow and increased smoltification. However, recent NMFS research has not demonstrated a relationship between flow and survival for spring migrants through Snake River reaches. The relationship between flow and fish travel time is somewhat weaker for summer migrants (e.g., fall chinook) than observed for spring migrants. Fall chinook have a more complex migratory behavior than spring migrants, with fish size, feeding, and rearing all affecting their migration. Nevertheless, a strong relationship between flow and survival has been observed for summer migrants from point-of-release in the free-flowing river to Lower Granite Dam. Both temperature and turbidity are also correlated with survival of summer migrants.

Juvenile spring fish survival (estimated from the upper dam on the Snake River to Bonneville Dam) has increased since the 1995 FCRPS Biological Opinion (BO) measures were implemented. However, the benefit conferred by flow cannot be isolated from the effects of other management activities. While no direct flow-survival relationship has been detected within the reaches studied, higher flows might improve conditions in the estuary and survival of migrants in the estuary and plume. In addition, higher flows and reduced exposure to stressors during migration through reservoirs might improve fish condition upon arrival in the estuary.

In summary, research suggests that the spring flow objectives outlined above are reasonable. Flow augmentation does not restore historic flow conditions, but survival rates for juvenile spring/summer chinook passing eight dams approach the levels observed for fish passing four dams. This suggests that flow management coupled with other passage measures has had a positive effect on juvenile survival. In the case of summer migrants, flow augmentation has benefited juvenile survival, and additional flows beyond those currently provided may provide further benefit. However, summer flow augmentation also poses some risks associated with higher water temperatures, depending on the sources of water used. It should also be noted that flow augmentation to improve temperature conditions for juvenile migrants also benefit adult migrants (i.e., steelhead and fall chinook) during the late summer and fall.

Predation on juvenile salmonids by both native and exotic resident fishes and birds has also been exacerbated by development of the hydrosystem. Reservoirs provide habitat for resident predators, particularly northern pikeminnow, walleye, and smallmouth bass, which have enabled their populations to thrive. Juvenile salmonid are also more vulnerable to predation by both resident fishes and birds, such as gulls, terns, and cormorants, because of the increased concentration and density in which they are released from hatcheries, travel past dams, and congregate when they are disoriented after passing dams.

Protracted outmigrations result in juvenile migrants passing dams and through reservoirs during periods when water temperatures are warmer and consumption rates of predatory fishes are higher. Predation losses also increase later in the season, particularly during the summer.

Research conducted in the 1980s in the John Day reservoir suggested that 14 percent of all juvenile salmonid migrants that passed McNary Dam were lost annually to predation by northern pikeminnow. Monthly losses ranged between 7 percent in June to 61 percent in August. Subsequent assessments suggested that relative losses increased in reaches downstream of John Day Dam and decreased in reaches upstream of McNary Dam. It was estimated that systemwide millions of juvenile outmigrants were lost to northern pikeminnow each year. Other researchers concluded that unlike the Lower Columbia River, where northern pikeminnow are the dominant predator, smallmouth bass are the dominant predator in the Snake River.

The Northern Pikeminnow Management Program was designed to substantially reduce predation losses of juvenile outmigrants. Northern pikeminnow harvest fisheries have been employed since 1990 as a tool to reduce these losses. To date, over 1.3 million northern pikeminnow have been removed from the system, resulting in an estimated 25 percent reduction in systemwide predation mortality compared to pre-program levels. Smallmouth bass and a number of other introduced predators are protected by the state fisheries agencies for resident fisheries.

2. *Existing Passage Conditions*

Dams are an obstacle to passage of both juvenile and adult salmonid migrants. Grand Coulee, Hells Canyon, and Dworshak Dams were constructed without fish passage facilities, which eliminated salmonid access to spawning grounds upstream. Even at those dams that were constructed with fish ladders to enable continued access to areas upstream, there may be delays in passage, expenditure of energy reserves, or cumulative stresses that can reduce survival or spawning success. Recent research (Bjornn, 1997-1999) indicates, however, that adult fish facilities at the COE dams on the Columbia and Snake Rivers readily pass salmon and steelhead, and that their migration through the dams and reservoirs is faster than in the free-flowing reaches above the dams. Mainstem dams were either constructed without specific provisions for downstream juvenile passage, or those facilities that were included at time of construction were ineffective.

General concepts for adult fish passage at low-head dams were fairly well established at the time that large dams were constructed on the Columbia River. As a result, adult passage facilities, such as fishway entrances, collection/transportation channels, and ladders, were incorporated into the original construction of some mainstem dams. Established bioengineering requirements for these facilities also led to relatively effective passage performance. That is not to say there were no problems, but in contrast to what has become apparent about juvenile passage, adults seemed to have been fairly well accommodated.

The primary focus up until the 1960s was on further development and refinement of design and operating criteria for adult passage facilities. In general, the migration rate of adult migrants through dams and reservoirs appears to be similar to that of pre-impoundment. Any delay in passage that may occur at dams, ranging on average between one and two days, is offset by the faster migration rate through reservoirs as compared to free-flowing rivers. The most notable factors affecting adult passage through the FCRPS include spill, fallback, warm water temperatures, and any fish traps that may be operated within the adult facilities.

Issues surrounding passage of juvenile migrants were not understood in the earliest years of dam construction. Even as knowledge was gained on turbine-related mortality, the numbers of turbines within a dam and the number of dams within the system were limited, and the cumulative effects of turbine passage were also limited. Most fish were expected to pass over spillways and survive at relatively high rates. As additional dams were constructed, however, dissolved gas supersaturation throughout the river system increased to levels that were lethal to both juvenile and adult migrants.

At about the time agencies and scientists began to recognize and address the dissolved gas supersaturation problem, more storage projects were completed and additional turbines were installed. This resulted in decreased spill, as well as dissolved gas supersaturation, but it meant a greater proportion of juvenile migrants were passing through turbines. Attention was then focused on the need for measures to reduce turbine-related mortality. The devastating effects of the extreme drought conditions of 1973 and 1977 acted to direct even more attention to the needs of juvenile migrants.

3. *Strategies and Actions for Improving Passage*

Historically, it has been assumed that turbine mortality is on the order of 10 to 15 percent. If no other provisions for juvenile fish passage are provided (e.g., sluiceways, spill, or bypass), then total project passage mortality equals turbine mortality (i.e., all fish are passing through turbines and subject to turbine-related mortality). If this level of mortality were incurred across multiple dams, then the total system mortality would escalate rapidly as a result of cumulative effects.

In contrast, spillway (and sluiceway) mortality is generally on the order of only 2 percent. During conditions of spill (or sluiceway operation), the total number of fish passing through non-turbine routes increases, and this results in increased project passage survival. Until the 1970s, turbines and spillways (sluiceways at some dams) were the only available passage routes for juveniles. Since spill and sluiceway operations were limited, most fish passed through turbines.

Currently, most juvenile migrants pass dams through non-turbine routes (termed fish passage efficiency or FPE). Resulting FPE at each project is the combined effect of operations (e.g., spill) and project configurations (e.g., screens, surface bypass) that reduce the proportion of fish that pass through turbines.

(a) Screens

Turbine intake screens are devices designed to intercept fish that enter turbine intakes. The screens guide the fish to a channel that conveys them to the downstream side of the dam and back into the river or into trucks or barges for transportation to below the dam. Screened bypasses have been under development and in use at mainstem dams since the 1970s. Two kinds of screens are currently employed: submersible traveling screens (STS) are installed at Bonneville, John Day, Ice Harbor, and Lower Monumental Dams; and extended-length submersible bar screens (ESBS) are installed at McNary, Little Goose, and Lower Granite Dams. The Dalles Dam is the only Federal mainstem dam without mechanical screens.

The performance of mechanical bypasses is measured as fish guidance efficiency (FGE), which gauges the percentage of fish entering turbine intakes that are guided by the screens. The performance of screens varies by type, dam, season, and fish species. In general, screens are relatively effective during the spring season for chinook and steelhead, with FGEs typically in the 60 to 70 percent range for STSs and 80 to 90 percent range for ESBSs. Screens are somewhat less effective for sockeye and in the summer period, for fall chinook; FGEs are typically in the 30 to 50 percent range for STSs and in the 60 percent range for ESBSs.

(b) Transportation

Juvenile fish transportation was developed as a means to convey fish past multiple dams and reservoirs to reduce the cumulative effects of dam-related and reservoir-related mortality. Juvenile migrants that are guided by turbine intake screens can be collected and loaded onto trucks or barges and transported for release below Bonneville Dam. There they continue their migration to the ocean. Transport to inriver adult return ratios (T/Is) are used to express the effectiveness of juvenile fish transportation. Evaluations of transportation conducted over the past 25 years have shown that in nearly all studies, T/Is are higher for transported fish than those that migrated in-river. Generally, T/Is for spring migrants (i.e., spring/summer chinook and steelhead) have ranged from approximately 1.5 to greater than five, for transportation from both Snake River projects. Data on summer migrants (i.e., fall chinook) is more limited, but T/Is observed for fish transported from McNary Dam were generally near 3.0. Nevertheless, overall smolt to adult returns (SARs) are still generally lower than they were prior to completion of the Lower Snake River Dams and John Day Dam on the Lower Columbia River. This has led some to conclude that juvenile fish transportation is ineffective.

Researchers have evaluated various factors relative to transportation, including smolt performance, stress, mortality, disease transmission, and behavior. Results of these studies have been incorporated into the management of the transportation program. Overall, direct survival of transported migrants is high, estimated at greater than 98 percent. Behavior and survival of transported fish following release below Bonneville Dam is similar to that of in-river migrants. Some people believe that indirect mortality of transported fish is high (i.e., many of the fish that survived during transportation die later; delayed transportation mortality), but this is a subject of ongoing research. Some have also suggested that fish that migrate in-river and are undetected at dams return at higher rates than those that were transported. While some differences in SARs exist between transported and undetected in-river migrants, no significant differences have been observed.

(c) Spill

Based on the differential in passage mortality through turbines (typically assumed to be 10 to 15 percent) compared to spill (typically assumed to be 2 percent), voluntary spill has been used as an interim passage strategy since the late 1970s, pending development of more effective alternatives. In general, moderate levels of spill provide for increased FPE at relatively low risk. However, as FPE increases, the incremental effect of increasing spill diminishes. At higher spill levels, the risk of undesired effects also increases, including risks to both juvenile and adults migrants (as well as resident species) from gas supersaturation and adverse hydraulic conditions. Spill at transport projects also increases the number of in-river migrants, thereby decreasing system survival benefits of juvenile fish transportation.

Currently, voluntary spill for fish passage is provided at each of the eight Federal mainstem dams in the spring, up to interim dissolved-gas limits established by the States of Oregon and Washington – 120 percent in the tailraces and 115 percent in the forebays. Fish spill is provided at Bonneville, The Dalles, and Ice Harbor Dams for 24 hours/day, and for 12 hours/day at John Day, McNary, Lower Monumental, Little Goose, and Lower Granite Dams. Transportation of juvenile fall chinook is maximized during the summer migration to increase system survival. Therefore, spill is not provided at transport projects during the summer, i.e., McNary, Lower Monumental, Little Goose, and Lower Granite.

Spill has the undesired effect of increasing levels of dissolved gas in the water, which in turn increases the risk of gas bubble disease (a condition similar to the bends in humans) to aquatic organisms. Both structural and operational measures have been employed to reduce dissolved gas supersaturation levels during periods of spill. For example, flow deflectors (flip lips) have been installed on spillways to reduce the depth of the plunge of spilled water, which is the primary cause of supersaturation. Involuntary spill is distributed at projects throughout the region to minimize any adverse effects of elevated dissolved gas supersaturation levels at particular sites. Other measures are also employed to manage dissolved gas and additional measures are under development for potential future consideration.

(d) Surface Bypass

The concept of surface bypass gained momentum with the development of the spillway bypass at Douglas County Public Utility District’s Wells Dam in the 1980s. The unique configuration of Wells Dam lends itself to high FPEs with relatively small volumes of water. The effectiveness of ice and trash sluiceways at Bonneville, The Dalles, and Ice Harbor Dams also exemplifies the potential opportunities for surface bypass at more conventionally configured dams in the FCRPS.

The surface bypass concept includes key attributes that are expected to provide a more fish friendly passage environment when compared to alternative passage routes. This includes an entrance location to intercept juvenile migrants in the water column where they normally migrate. In this way, the fish are allowed to pass the dam without an unnatural change in depth, which reduces stress. Surface bypasses also tend to be relatively effective with lower discharge rates. This reduces potential risk of physical injury or gas bubble disease associated with higher discharge rates of other passage alternatives.

Prototype surface bypass facilities are currently being tested at Lower Granite and Bonneville Dams. Other surface bypass related research has been conducted or is ongoing at Ice Harbor, John Day, and The Dalles Dams.

4. *Major Questions and Uncertainties*

The lifecycle of salmonids is extraordinarily complex. It covers a number of years, and encompasses both fresh and salt water. In addition, salmonids have a geographic range of thousands of miles. There are a variety of biotic and abiotic factors affecting salmonid survival, many of which interact with one another. This makes it difficult to develop a clear understanding of how individual factors, or combinations of factors, affect fish survival. While it is necessary to address key uncertainties within a particular life stage, the interpretation of information on those uncertainties in the context of the full life history is critical for salmon recovery efforts to be successful.

Many factors contribute to the survival of juvenile salmonids, including natural hydraulic and environmental conditions, as well as operational and configuration improvements at dams and within the hydrosystem. Over the past couple of decades, and particularly since the early 1990s, survival of juvenile migrants has increased substantially. Flow and spill management, bypass screens, predator control, and other mitigation measures have likely contributed to these survival improvements. In recent years, basinwide precipitation and snow-pack levels have also provided more favorable conditions than those observed during the extended drought of the late 1980s and early 1990s. In-river survival from above Lower Granite to below Bonneville Dam is currently estimated to be approximately 40 to 50 percent for spring migrants. This is higher than ever observed, and similar to that before dams were built on the Snake River. Survival of fall chinook is somewhat lower (compared to spring migrants) as a result of lower flows, warmer water temperatures, and increased predation, among other factors.

While survival of juvenile migrants has increased in recent years, SARs have remained low. This does not suggest that improvements in hydrosystem survival are unimportant or that recent improvements have not contributed to adult production. But it does suggest that other factors, such as habitat, hatcheries, harvest, and estuarine/ocean conditions, may be limiting factors that are continuing to depress potential adult production and escapement. It could also be a result of latent mortality: indirect mortality of juvenile migrants that is a result of passing through the hydrosystem but is not manifested until after passage into the estuary or ocean.

Two forms of delayed mortality are described below. Questions of delayed mortality are critical for two reasons. First, if delayed mortality exists, then more traditional evaluations of passage or passage survival may be insufficient for determining the contributions of actions intended to increase survival and probability of rebuilding and recovery of salmon and steelhead. Second, delayed mortality is, by definition, a result of the effects of various factors that are not manifested until later in the fish's life. As such, evaluations of delayed mortality require relatively comprehensive reconstruction of the fish's life history, including the period prior to its arrival in the hydrosystem. In other words, these evaluations must be integrated across life-history stages.

(a) Differential Delayed Transportation Mortality

Today, a large portion of the juvenile salmon and steelhead coming out of the Snake River Basin are transported in trucks and barges to below Bonneville Dam. This is a way to circumvent direct mortality during passage at the hydro projects. Before these fish return to spawn, they may suffer additional mortality that exceeds what would have occurred if they were not barged. This mortality is termed *differential delayed transportation mortality* (measured by the "D-value"). This is one of the most important parameters with regard to deciding upon the role of juvenile fish transportation in salmon recovery and assessing the potential benefit of dam breaching. This delayed mortality may also be a result of transportation of juvenile fish that were diseased or in poor condition; therefore, the D-value and partitioning any factors contributing to it are important. Ongoing analysis and future research are likely to resolve the uncertainty in 5 to 10 years.

(b) Extra Mortality

Another major uncertainty involves what has been termed "*extra mortality*." Historically, a much larger percentage of the fish that left the Snake River as juveniles returned to spawn compared with today. Even after accounting for direct losses attributed to passage through the hydrosystem, additional losses must occur to account for the low observed SARs. This unexplained mortality that occurs outside the migration corridor is termed extra mortality. Extra mortality may manifest itself at either the juvenile or adult stage.

The cause of this extra mortality is unknown, although many hypotheses have been proposed. These include: the hydrosystem itself may weaken fish and disrupt their natural rhythms; hatcheries may interfere with the fitness and survival of wild fish; habitat degradation may reduce stock vigor; genetic effects may reduce stock viability; and degraded ocean conditions may differentially take a toll on salmonids that spawn above the Snake River Dams. The impact of dam breaching compared to keeping the dams intact depends on which of these alternative sources of extra mortality one assumes to reflect the truth. New PIT-tag technology, the emergence of large-scale geographic data bases, and experiments with hatcheries provide opportunities for science to address uncertainty about extra mortality over a period of 10 to 20 years.

(c) Estuarine/Ocean Survival

Changes in marine survival of salmonids can have huge impacts on the overall productivity of populations. Recent and dramatic declines in ocean survival have been observed for populations extending up the west coast from Oregon north to British Columbia and Alaska. Partitioning of survival by life stage is necessary to adequately account for the effectiveness of actions in terms of returning adults. This, in turn, contributes to the opportunities for more effective management strategies in the freshwater environment. An improved understanding of marine survival is also key to evaluating delayed transportation mortality and extra mortality.

(d) Mainstem Habitat

Historically, the hydrosystem has been viewed as a migration corridor, with primary focus on flows, river velocities, and predation. There are, however, other important biological and ecological attributes that might be enhanced through operational and/or structural measures that would contribute to the survival of both resident and anadromous species.

(e) Other Issues

While the following issues may be important in terms of extra mortality, they are significant in their own right as well.

The effect of *multiple detection/bypass* on survival and adult productivity is unclear. Juveniles can pass through multiple bypasses on their migration route. Information on adult return rates suggests an inverse relationship between the rate of returns and the number of bypasses a juvenile encounters. Information is limited, however, and further investigation and analysis is necessary to reduce this uncertainty. Future decisions on the role of mechanical bypass depend on a better understanding of this issue.

There is a potential for *differential effects from various passage strategies,* such as transportation, screened bypasses, and spill, which could affect survival. The effects could also be different, depending on the life-history stage, stock, or species of the fish. The question for researchers is the extent to which FCRPS mitigation strategies may exert selective pressures. Improved understanding in this area is needed to guide actions that may affect genetic diversity and to develop adequate multispecies protection strategies.

Estimates of *unaccounted losses of adult migrants* contribute to projections of conversion rates and the numbers of adults expected to arrive at spawning grounds. Partitioning of unaccounted losses of adults throughout the migration corridor is necessary to determine any corrective measures that may be appropriate relative to hydrosystem operations or configurations. Consideration of factors such as fallback, cumulative delays and/or stress, water quality, tributary turnoff, mainstem spawning, harvest, and other factors are important considerations to answer questions associated with adult passage.

The *incremental effect of dam passage improvements* on juvenile fish survival is also unclear. Juvenile fish passage survival has been increased dramatically over the past two decades. Additional opportunities to further enhance passage survival still exist through both operational and structural changes, but the increment of any improvement is small compared to the past. Optimization of passage strategies is necessary to make best use of available resources and to balance the potential conflicts measures can present to different species or at various life history stages.

Development of effective *surface bypass* at FCRPS projects depends on improved understanding of juvenile migrant behavior in relation to the hydraulic environment and in-river structures. Continued development of surface bypass could provide the opportunity to enhance passage survival for all migratory species at relatively low biological risk.

B. Resident Fish

1. Current Configuration and Operations for Listed and Special Status Resident Fish

Fisheries operations in the FCRPS are focused on the 1995 BO for Snake River salmon and the 1998 Supplemental BO for Snake River, Upper Columbia River, and Lower Columbia River steelhead. Special flow operations for Kootenai River white sturgeon spawning and egg incubation are typically in effect at the Libby project from April 1 through early July. In 1999, temporary flow-ramping rates and stable flows were established for the Libby Project to protect bull trout.

2. *Existing Passage and Habitat Conditions for Listed and Special Status Resident Fish*

(a) Kootenai River White Sturgeon

The Kootenai River white sturgeon is a genetically distinct population that lives in Kootenay Lake in British Columbia and the Kootenai River in Idaho. It has been isolated from other populations of white sturgeon in the Columbia River system since the last ice age (10,000 years). Human activities have changed the natural hydrograph of the Kootenai River, which has altered white sturgeon spawning, egg incubation, nursery and rearing habitats, and reduced overall biological productivity. These factors have contributed to a general lack of recruitment of fish to the white sturgeon population since the mid-1960s. In 1994, the USFWS listed Kootenai River white sturgeon as endangered because few juveniles have survived to enter the population. The population now consists mainly of older fish with few younger than 20 years old. Males of most sturgeon species reproduce between ages 10 to 20 years while females reproduce between ages 15 and 25 years. Estimates of the Kootenai River white sturgeon population range from about 785 (BPA, 1993) to 1,468 (COE *et al.*, 1999) fish.

The USFWS (USFWS, in preparation) has identified Libby Reservoir refill operations, especially in spring and summer, as the major factor affecting the survival of Kootenai River white sturgeon. These changes are believed to have affected reproductive success of sturgeon by reducing the volume of river flow and altering water temperatures during the spawning period. They are also thought to have affected the distance upstream that sturgeon migrate to spawn.

Since the construction of Libby Dam, average spring peak flows in the Kootenai River have been reduced by more than 50 percent, and winter flows have increased by 300 percent compared to pre-dam conditions (USFWS, in preparation). The sturgeon spawning run originally coincided with the spring freshet, when flows and water temperatures increased. Before construction of Libby Dam, spring flows in early June often were greater than 60,000 cfs. It is believed that before Libby Dam was built, sturgeon migrated farther upstream to spawn over a cobble substrate. Sturgeon presently spawn in downstream reaches where finer sediments have built up on the river bottom.

Average water temperatures in the Kootenai River are typically warmer in the winter and colder in the summer than they were before Libby Dam was built; however, when large volumes of water are released from Libby Dam in the spring, water temperatures may be colder. This may affect the spawning behavior of sturgeon. Periodic high flows that flushed out fine sediments from the cobbles and gravels in the Kootenai River have not occurred since flood control operations have been in effect. This has allowed fine sediments to build up in the Kootenai River's cobbled areas, which has affected sturgeon egg survival, juvenile fish security cover, and aquatic insect production.

Other factors are thought to affect the reproductive success of sturgeon. These factors include: (1) power peaking which disrupts spawning behavior and dewaters shallow water habitat used by fry; (2) loss of side-channel rearing habitat due to diking and riverbank protection projects; (3) changes in Kootenay Lake elevations which induce sturgeon to spawn in undesirable locations; (4) lowered river flows after sturgeon hatch which may allow for greater predation; and (5) nutrients that are trapped in Lake Koocanusa which have lowered the productivity of the Kootenai River and Kootenay Lake; and poor water quality.

b) Bull Trout

Bull trout are estimated to have once occupied 60 percent of the Columbia River Basin and now are estimated to occur in about 45 percent of their former range (Quigley and Arbelbide, 1997 *in*: COE *et al.*, 1999). Presently, bull trout occur in much of the FCRPS operating area.

Fluvial and adfluvial forms of migratory bull trout occur in the FCRPS area. Although both forms spawn and rear in tributary streams, fluvial fish migrate to larger rivers to overwinter and feed in spring and summer while adfluvial bull trout reside in lakes. The largest populations of bull trout in the FCRPS system occur at the Hungry Horse and Libby projects. Smaller populations are also present in Lake Pend Oreille (Abeni Falls project), in the Lower Snake River, Lake Roosevelt, in Dworshak Reservoir, and the Bonneville pool.

Water management practices have impacted bull trout. The major impacts associated with the FCRPS include the following: (1) passage barriers; (2) inundation of spawning and rearing habitat; (3) modification of the streamflow and water temperature regime; (4) dewatering of the shallow water zone; (5) reduced productivity in reservoirs; and (6) gas supersaturation.

At least 39 dams have been built within the range of bull trout in the Columbia Basin (COE *et al.*, 1999). Dams in the FCRPS that were built in areas inhabited by bull trout include Hungry Horse, Libby, Albeni Falls, Grand Coulee, Dworshak, Bonneville, and the Lower Snake River projects. Hungry Horse, Libby, Albeni Falls, Dworshak, and Grand Coulee Dams were built without fish passage facilities and are barriers to bull trout migration. The Lower Snake and Lower Columbia River projects have fish passage facilities, but these fishways were designed for anadromous fish. It is not known if these facilities are adequate for bull trout. The total barriers have isolated subpopulations of migratory bull trout from the larger meta-populations. Dams with fish passage facilities not readily passable by bull trout may also have isolated populations. Migratory bull trout formerly linked resident bull trout to the overall gene pool for this species. Migration barriers have isolated these populations potentially causing a loss of genetic diversity.

Reservoirs have inundated spawning and rearing habitat. For example, reservoirs created by Libby and Hungry Horse Dams have inundated miles of mainstem and tributary habitat used by many subpopulations of bull trout (COE *et al.,* 1999). In some cases, reservoirs such as Libby, Hungry Horse, and Dworshak provide habitat that is used by adfluvial populations of bull trout. The extent to which other reservoirs are used by bull trout is unknown. A migratory subgroup in the Tucannon River apparently utilizes the mainstem Snake River for adult rearing on a seasonal basis. Their occurrence has been verified by incidental observations during sampling in Lower Monumental Pool and in the adult fish passage facilities at Lower Monumental and Little Goose Dams in the early 1990s. Bull trout have been observed at Powerdale Dam near the mouth of the Hood River and are thought to migrate to the Bonneville pool. Bull trout are also present in Lake Pend Oreille. These fish migrate into tributaries of Lake Pend Oreille to spawn.

Flow releases from storage projects such as Libby Dam alter the natural flow regime, affect water temperature, and cause repeated and prolonged changes to the wetted perimeter of the Kootenai River. Reservoirs are also drawn down substantially during drought years. This reduced volume of water in the reservoirs affects their overall productivity, which may ultimately reduce the food base of predators such as bull trout.

Power peaking operations that cause severe daily flow fluctuations in the Kootenai and Flathead and South Fork Flathead Rivers negatively impact bull trout by affecting their food supplies. Rapid river stage fluctuations can cause stranding of small bull trout that normally orient to shallow near-shore areas. Predation, especially by lake trout in the Flathead River, may also be a problem for juvenile bull trout survival. Power peaking operations may also increase the susceptibility of young bull trout to predation as they move from secure cover in response to rapid changes in river flow and stage.

Entrainment of bull trout through turbines may also occur at various projects including Libby, Hungry Horse, Albeni Falls, Dworshak, Bonneville, and the Lower Snake River Dams. Fish can be killed or injured, and those that survive passage may be isolated in downstream reaches.

There is evidence of bull trout entrainment through Dworshak Dam into the tailrace. Bull trout are observed in the North Fork Clearwater River every year below the dam, are incidentally caught by anglers, and occasionally find their way into the adult trap at Dworshak National Fish Hatchery. At the Lower Columbia and Lower Snake River projects, bull trout may pass dams downstream via the juvenile fish bypass systems. Bull trout may also pass these projects during periods of spill. Controlled spill for juvenile salmon passage or uncontrolled spill at Lower Snake River Dams is likely to increase the entrainment rate of individual bull trout that migrate into the reservoirs to feed seasonally. Once entrained bull trout can become stranded or isolated in the downstream reservoirs or significantly delayed in their return migrations.

The mainstem Columbia and Snake River Dams are equipped with fishways for adult anadromous salmonids. However, there are no data available to suggest that the Lower Snake adult fishways are suitable and efficient for passing bull trout. Other projects such as Libby, Hungry Horse, Albeni Falls, and Dworshak completely block migration of any upstream migrating bull trout that may have moved downstream past those projects.

High levels of gas supersaturation in the water can cause gas bubble trauma in fish. Uncontrolled spill at FCRPS projects, which can produce extremely high levels of total dissolved gas, may impact bull trout and other species.

(c) Burbot

Burbot occur in the Kootenai River system upstream and downstream from Libby Dam. Burbot are also present in the Upper Columbia River system and have been reported in Lake Roosevelt, Lake Rufus Woods, and Banks Lake. The Kootenay Lake burbot population downstream from Libby Dam is of particular concern because of its poor spawning success in recent years. Kootenay Lake burbot migrate upstream into the Kootenai River to spawn in the main river or its tributaries. Burbot spawning has not been documented in the Kootenai River downstream from Libby Dam since that project began operating. High winter flows and rapid flow fluctuations in the Kootenai River from Libby Dam operations are thought to have affected spawning migrations and the spawning synchrony of burbot. Burbot spawning migrations and spawning in rivers that are not affected by impoundments usually occur during stable low flow periods in the winter.

Flow fluctuations in the Kootenai River may be adversely affecting burbot. Burbot stage in Kootenay Lake prior to spawning and enter the river in late December and January on their spawning runs. Burbot are weak swimmers and reportedly cannot sustain themselves to migrate upstream in the Kootenai River at flows greater than 9,000 cfs. Studies conducted in 1997 and 1998 indicate that increased flow in January affected the burbot spawning migration. About 50 percent of the burbot being monitored by radiotelemetry during those studies quit their upstream migration and moved back to slack water (V. Paragamian, personal communication). Daily flow fluctuations between 4,000 and 27,000 cfs caused by electrical load following operations now occur during the burbot migration and spawning period.

(d) Westslope Cutthroat

Westslope cutthroat inhabit the Upper Kootenai, Clark Fork, Spokane, Coeur d'Alene, Clearwater, and Salmon River drainages. Historically, migratory westslope cutthroat were present in the Pend Oreille and Kootenai River systems. In general, westslope cutthroat populations have declined throughout much of their range. Habitat degradation, competition with non-native trout, and overharvest have contributed to this decline. Significant changes in the Kootenai, and Pend Oreille/Clark Fork River systems have affected their populations of westslope cutthroat. Construction of Cabinet Gorge and Albeni Falls Dams eliminated 90 percent of the available spawning and rearing habitat of westslope cutthroat trout using the Clark Fork River system. Albeni Falls Dam and other dams have formed barriers that have isolated westslope cutthroat trout in the Pend Oreille River system. Entrainment of westslope cutthroat may also occur at these dams.

The annual flow regime of the Kootenai River has changed dramatically due to the operation of Libby Dam and consequently increased water temperatures (Paragamian, 1995). The river is now subject to highly variable peaking flows for power generation, resulting in daily fluctuations in water depth of one to several feet. Libby Reservoir also acts as a nutrient sink, retaining about 50 percent of the total phosphorus that enters it (Daley *et al.,* 1981 *in*: Knudson, 1994). This limits the productivity of the Lower Kootenai River and Kootenay Lake, and lowers their carrying capacities for resident fish.

(e) Redband Trout

Migratory interior redband trout are believed to spawn and rear in tributaries of the Kootenai river and then migrate down the river to Kootenay Lake (S. Deeds, personal communication). Little information is available concerning redband trout in other areas of the FCRPS. Rainbow trout of both coastal and interior origin occur in the Pend Oreille River system, but are believed to be of hatchery origin. Redband trout are believed to be present in Lake Roosevelt (K. Underwood, personal communication). Redband trout have not been recorded from the Lower Snake River.

(f) Lower Snake River and Lower Columbia River White Sturgeon

White sturgeon are present throughout the Lower Snake and Columbia Rivers. The estimated populations of sturgeon within each reservoir are: Little Goose-6,492; Lower Monumental-4,262 (DeVore, *et al.,* 1999); Ice Harbor-4,832 (DeVore *et al.*, 1998); McNary-6,500; John Day-30,600; The Dalles-73,500; and Bonneville-52,000 (North *et al.,* 1999).

Sturgeon spawning occurs from May through early July at water temperatures of 13 to 15º C. Spawning has been documented in the tailraces of all eight

Lower Snake and Lower Columbia River Dams. The most successful spawning occurs in the tailraces of Bonneville, Ice Harbor and Lower Granite Dams. Sturgeon require high flows for spawning so flow augmentation in the spring for listed anadromous salmonids appears to also benefit sturgeon.

Sturgeon have been isolated into separate groups residing within the pools of individual dams. Minor passage of sturgeon occurs at all projects. Passage is primarily downstream. Some upstream passage of sturgeon has been observed at The Dalles Dam Washington-shore fish ladder.

3. *Strategies and Actions for Improving Passage and Habitat*

(a) Kootenai River White Sturgeon

Present operations. The draft Kootenai River white sturgeon recovery plan (Recovery Plan)(USFWS, in preparation) has made restoration of natural recruitment of sturgeon to the population a highest priority effort to prevent extinction. The current strategy related to operation of the FCRPS involves flow augmentation from Libby Dam for sturgeon spawning and incubation. The present sturgeon operation is a mixture of that described in the 1995 Sturgeon BO (USFWS, 1995), which specifies flow targets of 35,000 cfs at Bonners Ferry for 42 days followed by 21 days of incubation flows of 11,000 cfs, and a tiered flow approach contained in the draft Recovery Plan. The tiered approach would vary the volume of flow required each year, depending on the volume of inflow to the reservoir expected between April 1 and September 30. There would be no flow augmentation during low water years.

Since 1991, the COE, in cooperation with the BPA, USFWS, and state and tribal entities, has provided higher experimental flows in the spring to improve sturgeon spawning. Some spawning has been documented by collection of eggs. No larval sturgeon have been collected by sampling during 1991 through 1995. However, six unmarked juvenile sturgeon aged to the 1991 year-class were found in later sampling (USFWS, in preparation).

Flow augmentation from Libby Dam is targeted for release when low elevation runoff from Kootenai River tributaries occurs and when water temperatures in the main river are between 10 and 14ºC. At Libby Dam, operators can selectively withdraw water from various depths of the reservoir to provide water in the 10 to 14ºC. range. Water is provided to meet this temperature range at Bonners Ferry when possible.

Fluctuations in streamflow may also disrupt sturgeon spawning. In recent years, operating guidelines developed by the USFWS have specified that discharges from Libby Dam not be fluctuated for electrical load following purposes. Generally, this request has been implemented.

Additional Actions. These include improved capability to increase flow augmentation from Libby Dam. Presently, necessary flows for sturgeon migration are limited by the volume of water that can be released without spilling water at Libby Dam. Turbine capacity limits the volume of flow augmentation water that can be discharged from Libby Dam to about 27,000 cfs. Additional flow augmentation could be provided by spilling water at Libby Dam; however, spill is limited by Montana's total dissolved gas water-quality standard of 110 percent saturation.

Two approaches have been proposed to provide additional flow without increasing total dissolved gas levels. These include installing additional turbine generation capacity and constructing flow deflectors (fliplips). Presently, there are three unused turbine bays at Libby Dam that, if operable, could provide a greater volume of water without spilling. The parts for the turbines are stored at the dam and may be available, although it is not known if all parts for these units are available or if they are in working condition. The COE and BPA have investigated the installation of additional turbines and have not found it to be cost-effective. Installation of flow deflectors has not been investigated in detail. Either of these measures would provide greater flexibility to increase flows for sturgeon and to refill the reservoir.

Specific flow requirements for natural white sturgeon spawning and successful recruitment in the Kootenai River remain largely unknown. Until flows that contribute to successful recruitment are established, annual Kootenai River flow augmentation for white sturgeon should be based on water availability in the Upper Kootenai River Basin. The draft Recovery Plan proposes implementing new Libby Dam operational guidelines, such as using tiered flows (Kootenai Integrated Rule Curves) to set aside water volumes for spring sturgeon flows and VARQ (an enhanced flood control protocol) to ensure that more water is available for white sturgeon, salmon, and all species in lower water years. The Montana Department of Fish, Wildlife and Parks has shown that storing water behind Libby Dam in winter not only increases water availability for sturgeon flow augmentation, but also reduces impacts to the Koocanusa Reservoir fishery. This operation may also benefit westslope cutthroat trout, rainbow trout, and burbot in the Kootenai River since water releases under this operating strategy would correspond to their life cycle requirements.

Under these operational guidelines, flow targets will vary annually by water temperature, water volume, duration, and shape. The effects of flow and water temperature on various life stages of white sturgeon will also be monitored. The intent of this operation would be to store more water in Lake Koocanusa before the spring runoff to increase its refill probability. This operational strategy was designed to balance resident fish concerns with power production, flood control, and Koocanusa Reservoir refill under varying water availability ranging from drought to flood conditions.

(b) Bull Trout

Presently, there are few special structural measures in place to protect bull trout. A selective water withdrawal system at Libby Dam provides temperature control to protect cold-water fish such as bull trout in the Kootenai River. No FCRPS project has fish passage facilities specifically designed for bull trout. As a result, it is unknown if the existing fishways at the Lower Snake or Columbia River Dams are suitable for bull trout. There are no fish passage facilities at Albeni Falls Dam at the outlet of Lake Pend Oreille.

Temporary operational measures have been requested at Libby Dam to protect bull trout in the Kootenai River. The USFWS has specified special rates for reducing flow in the Kootenai River downstream from Libby Dam following flow augmentation for sturgeon spawning and incubation. In 1999, the USFWS requested through the regional Technical Management Team that river flow be ramped down at a rate of 10 percent per day when flows are less than 14,000 (cfs). The FWS requested this to minimize stranding and desiccation of aquatic life along the river edges. The USFWS also requested that steady flows of 8,000 cfs be maintained between the end of the sturgeon flows and the start of augmentation flows for salmon. A modified ramping rate and steady flows of 8,000 cfs were implemented by the COE in the Summer of 1999.

The present strategy for improving bull trout habitat conditions include maintaining steady summer streamflows and reducing short-term flow fluctuations downstream from both Libby and Hungry Horse Dams. Future conservation measures at both Libby and Hungry Horse will likely center on the load following or peaking operations on a year-round basis. Both facilities operate without substantive restrictions during the winter period. This results in rapid and dramatic changes in both river flow and stage downstream of the dams. Bull trout may utilize the five miles of the South Fork Flathead River and are present in the mainstem Flathead River and in portions of the Kootenai River. All these stream reaches are to some extent subject to extreme flow fluctuations: 4,000 cfs to 27,000 cfs in 3 hours in the Kootenai River, 145 cfs to 11,700 cfs instantaneously in the South Fork Flathead River. Flow fluctuations from the South Fork also affect the mainstem Flathead River.

Conservation needs will focus on a minimum flow for flows controlled by the dams, and ramping rates (both up and down) at both dams. Additionally, reservoir operations that may affect river flow fluctuations will need to be addressed. For example, power or anadromous fish flow augmentation operations should be conducted so as not to cause rapid flow rate changes. Seasonal rates of change in flow requests will also have to be addressed. The difference between the double peaks in flows for sturgeon and anadromous salmonids and lower flows for bull trout should be minimized.

Reservoir operations that affect the probability of refill for all needs, and rates and extent of drawdown will need to be addressed. This may involve assessing and/or adopting IRC and VARQ operations for bull trout conservation in the reservoirs and downstream river reaches. It may also include provisions for reducing winter flow fluctuations.

(c) Burbot

Presently, there are no specific measures designed to improve conditions for burbot migrations or spawning. A possible strategy for burbot recovery in the Kootenai River would involve restoring habitat conditions for all life stages during their period of river residence. Measures to ensure suitable habitat conditions include providing suitable streamflows for upstream migration by spawners, maintaining natural flow conditions for out-migrating juveniles, and providing adequate food (through fertilization) for juvenile rearing in the Kootenai River and Kootenay Lake. It may be possible to simulate pre-dam flows for upstream migrants by maintaining flows of about 6,000 cfs from Libby Dam during January and the first two weeks of February.

(d) Westslope Cutthroat

Presently, there are no specific strategies to improve conditions for westslope cutthroat.

(e) Lower Snake/Columbia River White Sturgeon

Presently, there are no specific operations or structural measures in place to improve conditions for white sturgeon in the Lower Snake or Columbia Rivers.

4. *Major Questions and Uncertainties*

(a) Kootenai River White Sturgeon

Although much has been learned of the basic life history and habitat requirements of Kootenai River white sturgeon, additional information is needed on growth, longevity, age at maturation, migration patterns, specific spawning locations, egg and larvae survival, and food habits. The draft Recovery Plan includes a Recovery Measure to conduct research on basic life history and to monitor the level of recruitment, survival, and recovery of Kootenai River sturgeon. The draft Recovery Plan includes several actions to collect life history information. These include sampling juvenile and adult sturgeon to determine age and growth rates, conducting a genetic analysis of the sturgeon population, annually refining population size estimates, and developing a juvenile year class index.

Specific flow requirements for natural white sturgeon spawning that result in successful recruitment are not yet well-defined. The draft Recovery Plan includes a Recovery Measure to describe the Kootenai River flows required for natural spawning, incubation, rearing, recruitment, and survival of white sturgeon. A primary task is to describe the response of spawning white sturgeon to various Kootenai River flows, water temperatures, total dissolved gas saturation levels, and Kootenay Lake elevations. Activities needed to accomplish this task include annually measuring sturgeon spawning, sturgeon larvae, fry and juvenile abundance in the Kootenai River and in Kootenay Lake, and quantifying spawning/incubation and early rearing habitats using the Instream Flow Incremental Methodology. Results of these studies would better define the specific flow requirements for Kootenai River white sturgeon.

Koocanusa Reservoir acts as a nutrient sink that limits the primary and secondary productivity of the Kootenai River downstream from Libby Dam. The draft Recovery Plan includes an action to assess the need to increase nutrients in the Kootenai River.

(b) Bull Trout

There is no information regarding the use by bull trout of the five-mile reach of the South Fork of the Flathead River downstream from Hungry Horse Dam and the effects of flow fluctuations on bull trout in that reach of river. Bull trout use of this reach should be studied to determine if changes in operation of the Hungry Horse Project are warranted.

Additional information is needed on the life history requirements, distribution, and factors that regulate bull trout populations in the Kootenai River drainage.

Bull trout may pass the Lower Snake River Dams via spill, turbines, or juvenile fish bypass facilities. There is the potential for the surviving individuals to return upstream. This is an area that needs additional study in the Snake River system. The ladders at the Snake River Dams also need an evaluation for bull trout passage efficiency. Passage rates should be determined at these fishways to estimate the effects of delay associated with the ladders.

The extent of entrainment of bull trout through the turbines at Libby Dam and other dams is not known. The manner in which operations at Libby and other dams entrain bull trout and the number of fish entrained need to be estimated to determine the impact of present operations on bull trout.

(c) Westslope Cutthroat

Little information is available concerning the migration and distribution of westslope cutthroat in the Pend Oreille River system. Intensified springtime trapping for adfluvial westslope cutthroat in at least three tributaries downstream from Albeni Falls Dam would help to identify the size of the remaining migratory component of this species.

A tracking study should be conducted to determine if westslope cutthroat are passing downstream through Albeni Falls Dam during migration, where they are going, and if any are trying to migrate back upstream to the dam. This would help to determine if there is a need for fish passage at Albeni Falls Dam. A study of the genetic composition of westslope cutthroat upstream and downstream of Albeni Falls Dam would also aid in determining fish passage needs.

If conditions are changed to favor cold-water species in the Pend Oreille River system, it will be necessary to determine how to restore migratory forms of westslope cutthroat. Potential means of restoration include seeding from resident fish, seeding from the remnant migratory populations, and artificial propagation.

It is unknown how large the westslope cutthroat component was of the overall fish population in the Kootenai River and whether there was a migratory form in the system. Interior redband trout occupy most of the lower reaches of tributaries while resident westslope cutthroat occupy upper reaches above passage barriers. A possible research need would be an analysis to determine whether a migratory westslope population was a major part of the fish population in the Kootenai River system. This would be applicable to the Kootenai River in Idaho downstream from Libby Dam.

(d) Burbot

Presently, limited information regarding the distribution, life history, and factors limiting populations of burbot in the Kootenai River system is available. A burbot study was started in 1992 to collect this information.

(e) Lower Snake/Columbia River White Sturgeon

Major questions about white sturgeon in the Lower Snake and Columbia Rivers include the extent of upstream and downstream passage at all the mainstem dams and the adequacy of the forage base in the reservoirs. Diminished runs of anadromous salmonids and lamprey have reduced the availability of these fish as food for sturgeon. Sturgeon are, therefore, feeding on other organisms in the reservoirs including resident fishes and invertebrates. There is concern that some reservoirs may be at or above their carrying capacities for sturgeon.

Downstream movement by adult and juvenile sturgeon appears to occur at all dams in the Lower Snake and Columbia Rivers. The actual route of passage and incidence of injuries or mortalities incurred during passage are unknown. Research to answer these questions is necessary.

C. Water Quality: Temperature and Total Dissolved Gas Conditions

Hydropower development, irrigated agriculture, logging, mining, stream channelization, and urbanization affect water temperature and total dissolved gas (TDG) in the Columbia River system. Impoundments have modulated temperature extremes in the main stem (Stober, 1992), delaying the annual thermal maximum below Grand Coulee by about 30 days. Warm temperature occurs seasonally at the mouths of tributaries, which may delay the return of adult salmonids to spawning grounds. High spill at dams may supersaturate the river water with air and cause gas bubble disease in fish.

After a stream is impounded, more water surface area becomes exposed to solar radiation, precipitation, evaporation, and wind effects. Large and deep reservoirs, such as Libby, Hungry Horse, Grand Coulee, and Dworshak, cause stratification or layers of water with different physical and chemical properties. Dams can also change the temperature and gas pressure of the water released downstream, impacting the aquatic ecosystem.

Libby. In general, the construction of Libby Dam reduced discharge extremes, increased overall water discharge temperatures, decreased summer discharge temperatures, and decreased nutrient levels in the Kootenai River downstream of the dam (Whitfield and Woods, 1984).

Hungry Horse. Surface water temperatures vary widely in Hungry Horse, ranging from frozen, 32^{o}F (0^{o}C), in winter to over 73.4^{o}F (23^{o}C) in late summer. The reservoir thermally stratifies in summer, typically June through September, but is isothermal (no temperature gradient) in spring and winter. Downstream, hypolimnetic discharges from Hungry Horse have lowered the summer water temperatures and raised the winter water temperatures in the Flathead River from historical levels (Beattie *et al.*, 1988). Cold water released from the deep layers of the reservoir reduces trout growth in the South Fork and mainstem Flathead Rivers to a fraction of pre-dam levels.

Upper Columbia. Data collected at the international boundary has shown a dissolved gas problem at certain times of the year, reflecting the operation of both Canadian and United States' hydropower and flood control projects in the upper reaches of the basin.

Snake River. The spill for fish passage over the dams in the Lower Snake River has increased TDG saturation, although pre-dam conditions might have also created supersaturation. TDG levels typically range from 105 to 110 percent saturation in Lower Granite forebay during the spring in high flow years. Saturation levels increase successively downstream through the Little Goose, Lower Monumental, Ice Harbor, and McNary forebays when all projects are spilling in accordance with the existing BO. Installation of spillway deflectors at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams has reduced the levels of TDG supersaturation associated with spillway discharges. However, maximum supersaturation ranging from 110 to 140 percent has still been observed for extended periods during high-flow events.

Water storage capacity at the four Lower Snake River dams is very limited and retention time is approximately 8 to 20 days, depending on the flows. Therefore, thermal stratification (vertical temperature gradients decreasing from top to bottom) is rare, but during some low flow years, stratification may occur for short periods and range up to 7^{o}F (3.9^{o}C). In general, however, the maximum difference is about 4^{o}F (2.2^{o}C). Temperatures are generally lower during the spring of a high-flow year, but they increase in July or August.

Vigg and Watkins (1991) have further characterized temperature in the Snake River as follows:

> *Mean water temperature in the Lower Snake during 1985-89 was above 70^{o}F (21^{o}C) from 17 July to 19 August; considerable annual variation occurred with temperatures exceeding 70^{o}F (21^{o}C) from 10 July to 14 September in individual years. Based on an analysis of 1938 to 1966 USGS data, the effect of the hydropower system and other anthropomorphic (human-caused) changes on temperature in the Columbia River became apparent in the mid-1950s; the major effect has been shifting temperature maximums so that warmer temperatures occur later in the year (EPA and NMFS, 1971; Crawford et al., 1976). The most significant changes have been above the confluence of the Snake and Columbia Rivers. Pre-dam (1955 to 1958) water temperatures were high--greater than 72^{o}F (22^{o}C)--in the Lower Snake River during mid-July to late August (FWPCA, 1967). Other human-caused watershed disruptions (e.g., defoliation [loss of riparian vegetation] and water diversion) probably elevated maximum temperatures over historic levels in the Snake River Basin (for example, irrigation-associated influences increased river temperature 6^{o}F (3.3^{o}C) to 7^{o}F (3.9^{o}C) between Parker and Kiona in the Yakima River (FWPCA, 1967).*

Dworshak. Dworshak Reservoir is a deep (600 feet in the forebay) and narrow impoundment that thermally stratifies every year with a thermocline at approximately 40 to 50 feet. Deep-water temperatures, below 40 to 50 feet, remain consistent throughout the year at about 39^{o}F (4^{o}C) to 41^{o}F (5^{o}C). The release of cold Clearwater River water from the deep reservoir behind Dworshak Dam could reduce water temperature at Ice Harbor by about 1^{o}F in some years. Temperature reductions at

Lower Granite would be more significant, as would those in the North Fork and mainstem Clearwater. Extreme drafting from Dworshak during late spring and summer, however, could change the thermal structure of the reservoir. Rapid lowering of the reservoir could increase the depth of warm water during summer stratification and potentially increase the temperature of discharge. If the discharge temperature is significantly increased, the use of Dworshak flow to cool the Lower Snake River as a mitigation measure would not be as effective. Thermal effects would not be cumulative, as the reservoir re-establishes isothermal conditions, 39^{o}F (4^{o}C), during the fall/winter turnover.

Lower Columbia River. The factors affecting TDG saturation in the Columbia River are similar to those described for the Lower Snake River. When spilling is minimal (September through March), the saturation level is near normal (100 percent). However, TDG concentrations increase to as much as 140 percent during heavy spill from April through August. Lower Columbia River water temperatures vary seasonally and have a recorded range from 31^{o}F (-0.5^{o}C) to 75^{o}F (24^{o}C). Winter temperatures (December to March) range from 32^{o}F (0^{o}C) to 48^{o}F (9^{o}C), and from March and June, water temperatures rise to about 58^{o}F (14^{o}C). By August, the river usually warms to its annual maximum average of 68^{o}F (20^{o}C).

SECTION III. PERFORMANCE MEASURES AND STANDARDS

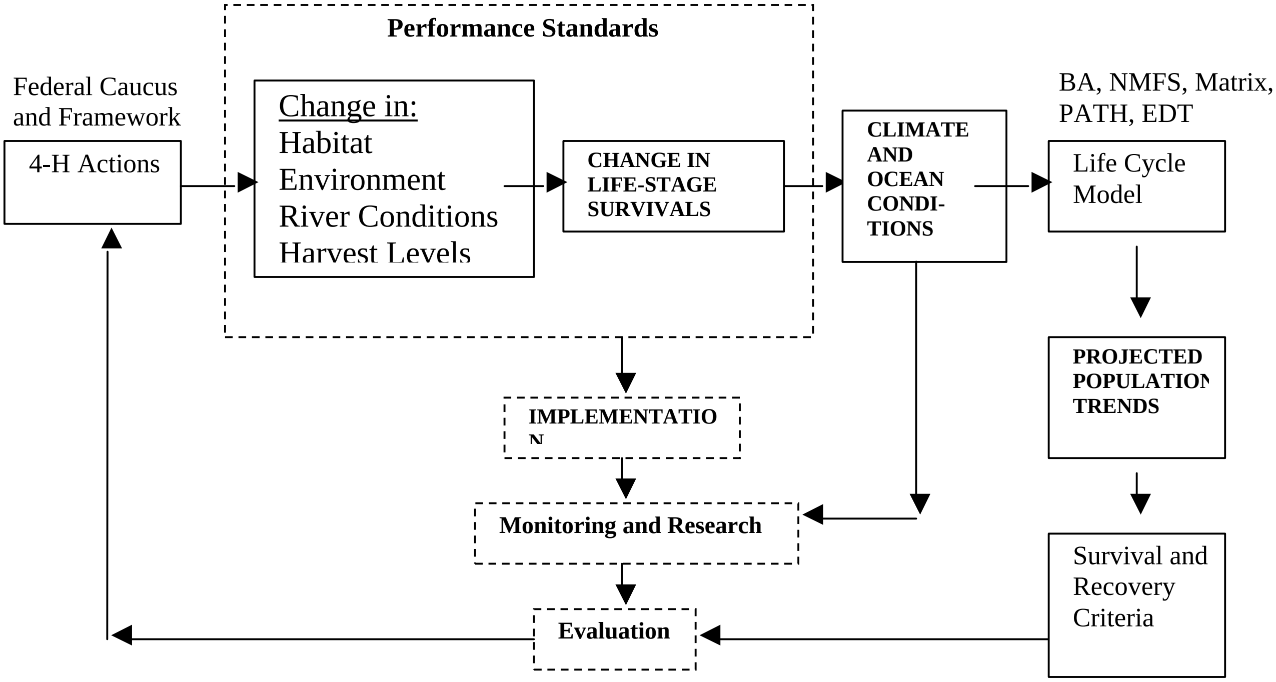
The hydro workgroup has identified both the management and biological values of establishing performance standards in each life stage to reduce adverse impacts and increase survival. These standards, when combined for each life stage in a lifecycle model such as the Cumulative Risk Initiative (CRI), should demonstrate a high potential for survival and recovery of listed species.

A primary focus in this appendix is the maintenance of juvenile and adult salmon and steelhead viability and survival during their passage through the hydrosystem. In theory, after environmental variation and survival in other life stages are taken into account, there should be a level of juvenile and adult salmon viability and survival that is necessary during passage to achieve recovery. Those viability and survival levels can be considered to be standards of performance for the hydrosystem that need to be achieved. It is not a simple matter to define what those standards are and how to measure whether they are achieved. Toward that end, the following construct in under consideration by the Federal agencies and presented here as a possible approach.

Proposed Construct for Performance Standards

Salmon recovery depends on achieving a level of biological performance in each life stage that combines with natural variability in environmental and hydrological conditions to result in an increasing and sustained trend in adult returns over time. Survival through the hydrosystem is an important part of the salmon's complex life history. But hydrosystem measures need to be integrated with other actions across all life stages for successful salmon recovery and to determine how to allocate available resources most effectively.

The following figure represents an analytical approach to developing performance measures for each life stage:



Physical objectives have generally been used as surrogates for survival-based objectives for migration through the hydrosystem. For example, FPE has been used in lieu of passage survival across-the-concrete. Similarly, flow targets and flow augmentation volumes have been used in lieu of in-river migrant survival objectives. Two primary reasons for using these surrogates are: (1) it has not been possible until recently to accurately or precisely measure fish survival; and (2) conventional wisdom and intuition suggest these physical parameters were reasonable surrogates.

We now have the ability to measure fish survival, and it is clear that these physical objectives are not adequate surrogates. New information also suggests that physical parameters may not capture all of the biological effects. Equally important, the objectives identified for the hydrosystem lack adequate linkage to other life stages, performance in terms of returning adults, and the relationship of returning adults to recovery objectives.

Integrating biological performance measures across life stages serves several important functions. First, the performance measures represent biologically derived objectives that are benchmarks for success. Second, in order to assess progress toward the measures, there has to be sufficient monitoring and evaluation, which allows for adjustments to be made if the measures are not performing as expected. In addition, with the establishment of clearly defined measures as well as monitoring and evaluation, there is a basis for prioritizing and allocating resources. And there are mechanisms for accountability.

This process is a way to achieve effective adaptive management, which will contribute to the knowledge on which we can base decisions and to actions that lead to increasing fish survival and recovery.

A. Anadromous Fish: Proposed Measures and Standards

Performance measures and standards are critical underpinnings of any management framework. They define the contribution that is needed at each life-history stage to achieve the overall biological goals and objectives, and they do so in context with the contributions from other life stages.

A performance standard is the specific level of achievement that is required in a particular performance measure or metric. Its purpose is to establish the performance objective of a measure or action. Achievement of the objective indicates the action has been successful.

The following principles will be used to guide the development of performance measures and standards:

- Performance measures and standards will be developed with consideration for the impacts of habitat, harvest, hatchery, and hydro (the Four Hs), particularly on wild stocks.
- Performance measures and standards will be defined for all Four Hs.
- Performance standards for actions in each H will be based on either the relative contribution to improved survival or an aggregated least-cost method for achieving recovery.
- Performance standards will be adjusted over time to reflect success or failure in achieving recovery.
- Performance standards for Federal and non-Federal hydro will be applied consistently.

1. *Steps for Establishing Performance Standards*

The following steps outline a method for establishing performance standards and implementing them as part of a recovery scenario.

Step 1: Define Biological Goals. Define the biological goals for the species at the outset. These goals will ultimately be translated into specific, quantifiable objectives, such as ESA survival and recovery thresholds, and/or an acceptable risk of extinction.

Step 2: Define the change in Survival and/or Environmental Attributes Required to Achieve Biological Goals. Once the biological goals and objectives are defined, the responsibility for changes in survival is allocated among the different life-history stages, based on their relative ability to contribute to the overall goals. There may be many different combinations of actions across the life-history stages that can be undertaken. This step requires analysis of the improvement at specific life-history stages, as well as the overall effect on progress toward the biological goals and objectives.

In the Federal agencies' Four H process, matrix modeling conducted under the Northwest Fisheries Science Center's CRI is being used to evaluate the sensitivity of changes in a specific life-history stage and the relative effect of changes in other life-history stages on achieving the biological goals and objectives. The analysis will determine if one or multiple Four H combinations exist to achieve the biological objectives. When this analysis is completed, some combination of actions will be defined that achieve the biological goals. The Four H combination will include a required level of change in hydrosystem survival (as well as each of the other life stages) that is necessary to contribute to progress toward the biological goals and objectives. This becomes the hydrosystem performance standard.

Step 3: Establish a Plan to Achieve Results. A proposed set of actions that are most cost-effective in achieving the performance standards can be developed next. The list of actions may include a balance of configuration and operational changes.

Step 4: Assign Management Responsibility. In this task, the region will identify specific entities that will be delegated responsibility for achieving the performance standards. In addition to the responsibility, these entities must also have the operational control and authority to see that actions to achieve the goals are taken. Without a clear delegation of responsibility and authority, the process of implementing biological performance standards will lack accountability. The managers who have responsibility for achieving the standards will also have authority to modify the actions if needed to achieve the desired outcome.

Step 5: Measure Against Projected Results. In this step, the managers regularly assess the performance of the hydrosystem relative to the performance standards. If the monitoring and evaluation finds that the hydrosystem is not meeting the performance standard, those with management responsibility may modify the list of actions in order to achieve the performance standard.

Step 6: Modify Performance Measures As Necessary. The responsible management entity for each of the life-history stages is responsible for modifying actions and/or implementing new actions to achieve the performance standards. The performance standards in one or another of the Hs or in one or another of the life-history stages may be adjusted to ensure that the biological goals and objectives are achieved overall.

2. *Proposed Construct for Performance Measures*

The CRI analysis will provide insight into the increase in hydrosystem survival that is needed to achieve the overall biological goals and objectives. The hydro workgroup also sees value in further defining the performance measures for the hydrosystem to include project specific juvenile and adult standards**.**
The hydro workgroups proposed construct has four components:

1. A juvenile survival measure for the system
2. A minimum juvenile survival measure by project
3. An adult project survival measure[1]
4. A delayed mortality/fitness level adjustment

The following table is an example of components 1 and 2 for measuring juvenile survival through the hydrosystem.

Juvenile Passage Survival **Spring Migrants**		**Juvenile Passage Survival** **Summer Migrants**	
Measure	**Stndrd**	***Measure***	**Stndrd**
Lower Granite to below Bonneville survival		**Lower Granite to below Bonneville survival**	
Snake River System Survival		**Snake River System Survival**	
Lower Granite Project Minimum		*Lower Granite Project Minimum*	
Little Goose Project Minimum		*Little Goose Project Minimum*	
Lower Monumental Project Minimum		*Lower Monumental Project Minimum*	
Ice Harbor Project Minimum		*Ice Harbor Project Minimum*	
Lower Columbia System Survival		**Lower Columbia System Survival**	
McNary Project Minimum		*McNary Project Minimum*	
John Day Project Minimum		*John Day Project Minimum*	
The Dalles Project Minimum		*The Dalles Project Minimum*	
Bonneville Project Minimum		*Bonneville Project Minimum*	

Component 3: Adult Fish Passage Survival
The hydro workgroup determined that adult project survival standards should be considered and adult PIT-tag detectors installed at selected projects to enhance research aimed at identifying impacts to adult survival. Upon completion of this research, a standard for an adult system survival measure may also be implemented**.**

[1] An adult system survival measure may be added once initial research and partitioning of adult mortality is completed.

Component 4: Impact of Fitness/Delayed Mortality
The measure includes support for the study of fitness and the impacts of delayed mortality associated with passage through the hydrosystem. All data on survival levels will be adjusted to reflect the results of fitness and delayed mortality research to determine if survival measures are being achieved.

3. *Performance Measure Priority*

It may be impossible to achieve all of the performance standards in the near-term. The hydro workgroup proposes that the following order of priority be established to better direct investment and operational actions:

a. Adult passage Lower Columbia River
b. Adult passage Snake River
c. Summer Migrant Juvenile Passage Survival Snake River
d. Summer Migrant Juvenile Passage Survival Lower Columbia River
e. Spring Migrant Juvenile Passage Survival Lower Columbia River
f. Spring Migrant Juvenile Passage Survival Snake River.

4. *Interim Performance Measures*

The analytical process for defining performance measures across the Four Hs, as described in Step 2 above, is ongoing. The biological requirements for each life stage have not been determined, nor have specific performance measures for the Four Hs been established. Pending completion of the analytical process described above, interim performance standards will be developed for the hydrosystem using existing analytical tools and, models, and best available information. The interim standards will be set at levels that are feasible to achieve with dams in place and with the available resources. Resources will be allocated based on the interim performance standards to ensure their best use for improving fish survival. A feedback mechanism will be included so any new information that is developed and results from performance monitoring can be used to adjust the standards and/or actions taken to achieve them. The interim performance standards may be superceded when the results are available from the more rigorous and systematic process that addresses all life stages and all Four Hs.

A joint workgroup of the Multispecies Framework and Federal Caucus has been formed to facilitate regional dialogue on interim performance measures. This workgroup is coordinating the effort to develop a concept paper on a suite of candidate performance measures that may be used to assess the success or failure of individual management actions and progress toward rebuilding and recovery objectives. The concept paper will include methodologies for developing performance measures and standards for each of the Four Hs, assessment of biological, ecological, and environmental attributes that may be most informative; and the integration of performance measures across the Hs. Ultimately, this workgroup will link the approaches of various regional processes into a cohesive, comprehensive strategy addressing each of the Four Hs and rebuilding and recovery of anadromous and resident species in the Columbia River Basin. Their work will include coordination with the analytical work of the CRI, the Ecosystem Diagnosis and Treatment (EDT), Plan for Analyzing and Testing Hypotheses (PATH), and Quantitative Analysis Report (QAR).

B. Resident Fish: Proposed Measures and Standards

Specific and quantifiable survival objectives and performance criteria or standards for resident aquatic species in the basin listed under the ESA have only been developed for Kootenai River white sturgeon. The Recovery Plan for the Kootenai River White Sturgeon includes the following recovery objectives and criteria.

1. Recovery Objectives

The short-term recovery objectives of this Recovery Plan are to reestablish natural recruitment to the Kootenai River population of white sturgeon and prevent extinction through conservation aquaculture. Proposed recovery actions include providing additional Kootenai River flows and using hatchery propagation for white sturgeon. Due to uncertainties in egg-through-yearling survival for wild white sturgeon and the general lack of recruitment since the mid 1960s, conservation aquaculture should be used to rear juvenile white sturgeon for release into the Kootenai River, and possibly Kootenay Lake, in each of the next 10 years. The Kootenai River white sturgeon population could be considered for downlisting to threatened status in approximately 10 years if the criteria described below are achieved.

The long-term objectives for white sturgeon are to provide suitable habitat conditions and restore an effective population size, with the appropriate age structure, to ensure a self-sustaining population. Actions proposed in the Recovery Plan are intended to balance white sturgeon recovery with requirements for other fish species and recreational fisheries (Executive Order 12962 of June 7, 1995) within the Kootenai River drainage. In all but the most extreme low water years, the plan should complement conservation measures designed by NMFS to meet Snake River chinook and sockeye salmon recovery objectives downstream in the Columbia River.

2. Recovery Criteria

The following criteria are required for reclassifying Kootenai River white sturgeon as threatened, rather than endangered. All of the criteria must be met for the delisting to occur.

(a) Natural production of white sturgeon occurs in at least three years of a 10-year period. A naturally produced year-class is demonstrated by recapture (using standard recapture methods) of at least 20 juveniles from the same class that have reached more than one year of age.

(b) The estimated white sturgeon population is stable or increasing, and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. For this purpose, a year-class will be represented by the equivalent of 1,000 one-year-old fish from each of 6 to 12 families, i.e. three to six female parents. Each of these year-classes must be large enough to produce 24 to 120 white sturgeon surviving to sexual maturity. Over the next 10 years, the number of hatchery-reared juvenile fish released annually will be adjusted depending upon the mortality rate of previously released fish and the level of natural production detected. Additionally, if measures to restore natural recruitment are successful, the conservation aquaculture program may be modified. Conversely, USFWS may recommend that the conservation aquaculture program be extended beyond 10 years if adequate natural recruitment to support full protection of the existing Kootenai River white sturgeon gene pool is not clearly demonstrated,

(c) A long-term Kootenai River flow strategy is developed at the end of the 10-year period in consultation with interested Federal, state, and Canadian agencies, and the Kootenai Tribe. The strategy will be based on results of ongoing conservation actions, habitat research, and fish productivity studies. This strategy should describe the environmental conditions that resulted in natural production, i.e., recruitment with emphasis on those conditions necessary to repeatedly produce recruits in future years.

Specific delisting recovery criteria will be developed as new population status, life-history, biological-productivity, and flow-augmentation monitoring information is collected. It will be approximately 25 years following approval of this recovery plan before delisting of the white sturgeon population can be considered. Twenty-five (25) years is the approximate period for a female white sturgeon added to the population in the next 10 years to reach maturity, reproduce, and complete a new generation or spawning cycle.

C. Water Quality Measures and Standards

In addition to performance measures for anadromous and resident fish, the hydro work considered the water quality goals that have been developed through state and tribal water quality standards under the Clean Water Act. It may not be possible to achieve these water quality standards in the highly modified Columbia River system. There is a need, however, to continue to make improvements in water quality in the FCRPS for improving the survival of listed species and to avoid jeopardy under the ESA. It is also recognized that tributary restoration efforts under way at this time in Oregon, Washington, and Idaho may go a long way toward restoring the Columbia

River ecosystem and provide much needed habitat restoration for fish and wildlife recovery, including water quality elements of habitat.

Water quality standards protect designated beneficial uses for aquatic life and public health in rivers, streams, and lakes, and provide overall water quality goals. Once designated uses are established, standards are established to support those uses. The Columbia/Snake River mainstem is designated for salmonid migration, rearing, and spawning use, and the Environmental Protection Agency (EPA) has established standards to protect that use. The Clean Water Act also requires action to insure that outstanding natural resource waters are not degraded.

The water quality parameters of paramount concern in the hydrosystem are water temperature and dissolved gas. Elevated temperatures throughout the Columbia River Basin and high dissolved gas in the mainstem can contribute to the decline of anadromous and resident aquatic species. Elevated temperatures can impact smoltification and out-migration, migration timing and distribution of salmonids, adult pre-season holding, egg viability, juvenile growth, and disease resistance. Elevated temperatures can also increase predation on juvenile fish. Gas supersaturation can cause gas bubble disease in salmonids, resulting in morality, or weakening fish such that they become more vulnerable to predation and infection.

SECTION IV. OPTIONS AND ANALYSIS

A. Developing the Options

The hydro workgroup considered two objectives as paramount for the hydrosystem: (1) to provide adequate survival and maintain healthy adult and juvenile anadromous fish inhabiting and/or migrating through the hydropower system; and (2) to provide instream and reservoir environmental conditions necessary to the adequate survival of resident fish and other aquatic species. Strategies to accomplish these objectives include:

- Provide a variety of passage routes for juvenile salmonids and lamprey at mainstem dams while protecting life-stage diversity.
- Provide conditions in the mainstem to result in adequate spawning habitat and a high rate of survival for juvenile and adult salmonids and other at-risk species.
- Provide minimum flow levels to facilitate the downstream salmon migration and manage water temperatures consistent with the 1998 NMFS BO on hydrosystem operations.
- Implement physical measures and operational actions to optimize water quality conditions (temperature and dissolved gas) where consistent with overall objectives and other strategies.

The workgroup examined three basic options, or sets of measures and actions, to achieve the objectives and tested the sensitivity of different Evolutionarily Significant Units (ESUs) to them. The options are: (1) a continuation of the current program, leaving the existing system in place, maintaining the fish passage facilities associated with it, and upgrading some of the facilities over time; (2) an aggressive program that goes beyond the current level of investment to improve passage through the existing system; and (3) removal of Lower Snake River Dams. The options represent the major choices in direction and strategy for the hydrosystem.

These options are not intended to represent exact prescriptions of actions and measures that would ultimately be implemented as part of an overall Four H recovery plan. For example, with respect to options 1 and 2, new passage features and project operations that vary from what is presented in this document could be appropriate, depending on the outcome of ongoing design development, research, and other activities. Our aim was to try to determine how much improvement we could realistically expect to see with these substantially different approaches, and how much difference it would make for the fish overall and in combination with actions in the other Hs. Each option is described in terms of the strategies and actions it includes for the Columbia and Snake Rivers, respectively, and for system configuration (i.e., physical alterations at dams) and operation (i.e., flow, spill, transportation, etc.), respectively.

A summary of these options is provided in Tables IV-1 and IV-2; configuration elements of the options are shown in Table IV-1 and operations elements in Table IV-2. The configuration and operations elements are described in greater detail in Attachments One and Two to this paper. And Table ATT1-1, located in Attachment One, shows tentative decision and implementation dates, estimated total development and construction costs, and estimated annual development and construction cost summaries over an assumed period of 10 years.

Table IV-1 - Configuration Activities for the Three Federal Hydro Scenarios

Project	Action	Option 1 *Current Program (Framework #4)*	Option 2 *Non-Breach Aggressive (Framework #5)*	Option 3 *Lower Snake Dams Natural River (Framework#3)*
Middle Columbia - Bonneville	1. Emergency AWS	✔	✔	✔
	2. Gas Fast-Track		✔	
	3. B-1 JBS		✔	
	4. B-1 Surface Bypass		✔	
	5. B-2 Surface Bypass		✔	
	6. Adult Fallback	✔	✔	✔
	7. B-2 FGE		✔	
	8. RM+E - Juvenile Passage	✔	✔	✔
Middle Columbia - The Dalles	1. Sluiceway Outfall Relocation		✔	
	2. Gas Fast-Track Physical Injury Investigation	✔	✔	✔
	3. Collection Channel Dewatering		✔	
	4. Surface Bypass		✔	
	5. RM+E - Juvenile Passage	✔	✔	✔
Middle Columbia - John Day	1. Gas Fast-Track		✔	
	2. Surface Bypass		✔	
	3. ESBS		✔	
	4. Fishway Exit Mods	✔	✔	✔
	5. RM+E - Juvenile Passage	✔	✔	✔
Middle Columbia - McNary	1. Gas Fast-Track		✔	
	2. AWS	✔	✔	✔
	3. JBS Mods	✔	✔	✔
	4. Surface Bypass		✔	
	5. Adult Egress - JBS	✔	✔	✔
	6. RM+E - Juvenile Passage	✔	✔	✔
Lower Snake - Ice Harbor	1. Adult AWS	✔	✔	Breach
	2. Adult Egress - JBS	✔	✔	
Lower Snake - Lower Monumental	1. Surface Bypass		✔	Breach
	2. Gas Fast-Track		✔	
	3. ESBS/VBS		✔	
	4. JBS Mods		✔	
	5. Outfall Relocation		✔	
	6. Adult AWS	✔	✔	
Lower Snake - Little Goose	1. Gas Fast-Track		✔	Breach
	2. Surface Bypass		✔	
	3. Trash Boom	✔	✔	
	4. Adult AWS	✔	✔	
	5. JBS Mods		✔	
Lower Snake - Lower Granite	1. Gas Fast-Track		✔	Breach
	2. Surface Bypass		✔	
	3. JBS Mods		✔	
	4. More Barges		✔	
	5. Adult AWS	✔	✔	
	6. RM+E - Juvenile Passage	✔	✔	
Upper Columbia - Chief Joseph	1. Spillway Deflectors	✔	✔	✔
Upper Columbia - Libby	1. Gas Abatement		✔	
Universal (Middle Columbia and Lower Snake)	1. Replace Aging Fish Facilities	✔	✔	✔
	2. Turbine Passage RM+E		✔	
	3. Residual Fish Passage Needs - Assess Scope + Implement	✔	✔	✔
	4. Dissolved Gas Abatement	✔	✔	✔

Table IV-2 Checklist of Operation Measures

Operational Measures *for the Three Federal Hydro Options*

Project	Action	Option 1	Option 2	Option 3
		Current Program (Framework #4)	*Non-Breach Aggressive (Framework #5)*	*Lower Snake Dams at Natural River (Framework #3)*
Lower Columbia - Bonneville	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Modified fall-winter flows for salmon spawning blw BON	✔	✔	✔
	3. Spill at 1998 Bi-Op level and duration	✔		
	4. Increased spill based on configuration and/or spill evaluations		✔	✔
Lower Columbia - The Dalles	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at 1998 Bi-Op level and duration	✔		
	3. Increased spill based on configuration and/or spill evaluations		✔	✔
	4. Changes in system flood control		✔	✔
Lower Columbia - John Day	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at 1998 Bi-Op level and duration	✔		
	3. Increased spill based on configuration and/or spill evaluations		✔	✔
Lower Columbia - McNary	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at 1998 Bi-Op level and duration	✔		
	3. Increased spill based on configuration and/or spill evaluations		✔	✔
	4. Transport summer migrants only	✔		
	5. Transportation based on transport evaluation studies		✔	✔
Mid-Columbia - Priest Rapids	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at FERC-approved level and duration	✔	✔	✔
	3. Fall-winter flows per Vernita Bar Agreement	✔	✔	✔
	4. Modified spring flow operation to reduce stranding	✔	✔	✔
Mid-Columbia - Wanapum	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at FERC-approved level and duration	✔	✔	✔
Mid-Columbia - Rock Island	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at Chelan Co. PUD HCP level and duration	✔	✔	✔
Mid-Columbia - Rocky Reach	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at Chelan Co. PUD HCP level and duration	✔	✔	✔
Mid-Columbia - Wells	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Spill at Douglas Co. PUD HCP level and duration	✔	✔	✔
Mid-Columbia - Chief Joseph	1. Flows at 1995/1998 Bi-Op levels	✔	✔	✔
Mid-Columbia - Grand Coulee	1. Refill to FC elevation by April 10 85% of time	✔	✔	✔
	2. Provide flows at 1995/1998 Bi-Op levels	✔	✔	✔
	3. Draft to min elev 1280 feet, if needed, by Aug 31	✔	✔	✔
	4. Provide fall-winter flows for salmon blw PRD & BON	✔	✔	✔
	5. Draft below elev 1280 feet in summer in low water years		✔	✔
Upper Columbia - Albeni Falls	1. Operations at status quo	✔	✔	✔
	2. Operations to accommodate cultural resource surveys	✔	✔	✔
	3. Provide flows to support 1995/1998 Bi-Op flow objectives		✔	✔
Upper Columbia - Libby	1. Refill to FC elevation by April 10 75% of time	✔	✔	✔
	2. Provide flows at 1995/1998 salmon/sturgeon Bi-Op levels	✔	✔	✔
	3. Draft to min elev 2439 feet, if needed, by Aug 31	✔	✔	✔
	4. Implement Libby-BC summer draft exchange, if feasible	✔	✔	✔
	5. Implement VarQ flood control operations		✔	✔
	6. Draft below elev 2439 feet in summer in low water years		✔	✔
Upper Columbia - Hungry Horse	1. Refill to FC elevation by April 10 75% of time	✔	✔	✔
	2. Provide flows at 1995/1998 Bi-Op levels	✔	✔	✔
	3. Draft to min elev 3540 feet, if needed, by Aug 31	✔	✔	✔
	4. Implement VarQ flood control operations		✔	✔
	5. Draft below elev 3540 feet in summer in low water years		✔	✔
Upper Columbia - Canadian storage	1. Provide flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Participate in Libby-BC summer draft exchange, if feasible	✔	✔	✔
	3. Provide add'l salmon flow augmentation in spring & summer		✔	✔

Table IV-2 Checklist of Operations Measures(Continued)

Configuration Activities for the Three Federal Hydro Options

Project	Action	Option 1	Option 2	Option 3
		Current Program (Framework #4)	*Non-Breach Aggressive (Framework #5)*	*Lower Snake Dams at Natural River (Framework #3)*
Lower Snake - Ice Harbor	1. Flows at 1995/1998 Bi-Op levels	✔	✔	**Breach**
	2. Spill at 1998 Bi-Op level and duration	✔	✔	
	3. Increased spill beyond 1998 Bi-Op level and duration		✔	
Lower Snake - Lower Monumental	1. Flows at 1995/1998 Bi-Op levels	✔	✔	**Breach**
	2. Spill at 1998 Bi-Op level and duration	✔	✔	
	3. S-T-R transport for spring migrants; full transport summer	✔	✔	
	4. Increased spill beyond 1998 Bi-Op level and duration		✔	
Lower Snake - Little Goose	1. Flows at 1995/1998 Bi-Op levels	✔	✔	**Breach**
	2. Spill at 1998 Bi-Op level and duration	✔	✔	
	3. S-T-R transport for spring migrants; full transport summer	✔	✔	
	4. Increased spill beyond 1998 Bi-Op level and duration		✔	
Lower Snake - Lower Granite	1. Flows at 1995/1998 Bi-Op levels	✔	✔	**Breach**
	2. Spill at 1998 Bi-Op level and duration	✔	✔	
	3. S-T-R transport for spring migrants; full transport summer	✔	✔	
	4. Increased spill beyond 1998 Bi-Op level and duration		✔	
Lower Snake - Dworshak	1. Refill to FC Elevation by April 10	✔	✔	
	2. Provide flows at 1995/1998 Bi-Op levels	✔	✔	
	3. Draft to min elev 1520 feet, if needed, by Aug 31	✔	✔	
	4. Use DWR for temperature control during summer period	✔	✔	✔
Middle Snake - Brownlee	1. Provide flows at 1995/1998 Bi-Op levels	✔	✔	✔
	2. Shape or pass-thru U. Snake Basin flow aug. volume	✔	✔	✔
	3. Draft to min elev 2059 feet in Aug or Sept	✔	✔	✔
	4. Draft to min elev 2041 feet in Aug or Sept		✔	
Upper Snake Basin	1. Provide flows at 1995/1998 Bi-Op levels -- 427 KAF	✔	✔	✔
	2. Provide up to an additional 1 MAF for salmon flows		✔	

We did not examine the option of removing Federal Columbia River Dams. The Multispecies Framework Project will evaluate alternatives in which John Day and McNary Dams are removed. We did not include them here because they are not viable options for the Federal agencies for a decision in 1999. The COE has done extensive studies of the feasibility, environmental effects and benefit of removing Snake River Dams, and has conducted a preliminary assessment of John Day Dam drawdown.

We also did not examine configuration options for FERC-licensed projects, but recognize that changes at these projects may have benefits for fish. For example, removal of the Hells Canyon Complex could provide benefits to Snake River stocks. Opportunities for fish passage improvements at FERC-licensed projects should be considered during relicensing processes. Projects undergoing relicensing proceedings in the near-term include Pelton and Round Butte Dams, Hells Canyon Complex and three Mid-Columbia PUD Dams, Rocky Reach, Priest Rapids, and Wanapum.

Numerous existing sources of information and analysis were used to develop and evaluate the options. Notable sources included the Multi-Species Framework Project, the Lower Snake River Juvenile Fish Migration Feasibility Study, the COE' Columbia River Fish Mitigation Project, and the work of the regional System Configuration Team and its related technical coordination groups. The caucus' hydro workgroup worked closely with a hydropower subcommittee of the Framework Project to jointly develop specifications of the options and coordinate evaluation and new analyses such as biological considerations in the CRI and Ecosystem Diagnosis and Treatment (EDT), and hydroregulation studies of storage projects incorporating Integrated Rule Curves (IRCs). The three options correspond to the hydropower components in three of the seven Framework alternatives as noted below.

B. Option Descriptions

1. Option One: Current Program

This option would continue on the present path of ongoing improvements to the system, with roughly the existing level of investment continuing into the future. Both system operations and configurations under this alternative would continue as they have been developed under the NMFS 1995 and 1998 BOs, with minor modifications. As such, this might be termed the "status quo" option, because it continues the present program. However, this option does not represent a static state in terms of measures to improve fish survival. It focuses on addressing identified "problem areas" where potential fixes are relatively well understood. It also assumes that evaluations of fish passage measures that are less well understood will continue to better inform potential future decisions. In addition, the current program will ensure that fish passage facilities are adequately maintained and operated into the future. This option leaves open the possibility that dams may be breached in the future. It corresponds most closely to Framework alternative 4.

The rationale for this approach is that passage conditions for juveniles and adults may still be improved through the Lower Snake and Columbia River Dams and reservoirs, although not as significantly as what has occurred over the past two decades. For fish of Snake River origin, total direct passage survival today appears to be equivalent to the level that existed when there were only four dams in place on the Snake and Columbia Rivers. (Any indirect effects of hydrosystem passage are assumed to be small enough that they do not inhibit population growth and recovery.) Potential incremental fish survival improvements that may be associated with additional measures and investments would be investigated in this option. Concurrently, potential benefits of investments in non-mainstem measures will also be investigated. This option does not preclude future decisions on additional investments in passage measures if deemed appropriate based on survival evaluations, but it does not plan on them from the outset, except as listed below.

Columbia River Configuration Measures – The COE would continue to evaluate improvements to fish passage facilities at McNary, John Day, The Dalles, and Bonneville Dams, with total investments at approximately the same level or less than in the past five years. The current program would improve adult passage by adding emergency backups for the auxiliary water supply at fish ladders and other measures to reduce adult fallback or improve adult passage. Juvenile passage evaluations and improvements include:

- continued development and testing of a surface bypass at John Day and Bonneville Dams;
- continued investigation of the effectiveness of extended-length fish screens at John Day Dam;
- continued investigation of the effectiveness of extended screens, alterations to the juvenile bypass outfall, and/or a surface collector at Bonneville Dam first and second powerhouses;
- continued investigation of relocating the sluiceway outfall at The Dalles Dam;
- continued investigation of installing additional and/or modified spillway deflectors at all four dams;
- powerhouse turbine improvements such as minimum gap runners at Bonneville first powerhouse, if proven effective in improving turbine passage survival;
- flow deflectors at Chief Joseph Dam.

Columbia River Operational Measures – Operations for flow, spill, and transportation are essentially the same as those specified in the 1995 and

1998 BOs, with the addition of the operations specified in the 1999 Supplemental BO to protect ESA-listed salmonids spawning below Bonneville Dam. Project operations at Libby and Hungry Horse would provide spawning and recruitment flows for sturgeon, as well as other reservoir operations for bull trout according to the USFWS 1999 Recovery Plan or as specified in the 1999 BOs for sturgeon and bull trout. Minimum discharge requirements for fall chinook and chum salmon spawning and rearing needs in the Hanford reach and below Bonneville Dam would be provided. In addition, there would be a reduction in the fluctuation of flows from Priest Rapids to reduce fry stranding and stabilize riparian areas. The Federal agencies would continue to use the existing volume of water for management of flows throughout the year for the benefit of various fish stocks and species of concern.

Snake River Configuration Measures – Fish passage configuration measures include improving emergency water supplies for adult passage systems, relocating the bypass outfall at Lower Monumental Dam, and construction of a trash shear boom at Little Goose Dam.

Snake River Operational Measures – Operations for flow, spill, and transportation are essentially the same as those specified in the 1995 and 1998 BOs. The Federal agencies would continue to use the existing volume of water for flow augmentation from the Upper Snake River Basin to benefit summer migrants.

2. *Option Two: Aggressive Program*

In this option, we assume that the investigations in the current program for improved fish passage facilities, such as surface bypass, will be successful and are implemented to increase passage survival. Hence, the primary difference in configuration measures between this alternative and the current program is that the Federal agencies would seek increased funding to pursue more aggressive implementation of measures to improve passage survival. This option would also include more aggressive operational measures in terms of flow and spill. The Federal agencies would seek increased flow augmentation from Canadian reservoirs and improved water quantity and quality from the Upper Snake River. Spill at many projects might be expanded to daylight hours. This option corresponds most closely to Framework alternative 5.

There are generally three potential reasons why an aggressive approach might be pursued: (1) additional improvements in direct survival are deemed necessary and appropriate relative to their contribution to population growth and recovery; (2) improvements in system configurations or operations are expected to reduce indirect hydrosystem-related mortality and such improvements are deemed necessary to contribute to population growth and recovery; and/or (3) improvements in system configuration or operation are implemented to reduce economic effects of current conditions while providing equal or greater protection than current conditions.

Opportunities to dramatically improve direct survival through the system are limited. The best we can expect even with this aggressive program is on the order of 5 to10 percent increase in the survival of juveniles migrating in the river. But if juvenile and adult fish suffer latent mortality as a result of their experiences in the hydropower system, measures under this option may reduce this latent mortality by reducing delay and trauma to fish as they pass through the system. Spill can decrease delay, so increasing spill duration may decrease latent mortality. Surface bypass is another method for reducing delay and trauma to juveniles, and may reduce adult fallback mortality. Another example would be operational or structural changes that increase spill efficiency. Because this is an expensive option, it may reduce the dollars available to pursue other actions to benefit fish, such as the restoration of spawning and rearing habitat. On the other hand, structural passage features at dams such as surface bypass may modify other operational requirements and their costs; these cost saving could then be invested in other measures of potentially significant biological benefit.

Columbia River Configuration Measures – The COE would continue to improve fish passage facilities at McNary, John Day, The Dalles, and Bonneville dams. The aggressive program includes all of the measures specified previously for the current program and, depending on the results of investigations, may include some or all of the following measures:

- installation of surface bypass, either at the spillway or powerhouses, at McNary, John Day, and Bonneville Dams;
- installation of extended length screens at John Day and Bonneville Dams;
- relocation of the sluiceway outfall at The Dalles Dam;
- additional and/or modified spillway deflectors at all four dams;
- potential powerhouse turbine improvements such as minimum gap runners;
- flow deflectors at Chief Joseph Dam;
- flow deflectors or additional turbines at Libby Dam for dissolved gas abatement.

Columbia River Operational Measures - Efforts would continue to acquire additional water from Canadian reservoirs, implement VARQ flood control operations at Libby and Hungry Horse Dams to protect resident fish, and provide minimum discharge requirements for fall chinook and chum salmon spawning and rearing needs in the Hanford reach and below Bonneville Dam. In addition, there would be a reduction in the fluctuation of flows from Priest Rapids to reduce fry stranding and stabilize riparian areas. IRC operation at storage projects would be further evaluated and may be implemented based on tradeoffs in benefits to resident fish and effects on salmon habitat and other system operation purposes. Additional spill for fish passage (to dissolved gas cap levels as permitted by spillway deflectors), including daytime spill, may be implemented at McNary and John Day. The agencies would review modified system flood control operations that provide higher spring flows and refill probability in average and below average runoff years. This would include evaluation of initial control-flow operations. Based on the review and evaluation, modified operations may be implemented.

Snake River Configuration Measures – Additional improvements include spillway deflectors, surface bypass, either at spillways or powerhouses, modifications to the Lower Granite Dam juvenile fish facility, and two to five additional transport barges.

Snake River Operational Measures - Additional spill would be provided at three projects, additional water for flow augmentation would be sought, and storage would be used for mainstem temperature control in the summer.

3. *Option Three: Breach Lower Snake River Dams*

This option improves conditions for Snake River stocks by breaching the four Federal dams in the Lower Snake River. All four salmon and steelhead ESUs in the Snake River are listed as threatened or endangered and represent one third of the listed ESUs in the basin. Under this option, which corresponds most closely to Framework alternative 3, Snake River dams are breached as soon as congressional authorization and appropriation occur. During the interim period prior to breaching, minimal or no investments are made to improve the configuration of Snake River Dams. The rationale for this alternative is that passage through the hydropower system, whether in barges or in the river, causes latent mortality to Snake River juveniles. The best way to eliminate this latent mortality is by removing the dams.

Configuration measures in the Columbia River may occur at the same rate as under the current program, or may be reduced because of the cost of Snake River Dam removal. Operational measures in the Columbia River also may occur as specified in the 1995, 1998, and 1999 BOs, or may be reduced because of cost constraints. In the Snake River, operational measures would continue to include flow augmentation from Dworshak Reservoir as needed to moderate temperatures in the Lower Snake River. It would still be important to seek improvements in water quality from the Upper Snake River.

4. Other Considerations Relevant to the Options

a) Water Quality Plan Development

A water quality plan is another crucial element in recovering ESA-listed species. The following process outlines how a water quality plan would be developed and implemented. Federal agency representatives developed the process as a decisionmaking tool for water quality measures, both operational and structural. The process aims to enable decisions on the biological and economic implications, as well as the cost-effectiveness, of water quality measures.

Project Scope. The water quality plan will consist of a systemwide analysis of the factors that affect temperature and dissolved gas. The analysis will result in the development of a suite of actions that can be implemented to improve water quality, using established standards as both the goal and measure of progress for the basin. The Columbia River tributaries and mainstem will be treated as an ecosystem, with the mainstem addressed in context with tributary efforts.

The water quality plan will focus on what physical and operational changes to dams, both Federal and non-Federal, may benefit water quality in terms of temperature and dissolved gas, while improving survival of ESA listed species. Other factors that affect water quality, such as grazing, agriculture, forest practices, point sources, land use, mining, and water withdrawals, are being addressed in other forums, including the states' Total Maximum Daily Load (TMDL) processes.

For the initial phase, the plan will address actions from Grand Coulee on the Columbia River and Lower Granite in the Snake River to the tailrace of Bonneville Dam. Future work may include considerations above the international boundary. While the plan will aim to take into account the role of tributaries in water quality problems relative to the mainstem, it will not seek specific remedies in the tributaries. Ongoing Clean Water Act TMDL processes and other water quality improvement initiatives are under way in many of the tributaries and should not be delayed in anticipation of the plan.

Regulatory mechanisms to implement the plan include the 1999-2000 BO for Federal dams. For non-Federal dams, a water quality plan can be implemented as a FERC-relicensing condition, ESA Section 7 consultations, Clean Water Act section 401 certifications, and voluntary actions.

If after implementation of selected actions, water quality improvements are not attained, EPA, the states, and the tribes may use this data to begin discussing reevaluation of beneficial uses and water quality standards to meet current needs and realities in the system. It is not the purpose of the plan to target the revision of beneficial uses or standards as the primary goal. The purpose is to identify and test hypotheses, implement actions to improve water quality, and only then to consider revisions based on broader societal, legal, and policy considerations, as appropriate.

Plan Purpose. The Plan aims to accomplish the following:

- Assist in our understanding of loading capacity/loading allocation systemwide by assessing the existing effects at Federal and non-Federal dams and tributaries.

- Provide an organized, orchestrated approach to improving water quality with the goal of meeting water quality standards, which the states can integrate into their water quality management programs.

- Provide a framework to identify and implement actions for dam operators to use toward reducing temperature and dissolved gas.

- Provide a record of the actions that are and are not achievable with regard to structural and operational improvements aimed at improving water quality conditions and meeting water quality standards for dissolved gas and temperature. This information may provide a basis for future beneficial use and water quality criteria revisions.

- Present information for the decision process on dissolved gas and temperature in basinwide context, and provide a technical assessment of the relative value of a project in terms of water quality.

- Connect dissolved gas and temperature work into one process for both Federal and non-Federal dams on the mainstem Columbia/Snake system.

The process to move towards water quality standards in the mainstem is described below and depicted in Figure IV-1.

Plan Process. The steps for developing the plan will include:

- Identify applicable water quality criteria/goals;

- Identify source of loadings, including natural background;

- Allocate pollutant loads;

- Plan for implementation;

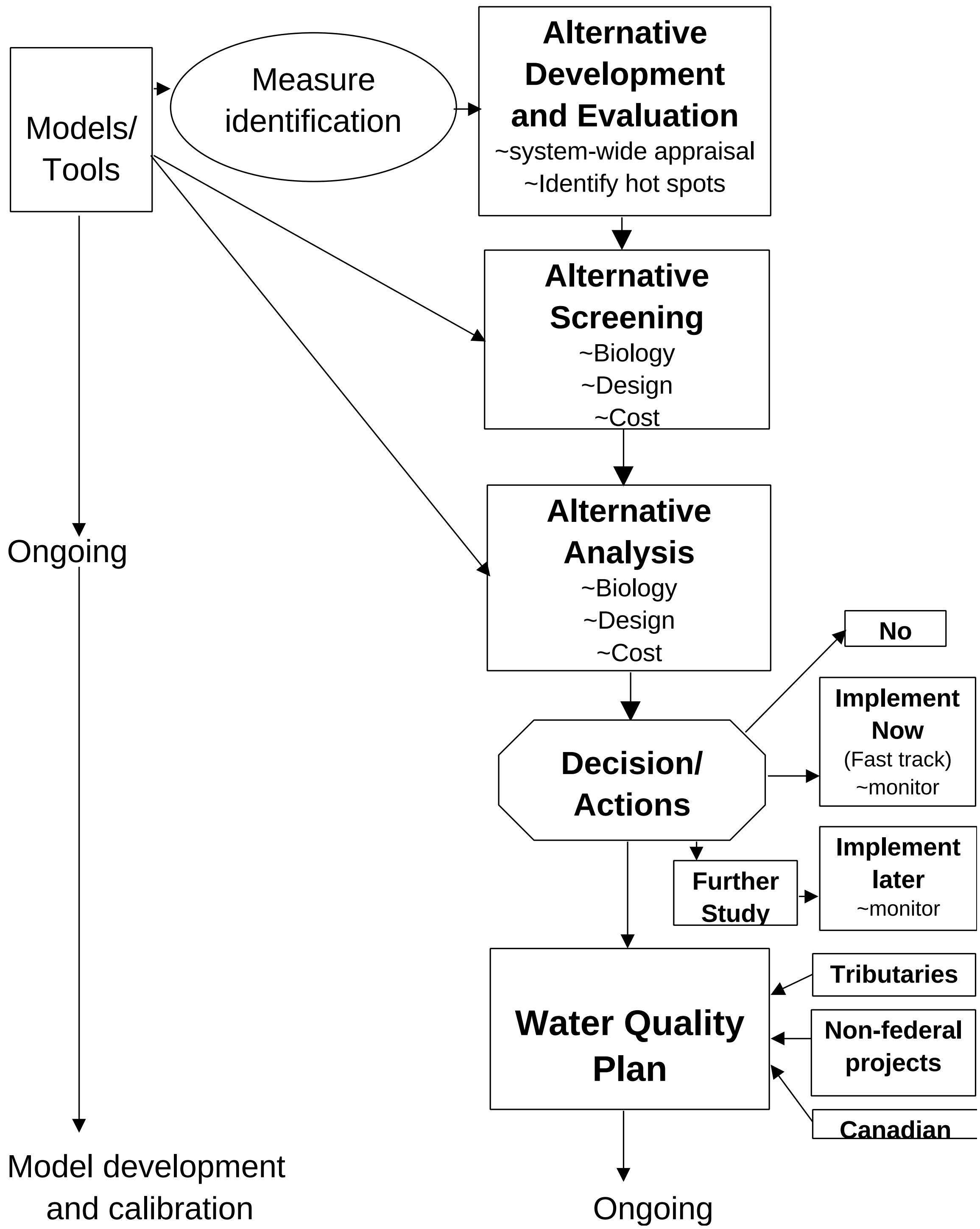
- Monitor and evaluate;

- Where appropriate, determine deviation from water quality criteria/goals.

Participants. To be successful, the plan must have the participation and cooperation of the key Federal agencies, states, tribes, and non-Federal dam operators. Because the allocations will likely identify existing effects at each dam and the necessity to reduce them, it is imperative that good science guide this effort. All of the participating organizations will need to provide long-term commitment of resources. It will likely be necessary to establish a structure for the effort that will include goals, objectives, short and long-term milestones, and a dispute resolution process.

Schedule. The first iteration of a water quality plan should be completed in 2001. Again, ongoing dissolved gas and temperature work for the Federal dams should *not* be delayed pending the completion of the plan, nor should state and/or local work in the tributaries be delayed.

Figure IV-1, Water Quality Plan Development Process
Draft Decision, July 1999



b) Research, Monitoring, and Evaluation

Research, monitoring, and evaluation (RME) activities provide information about how a new structure or operation works and its biological benefit. The activities are an important part of any recovery measure. RME has been incorporated into the current program and would be continued, with appropriate changes, under any of the options considered by the hydro workgroup.

RME can be designed to serve several purposes. Compliance or implementation monitoring can help a regulatory agency determine if a management action was carried out as described. Or RME can be designed to link a proposed management action, tested in prototype, with the intended outcomes. In either case, monitoring can be applied at the level of a single project, a group of projects, or a recovery plan. Critical RME elements include: (1) describing existing conditions (to compare with conditions after a management measure is implemented); (2) developing a record of important biological or environmental variables over time; and (3) testing critical assumptions that affect interpretation of the monitoring results.

The Federal agencies are continuing to explore RME approaches to address key uncertainties in a timely manner. We have neither identified what approaches are most appropriate to address outstanding needs nor what approaches would be feasible. However, we are considering information from both the recent NMFS "white papers" and products from the Plan for Analyzing and Testing Hypotheses (PATH) analyses in developing an approach to RME.

NMFS' white papers synthesize the existing information on salmonid passage through the FCRPS. The four papers address the existing data on dam passage, transportation, the flow survival relationship, and predation. The papers also characterize uncertainties associated with the existing data, and the uncertainties raised in recent analyses by regional forums such as PATH and the Independent Scientific Advisory Board. A hydro monitoring and evaluation framework that addresses these uncertainties should focus on the areas critical to making important configuration and operations decisions that cannot currently be addressed. These uncertainties, as identified by the white papers, can generally be described as the effects of passage through the FCRPS that might occur within or as a result of the hydrosystem, but that are thought to be manifested outside the system. A hydro monitoring and evaluation framework should consider the following four potential effects of passage: 1) effects of multiple bypass passages; 2) effects on adult reproduction; 3) delayed transportation mortality; and 4) estuarine and early ocean survival.

Effects of Multiple Bypass Passages
To address the potential effect that passing through existing juvenile bypass systems may have on the survival of smolts, fish with known migration histories could be held for extended periods to observe the longer-term effects of the hydropower system and explore possible mechanisms for any differential delayed mortality observed between treatment groups. Treatment groups could include fish the pass through no bypass systems, through one bypass system, and through multiple bypass systems. PIT tag diversion systems at a lower dam could be programmed to divert PIT-tagged fish. These "test" fish could be held in state-of-the-art holding systems and monitored for survival.

Test fish would be monitored for physiological and disease profiles prior to entering the seawater holding system and at the end of the study. Mortalities would be necropsied for cause of death. This extended rearing protocol would enable test fish with known bypass passage histories to be followed into the future, beyond the hydrosystem, and their condition and survival evaluated through a time period similar to that of smolts that reach and rear in the early ocean environment. Test fish from all treatments would be held together, and only after death would the passage history of the individual be determined. The cause of death and the animal's physiological and disease state at the time of death would be correlated to their passage history.

Effects on Adult Reproduction
The potential impacts of passage through the hydrosystem on adult reproductive success can now be evaluated using known-source PIT-tagged fish. Adults of known origin, based on PIT tags, could be marked with radio-telemetry tags at Bonneville Dam, weighed, and measured for lipid content. These individuals could again be sampled at Lower Granite Dam for weight and lipid content, and at their hatchery for weight, lipid content, and reproductive success (survival to the hatchery, fecundity, egg size, egg weight, and hatching rate). The use of non-lethal methods to collect information on weight loss and lipid loss allows researchers to quantify and correlate migrational behavior (delay, fallback, etc.) with reproductive success.

Delayed Transportation Mortality
Ongoing studies of transportation could be continued to build a time-series of D-value (D) estimates. Currently, estimates of D are being developed for each year transported and in-river fish are marked and released. Estimates of survival from the Lower Granite or Little Goose tailrace to below Bonneville Dam are multiplied by the ratio of SARs of returning adults from transported to in-river fish, which provides an estimate of D. Repeating the experiment over a series of years would accommodate environmental variability and provide an assessment of the importance of D in hydrosystem decisions.

Estuarine and Early Ocean Survival
The Columbia River estuary is a complex, diverse, and important transition habitat for salmon in their migrations to and from seawater. Attributes of the estuary that appear important to the ecology of the estuary and its influence on salmon include flow rate through the estuary and plume, the timing of the flow, and turbidity. These are factors that the FCRPS has potentially altered, with unknown effects on salmonid survival. In addition, the ecosystem changes attributable to the FCRPS must be considered in concert with the known large-scale declines in marine survival of salmon in Oregon and south-central British Columbia coastal waters.

Ongoing studies by NMFS that link the freshwater environment to the early ocean environment are important to understanding the relationship between the two. For example, data on the timing of release of barged or in-river fish at Bonneville Dam and their subsequent detection in PIT-trawl sampling at Jones Beach (RKm 75) allows for time-of-ocean-entry to be estimated. Studies of the near-ocean physical and chemical environment, and the biological community assemblages in these environments provide important information on the productivity and trophic structure of the plume and near-ocean. Marrying up data on the timing of ocean entry with conditions the fish experience upon entry is important to furthering our understanding of factors that influence early ocean survival.

Based on adult returns from fish PIT tagged for the 1995 transportation study, we know that SARs can increase as much as seven fold within a week. Interpretation of this information could suggest that timing of and conditions at ocean entry may be factors highly influential to SARs. It may also indicate that survival of these fish is dependent on their movement immediately following estuary entry. For example, preliminary data indicates that juvenile salmon moving quickly to northern British Columbia and southeast Alaska waters have as much as a 10-fold increase in survival compared with those remaining in southern British Columbia or U.S. waters. It is probable that a combination of these factors together determine the SARs, and additional research could lead to a better understanding of the possible role FCRPS operations (including transportation timing) have on the survival of smolts once they are downstream of the hydrosystem.

Studies to better understand the role of the estuary on the condition and fitness of smolts for ocean entry are being discussed and new research in cooperation with Canada will help us understand how population-specific factors associated with estuary entry and near-shore survival influence SARs. Information of this nature would also be helpful in understanding the effects of FCRPS operations on the ecology of the estuary and potential impacts on salmonid survival through this transition area. Potential anthropogenic effects from pollutants, channel maintenance, channel dredging, use of dredge disposal islands by bird colonies, and possible changes in estuarine currents and salt water intrusion are important and little understood areas for future research. The estuary ecosystem was once based on marsh productivity and infauna, but is now dominated by reprocessing of fluvial micro-detritus by the ETM (estuary turbidity maximum).

The role of many of these anthropogenic activities are not FCRPS related. However, the food-web processes and the dependence of salmonid productivity and preparedness for ocean entry and survival are areas that need to be better understood, within the context of managing the FCRPS to improve salmonid survival and the recovery of listed stocks.

The PATH process has suggested three types of RME that would be useful to hydro decision-making:

- Measure differential delayed mortality of transported fish under current operations;
- Explore mechanisms for delayed hydrosystem mortality under current operations; and
- Monitor environmental variables associated with the current oceanographic regime.

The general approaches described by PATH to address these three issues are similar to that which is outlined above. More detailed discussions on these and related topics are available in Marmorek *et al.,* (1999).

c) Contingent Breach Strategies

An implementation strategy being contemplated for the current and aggressive program options outlined above is to defer a decision on the breach of the Lower Snake River dams. Deferring a breach decision allows time for additional information to be developed that would reduce the uncertainty around many of the issues associated with dam breaching.

The Federal agencies are considering a number of decision factors and/or contingent outcomes that may be relevant to a deferred decision on breaching. These include:

- **Inability to Achieve Performance Measures**: Performance measures that define a level of increase in survival through the hydro corridor in a context of actions taken in the other Hs should be established. Breaching the Lower Snake River dams may be considered if the hydrosystem does not achieve the performance measures within some stated period of time, and analytical estimates indicate that removal of the Snake River dams would help the hydro system achieve the performance measures.

- **Scientific Evidence of Significant Delayed Mortality**: Breaching the Lower Snake River may be considered if experimental management results find the level of delayed mortality associated with transported fish is significant, particularly if transported survival is less than estimated natural river survival levels.

- **Risk of Delay**: Dam breaching could be pursued if new information or further analyses make it clear there is a substantially higher risk of extinction associated with a breaching delay.

A deferred or contingent breach decision could be approached in several ways. These include:

- **Contingent Breach**: Establish decision factor(s) and a date for evaluation to determine if the measures have achieved the results; if not, the region pursues breaching.

- **Delayed Breach**: A date, but no specific decision factors, is set for a reconsideration of breaching. This alternative recognizes that more time is needed to address key uncertainties and that it is currently premature to make a decision on breaching. A breaching decision is deferred to an established date in the future.

- **Informal Reconsideration**: No decision factor(s) or dates are established. This alternative recognizes there may later be key changes in system conditions that warrant a reconsideration of breaching the Lower Snake River dams.

d) Experimental Management

The goal of experimental management is to reduce key uncertainties about potential long-term management actions while promoting the recovery of listed salmonids. In practice, managers would choose to configure and operate the hydrosystem in the experimental management mode for a specified time. That is, the alternative scenario would be treated as an experiment, structured to study important components of the ecosystem, such as the differential delayed mortality of transported fish and sources of extra mortality.

Before pursuing an experimental management action, managers should be informed about the expected benefits (amount of learning possible), biological risks, and economic costs (Parnell *et al.*, 1999). Scientists would need to identify the number of years of experimental data required to differentiate among effects, given year-to-year variability. Some critical uncertainties may be resolved within a five to10-year timeframe. Others, such as the effects of a climate regime shift, may take decades to resolve (NWFSC 1999).

The Federal agencies are continuing to explore experimental management approaches to address key uncertainties in a timely manner, while ensuring that actions associated with the experimental management approach(es) do not put listed or weak stocks at further risk. We have neither identified what approaches are most appropriate to address outstanding needs nor what approaches would be feasible. PATH has undertaken a methodical, scientific assessment of experimental management approaches. The Federal agencies will take under consideration the products from PATH to advance this important and complex issue. However, the Federal agencies have not agreed to the approaches developed by PATH, as listed below, nor have we discussed whether or not the suggested approaches are feasible.

The PATH process has suggested several types of experimental management that would be useful to hydro decisionmaking (Marmorek *et al.*, 1999):

- Measure differential delayed transportation mortality under a modified transportation system;
- Measure differential delayed transportation mortality under an experimental system with transport turned off and on;
- Breach two dams on the Lower Snake River;
- Breach four dams on the Lower Snake River;
- Introduce salmon carcasses or chemical fertilizers to increase stream nutrient levels;
- Manipulate hatchery production; and
- Reduce effects of native and non-native predators.

Each of these proposals is briefly described below.

Differential Delayed Transportation Mortality Under Modified Transport System

Modifications to the transport system could include changes in the timing of delivery of smolts to the estuary and barging rather than trucking fall chinook. The data collected would clarify effects of the timing of ocean entry, interactions with other stocks during collection and transport, and the method of transport (barge or truck). These data would also reduce uncertainty about the magnitude of differential delayed transportation mortality and extra mortality for both transported and non-transported fish.

Turn Transport On/Off and Measure Differential Delayed Transportation Mortality

Under this experimental management option, the quantity of fish transported would be varied. In some years, most fish would be bypassed and transported. In others, nearly all fish would be bypassed but not transported. These resulting data would improve the contrast in survival rates between transported and non-transported fish, enabling the detection of significant differences, if any exist.

Breach Two Dams on the Lower Snake River

There are several possible combinations of dams would could be breached (e.g., Ice Harbor and Lower Monumental dams or Ice Harbor and Little Goose dams). The upstream, unbreached dams would be used to regulate and shape flow at the breached dams. The resulting information would provide more information on the ecological effects of dam breaching and could be used to resolve key uncertainties.

Breach Four Dams on the Lower Snake River

Under this option, the responses of regional stocks would be measured after all four Lower Snake River dams were breached (transportation would be stopped). These data would help resolve uncertainties about the potential benefit of a drawdown at John Day Dam on the Lower Columbia River.

Increase Stream Nutrient Levels

PATH scientists have proposed mortality or poor condition in the parr-to-smolt life-history stage as an alternative reason for the “extra mortality” of Snake River spring/summer chinook salmon. If this hypothesis is correct, introducing carcasses or chemical nutrients to streams would be expected to correspond with a decrease in spawner-recruit extra mortality, narrowing the uncertainty about hydrosystem effects.

Manipulate Hatchery Production

PATH scientists have also hypothesized that interactions with hatchery steelhead have decreased the viability of stocks of wild spring/summer chinook salmon smolts that migrate through the hydrosystem at the same time. Under an experimental management system to determine the magnitude of this effect, steelhead hatcheries would release a smaller number of smolts or smolts of a smaller body size or would delay smolt releases until later in the migration season.

Reduce Effects of Native and Non-Native Predators

Both native (northern pikeminnow) and non-native (American shad, smallmouth bass, walleye, channel catfish) fishes prey on listed salmonid smolts during passage through Lower Snake River pools. An experimental management system could be designed in which predation rates were estimated and appropriate actions implemented to reduce these effects.

Details of all seven of these options and the potential risks, as well as benefits, to listed stocks are described in Marmorek *et al.*, (1999).

C. Analysis

1. *Introduction*

The hydro workgroup examined three options to achieve the objectives of salmonid survival and recovery: a continuation of the current program, an aggressive program of improvements to boost passage survival, and breaching the four Lower Snake River dams. NMFS analyzed the effect that two of these alternatives, current program and breaching dams, would have on the probability of extinction for Snake River salmonids, using a tool called the Cumulative Risk Initiative (CRI). The CRI also produces an estimate of improvement in various parts of the life cycle, including the first year of life, downstream survival, survival below Bonneville Dam, ocean survival, and upstream conversion rates, that would be needed if any factor were relied on by itself to increase population productivity enough to reduce the probability of extinction to one in 10 within 100 years.

The hydro workgroup evaluated a third option, aggressive program, using the SIMPAS2 spreadsheet model to screen for components that could provide the required level of benefit. In the following sections, we describe the preliminary results of the CRI and SIMPAS2 modeling.

2. *Biological Analyses*

To date, the biological analysis reflects work conducted by PATH and the CRI for three ESUs in the Snake River. Additional information is expected as further CRI evaluations of the other Columbia River listed salmon and Framework EDT analyses are conducted. A summary of the CRI/PATH results for the Snake River is reported below.

a) PATH/Cumulative Risk Initiative

Snake River Spring/Summer Chinook
PATH Analysis. The PATH analysis indicates that dam breaching produces the largest fraction of simulated future fish populations exceeding particular survival and recovery criteria. The critical uncertainty in this PATH conclusion is the assumption that transporting fish in barges leads to a significant delayed mortality after the fish are released below Bonneville Dam, or that passage through the hydropower system by non-transported fish causes a significant "extra mortality" after the fish have passed Bonneville Dam and moved into the estuary and ocean.

In general, PATH analyses produce an optimistic picture of recovery if dams are breached. For example, the fraction of spring/summer chinook salmon simulations meeting 48-year recovery standards if dams are breached is 100 percent (Table 2-2.4-3 of PATH 1998 Final Report, Marmorek *et al.,* 1998). The management scenario corresponding to maximizing transportation and maximizing hydrosystem improvements is much less likely to yield recovery according to PATH analyses, but still has some marked chance of success on its own (roughly a 1 in 2 chance). It is not possible to use the PATH analyses to estimate the risk of not acting while more is learned about extra mortality or differential delayed transportation mortality.

CRI Analyses. In general, the CRI analyses are less optimistic than PATH analyses, because they indicate substantial risks of extinction for spring/summer chinook salmon over the next 100 years if current conditions hold, and significant extinction risks even within the next 10 years. The option of waiting until we learn more about extra mortality or differential delayed transportation mortality thus carries with it substantial risk of extinction for these species.

Detailed data concerning passage through the hydropower system are only available for spring/summer chinook, so this is the only species for which the effect of improving passage systems can be evaluated. For this species, predicted increases in survival of smolts through the migration corridor, or of adults migrating upstream from Bonneville Dam, will result in an increase in population growth rate of only 1 percent each (approximately 2 percent combined). Since an average population growth rate increase of 12 percent is necessary to reduce the risk of extinction for this species to 1 in 10 in the next 100 years, predicted passage system improvements alone do not substantially reduce the risk of extinction.

If downstream survival of outmigrating juveniles were raised to 100 percent (which is the maximum possible hydropower system improvement with respect to transportation and bypass options), that demographic change alone would still be insufficient to attain high enough annual rates of population growth to adequately reduce the extinction risk. If alterations of bypass, spill, or transportation systems increase survival below Bonneville Dam (i.e., reduce indirect mortality), however, then major benefits for population growth could be realized. Without the modifications that have already been made to the hydropower system, the current population growth rate would be reduced by 60 percent, so these improvements have been important in maintaining salmonid populations. Additional improvements to passage systems could be combined with improvements in other areas.

Current projections indicate that for spring/summer chinook, dam breaching alone is likely to result in an increase of population growth rate of about 5 percent due to reduced mortality of migrating smolts and spawners. (For this scenario, the improvements associated with breaching were assumed to result in a Bonneville-to-Basin survival of 80 percent, a downstream survival of 62 percent and an increase in estuarine survival of 30 percent (which corresponds to a **D** = .7)). By itself, then, dam breaching does not appear to be sufficient to adequately reduce the risk of extinction for this ESU.

As with passage systems, if dam breaching increases survival of fish below Bonneville Dam, then substantial increases in population growth rate could be achieved. For example, dam drawdown could also result in increases in habitat availability and possible improvements in survivorship during freshwater rearing (there is some evidence that young may experience elevated mortality when reared in reservoirs.) Dam breaching could also alter patterns of nutrient cycling and replenishment that in turn influence productivity. There could even be delayed effects of dam breaching in terms of increased fitness of fish that would be subtly manifested throughout the life cycle (as opposed to discrete improvements in the survival at any isolated stage.)

Snake River Fall Chinook
Data regarding survival downstream and the proportion of smolts transported is limited for this ESU, making assessment of both passage alterations and drawdown options difficult.

PATH Analysis. As with spring/summer chinook, PATH analyses indicate that for fall chinook, dam breaching produces the largest fraction of simulated future fish populations exceeding particular survival and recovery criteria.

CRI Analysis. Extinction risk analysis indicates that there is a significant risk of extinction over the next 100 years if current conditions are maintained (or worsened). An approximately 4 percent increase in population growth rate is expected to lower the probability of quasi-extinction within 100 years to one in a hundred.

The majority of effects of dam breaching would likely occur in the first year of life (s_1 stage), which includes both downstream migration and "post-Bonneville" survival in the estuarine environment, where latent effects of dams are likely to accrue. We examined the percent increase in population growth rate expected to result from a broad range of potential changes in first year survival. This level of improvement in population growth rate could be achieved with a less than 20 percent increase. Whether such a change would actually occur under dam breaching is unknown. Breaching would also increase the number of river miles available to fall chinook for spawning by 77 percent, and may therefore increase the carrying capacity for this species. Such an increase may be important for recovery of this species.

Snake River Steelhead
The impact of dam breaching on steelhead is much harder to evaluate because their life cycle is complex and data on passage survival rates are almost entirely lacking. Extinction risk analyses indicate that dam breaching alone

must enhance survival by 20 percent to increase the annual rate of growth to levels that would produce acceptably low risks of extinction.

Snake River Sockeye
Snake River sockeye are currently so depleted that no analysis can be conducted.

Other Columbia Basin ESUs
Other Columbia Basin ESUs have not yet been analyzed. Improving passage systems at the four Lower Columbia dams will benefit mid- and Upper Columbia stocks to an unknown degree. In addition, increased spring flows may result in unquantifiable benefits to all stocks, due to changes in estuarine conditions.

b) Passage Survival Estimates, SIMPAS2

As stated above, the CRI model indicates that improvements to direct passage survival alone would not result in high enough rates of population growth to reduce the extinction risk of Snake River spring/summer chinook salmon to 1 in 10 in the next 100 years. However, improvements that increase direct survival, combined with improvements in other areas, have the potential to reduce the risk of extinction to this species.

The hydro workgroup used the SIMPAS2 spreadsheet model to estimate the level of improvement in direct survival that could be expected with configuration and operational changes, including surface bypass systems and guidance curtains at the Snake River collector projects, extended-length guidance screens at John Day Dam and Bonneville Dam first powerhouse, more efficient turbines with minimum gap runners at most projects, and higher levels of spill at all projects. Results of SIMPAS2 modeling are preliminary and subject to revision pending regional review.

Snake River Spring/Summer Chinook Salmon
For Snake River spring/summer chinook salmon, the SIMPAS2 results are shown in Table IV-3. The 1995 BO stated that the action agencies should reduce or eliminate spill at Snake River collector projects during low-flow periods. The hydro workgroup has not yet addressed the question of whether the aggressive program would maximize spill at these projects under all flow conditions. The aggressive program was therefore modeled both ways, with and without spill in the low-flow year.

Assuming that maximum spill would be provided under all flow conditions, the effect of the aggressive program would be to significantly reduce the proportion of fish transported, compared to the current program; approximately 33 percent in the high-flow year, 60 percent in the medium-flow year, and 74 percent in the low-flow year. Assuming that the direct survival of a transported fish would be high (98 percent), a large reduction in the proportion of fish transported would decrease total direct survival to the tailrace of Bonneville Dam (9 percent, 21 percent, and 34 percent in the high, medium, and low-flow years, respectively). At the same time, the spreadsheet model indicates up to a 10 percent improvement in survival rates for in-river migrants under each water condition (10 percent under high flow and 9 percent under both medium and low-flow conditions). These findings do not address the question of differential delayed mortality of transported fish or extra mortality due to hydrosystem passage).

Assuming that spill would be eliminated at collector projects in low-flow years, the proportion of fish transported (88 percent) and total direct survival (87 percent) would be similar to estimates derived for the current condition; see Table IV-3. The survival rate of in-river migrants would be approximately 7 percent higher than under the current program, marginally lower than in the case where a high proportion of the run could pass the upper projects via spillways.

Upper Columbia River Steelhead

Upper Columbia River steelhead are not transported around the hydrosystem. The hydro workgroup used the spreadsheet model to estimate the direct in-river survival of juvenile steelhead from the point at which each spawning population enters the mainstem (i.e., above Wells, Rocky Reach, and Rock Island dams, respectively) both to the head of McNary pool and to the tailrace of Bonneville Dam; see Table IV-3. Survival to the head of McNary pool reflects the effects of the hydro projects operated by the mid-Columbia public utility districts (PUDs) (Chelan, Douglas, and Grant County PUDs). Estimates of survival to below Bonneville add the effects of passage through the Lower Columbia reach. For comparison to survival through the reach affected by the PUD projects, we also estimated survival from the head of McNary pool to the Bonneville tailrace.

The aggressive program assumes the PUDs achieve over 95 percent survival per project, a figured based on their Habitat Conservation Plan. Compared to the current program, the aggressive program would increase the direct in-river survival of Upper Columbia steelhead to the Bonneville tailrace by up to 9 percent (9 percent, 8 percent, and 8 percent in the high, medium, and low-flow years, respectively). When divided into two parts, the expected level of survival through the Lower Columbia reach is similar to that through the PUD projects. For example, in a high-flow year, survival through the lower reach would be approximately 70 percent compared to 74 percent from the point of entry to the head of McNary pool. In a low-flow year, estimates of survival would be approximately 65 percent in the lower reach and 69 percent upstream. As with Snake River spring/summer chinook salmon, these findings do not address the question of latent effects due to hydrosystem passage.

Table IV-3: Preliminary Results of SIMPAS2 Modeling for the Federal Hydro Caucus

NOTE: These results are rough estimates of direct survival through the mainstem hydrosystem (to the tailrace of Bonneville Dam).
These estimates do not include any possible delayed mortality effects caused by either the hydrosystem or the transportation program.

Wild Snake River Spring/Summer Chinook

Alternative	High-Flow Year			Medium-Flow Year			Low-Flow Year		
	With Transport		W/out Trans.	With Transport		W/out Trans.	With Transport		W/out Trans.
	Prop. Trans.	Total Surv.	In-river Surv.[1]	Prop. Trans.	Total Surv.	In-river Surv.[1]	Prop. Trans.	Total Surv.	In-river Surv.[1]
SIMPAS2 -- Current Program[2]	0.79	0.83	0.48	0.75	0.80	0.45	0.86	0.85	0.37
SIMPAS2 -- Aggressive Program[3]	0.46	0.74	0.58	0.15	0.59	0.54	0.12	0.51	0.46
SIMPAS2 -- Aggressive Program with no spill at LSR collector projects in the low flow condition, per the 1995 FCRPS Biological Opinion							0.88	0.87	0.44
LSR Natural River Drawdown - (FW Alt 3) Average of CRiSP and FLUSH -A3 Results[4,5]			0.65			0.64			0.58

[1] This estimate of In-river survival assumes that no fish are collected for transport. All fish entering the juvenile bypass systems are diverted back to the river.
[2] Pool survivals for high flow year estimated from recent NMFS reach survival studies: LGR, LGS, IHR = 0.97; LMN = 0.95; MCN, JDA, TDA, BON = 0.93.
These values were decremented for the medium- and low-flow conditions as follows: Snake River pools - medium flow (-2%) and low flow (-4%), lower Columbia River pools - low flow (-2%).
[3] For purpose of comparison, includes high levels of spill at LSR collector projects even under the low-flow condition.
[4] C. Toole (NMFS) memo to P. Kareiva (NWFSC) dated 7/12/99
[5] Overall average across FLUSH and CRiSP and both Snake River reach survival assumptions (i.e. 0.85 and 0.95).

Upper Columbia River Steelhead

Alternative	High-Flow Year			Medium-Flow Year			Low-Flow Year		
	In-river Survival to		Est. Surv. From	In-river Survival to		Est. Surv. From	In-river Survival to		Est. Surv. From
	MCN pool	BON tailrace	MCN to BON[5]	MCN pool	BON tailrace	MCN to BON[5]	MCN pool	BON tailrace	MCN to BON[5]
SIMPAS2 -- Current Program[4]	0.68	0.43	0.63	0.65	0.42	0.65	0.63	0.37	0.59
SIMPAS2 -- Aggressive Program	0.74	0.52	0.70	0.71	0.50	0.70	0.69	0.45	0.65

[4] Pool survivals for high flow year (< 135 kcfs at PRD) estimated from PUD survival studies: WEL=0.99, RRC=0.95, RIS=0.97, WAN=0.96, PRD=0.96 and from recent NMFS survival studies (MCN, JDA, TDA, BON = 0.93).
These values were decremented for the medium- and low-flow conditions as follows: Upper Columbia River - medium flow (-1%) and low flow (-2%), lower Columbia River pools - low flow (-2%).
[5] MCN pool to BON tailrace survival was estimated as (survival to BON tailrace) / (survival to MCN pool).

(c) Ecosystem Diagnosis and Treatment (EDT) Analysis

The NWPPC's Multispecies Framework Project will characterize a set of alternative futures for the Columbia River Basin that focus on a long-term vision for the region. The Framework will use an analytical technique called Ecosystem Diagnosis and Treatment (EDT) to compare the ecological impacts of various alternatives and describe the economic, social, and cultural impacts.

The EDT has some distinct features that distinguish it from other analytical tools the region has used. It focuses on long-term conditions and places an emphasis on habitat actions. The EDT zeros in on the relationship between habitat characteristics and the biological response. The ecosystem component of the analysis refers to describing the physical habitat without regard to a species of fish or wildlife. The diagnostic component is the scaling of that habitat with respect to specific species. In other words, it diagnoses the health of the environment with regard to a species. According to the analysis, a healthy environment results in productive and sustainable populations of the target species and achieves the social ends described in the long-term vision. Treatment is the set of strategies that will move the ecosystem from its present state to one that is healthy. The treatment takes the form of an action plan that aims to change the ecosystem and transform it to health.

EDT is an explanatory model. It attempts to provide a hypothesis about how species relate to their environment. In contrast to other analytical methods, it is not statistically based. It does not deal in probabilities and will not provide statistical confidence limits. The EDT philosophy is that statistical correlation does not always address the underlying cause of observed phenomena. While statistical predictions are useful, EDT attempts to explain the mechanisms behind observations. The EDT model will compare the long-term or end-state condition that would occur under different alternatives. It assumes that each strategy in an alternative is fully implemented and results fully realized.

EDT places a major emphasis on life histories of the species being evaluated. Habitat is evaluated for its relationship to each of several life history stages. There are, for example, 16 life-history stages for chinook salmon. EDT is able to identify a number of alternative pathways that may be successful under a particular alternative. As a result, EDT provides a way to compare alternatives with regard to their effect on species' life histories, in addition to the more traditional values of abundance and productivity.

Although EDT is new to the Council's Framework process and to overall regional planning, it is not a new analytical process. A crude form of EDT was used during the NWPPC's system planning effort in the late 1980s. The technique was refined during the Regional Assessment of Supplementation Project and has since been expanded and improved. Modern computers, data bases, and geographic information systems have greatly added to the capabilities of EDT, and it has been extensively used in development of subbasin plans in the Columbia River Basin and in the Puget Sound area.

3. *Other Analyses*

(a) VARQ and Integrated Rule Curve (IRC) Operation

A recent flood control operation has been proposed that improves the multi-purpose operation of Libby (LIB) and Hungry Horse (HGH) reservoirs. It is referred to as VARQ. This proposal reduces the flood control space available in years with moderate potential for flooding, increasing the late spring and summer project discharges. These higher discharges are more consistent with flow objectives required for flow augmentation in the NMFS and USFWS BOs. BPA conducted a 50-year hydroregulation study using the VARQs in order to compare the operations at reservoirs and resulting downstream effects to that obtained under current operating procedures.

The VARQ operations result in higher winter and spring elevations at both LIB and HGH in comparison to present BO operation. The range of higher elevations in the 50 years studied can be as much as 57 feet at Libby and 35 feet at HGH. An offsetting difference in flood control space exists for Grand Coulee. The range of lower elevations at Grand Coulee can be as much as 9.5 feet lower during years with moderate potential for flooding. The following table presents the average end-of-month elevation difference for all 50 water years for these three reservoirs compared to the present BO operation.

Libby, Horse and Coulee Average 50-Year Monthly Ending Elevation Differences (ft)

VARQ – BO	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
HGH Difference	0	0	0	0	0	0	4	2	2	8	10	5	3	1	2.2
LIB Difference	5	4	2	1	1	0	16	25	31	31	31	26	18	9	13.7
GCL Difference	0	0	0	0	0	0	0	0	-1	-2	-2	0	0	0	-0.2

The distribution of flows with VARQ has a flatter shape across the year. The regulation with VARQ has the effect of redistributing January through May discharges into June through December. This redistribution comes mostly from LIB, but also partially from HGH and GCL. This flatter shape has a benefit of lower average annual spill at most projects. Projects with fish programs that spill a percentage of total project flow (The Dalles (TDA) and John Day (JDA)) have higher summer spill with VARQ.

McNary Average 50-Year Monthly Flow Differences (kcfs)

	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
VARQ – BO	5.20	2.97	0.92	0.72	0.38	0.44	-9.19	-2.33	0.04	0.13	-1.49	-2.27	1.38	6.01	0.0

The differences in the Federal generation largely follow the same pattern as the discharge differences (see the following table). Average annual generation is highest with the VARQ study case compared to the present BO operation. The 23 average megawatt (aMW) benefit is too small to be considered significant and is less than 0.3 percent of the total Federal generation.

Federal Average 50-Year Monthly Generation Differences (aMW)															
	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
VARQ – BO	310	207	105	77	20	21	-491	-165	-55	182	-127	-97	111	454	23

The above differences were obtained from hydroregulation studies that are based on the current configuration of Federal and non-Federal hydropower projects and present flow augmentation objectives. Alternatives under exploration by the hydro workgroup of the Federal Caucus and the Frame workgroup that vary from the present configuration and flow augmentation objectives would not necessarily have the same differences.

Integrated Rule Curves (IRCs)
Current operation planning is, in part, based on Biological Rule Curves that attempt to fulfill the objectives declared in the BO. An alternative to these Biological Rule Curves are Integrated Rule Curves (IRCs). These IRCs strive to benefit both resident and downstream fish species and were designed to be consistent with the VARQ flood control alternative.

BPA conducted 50-year hydroregulations using the VARQ-based IRCs in order to compare reservoir operations and downstream effects to those obtained under current operating procedures.

With IRC operations, higher fall elevations result at both LIB and HGH in comparison to present BO operation. This operation allows resident fish species to have greater access to food sources and habitat. The IRC operation also causes a late-winter and early-spring elevation that is deeper at HGH and shallower at LIB. Grand Coulee (GCL) operates at slightly deeper elevations in the spring as a result of the VARQ component of the IRC operation. The following table presents the average end-of-month elevation difference for all 50 water years for these three reservoirs compared to the BO operation.

Libby, Horse and Coulee Average 50-Year Monthly Ending Elevation Differences (ft)															
IRC – BO	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
HGH Difference	4.0	6.7	7.1	9.8	10.3	10.7	7.1	-3.6	-17.6	-11.6	-5.8	-5.1	-1.2	2.1	1.7
LIB Difference	13.4	12.6	9.0	13.9	3.2	0.0	11.6	15.0	15.8	14.4	14.1	-0.5	2.1	13.7	9.2
GCL Difference	0.1	0.2	0.0	-0.5	0.0	0.7	0.5	0.1	-1.7	-1.4	-1.9	-0.5	0.2	0.0	-0.2

The average net effect of the higher fall and early-winter elevations results in greater availability of a winter draft. This reshapes the discharges through McNary and other lower river projects in comparison to the monthly discharge pattern achieved in the BO operation. The average impact of the IRC regulation causes slightly higher discharges for the general periods from November to May and somewhat lower during the rest of the year, as shown on the following table. Flows at McNary are 3.3 kcfs lower on average during August under IRCs. NMFS adopted drafts of up to 20 feet from these upper river storage projects to increase flows for listed Snake River fall chinook during July and August.

McNary Average 50-Year Monthly Flow Differences (kcfs)															
	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
IRC – BO	-3.3	-0.8	2.9	-3.5	6.8	1.3	-3.9	3.3	4.3	2.4	0.1	0.6	-0.5	-9.9	0.0

The differences in the Federal generation largely follow the same pattern as the discharge differences. As shown on the following table, average annual generation is highest with the IRC study case compared to the BO operation by a very small margin of 23 aMW, or 0.2 percent of the energy production of the Pacific Northwest's coordinated system.

Federal Average 50-Year Monthly Generation Differences (aMW)															
	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1	APR2	MAY	JUN	JUL	AVG
IRC – BO	-199	-55	241	-307	587	125	-181	344	345	99	-38	102	-105	-727	23

The above differences were obtained from hydroregulation studies that are based on the current configuration of Federal and non-Federal hydropower projects and present flow augmentation objectives. Alternatives that assume different configurations and flow augmentation objectives would not necessarily yield the same results.

(b) Implementation Cost Analysis

Implementation costs for configuration measures have been estimated for the three options. Also, considerable cost analyses has been conducted in related studies, primarily the Lower Snake River Feasibility Study and the related Drawdown Regional Economics Workgroup, which is addressing economic and social effects of the dam breach option. Additional analysis is expected in the Multispecies Framework. A brief summary of implementation costs is presented below. A summary of economic effects for the breach option is also provided.

For each option a range of estimated annual configuration development and construction costs was assessed. These include all costs beginning with initial planning and evaluation to full implementation of each measure. We also estimated the annual funding required to implement these measures over a 10-year period. The cost and funding estimates are intended to be used for planning and comparison purposes only; they are best estimates at this stage of analysis and are not necessarily precise. A comprehensive list of configuration actions and cost summaries is contained in Table ATT1-1 in Attachment One of this report.

Current Program – Implementation cost of configuration measures ranges from $185 million for continued investigations and implementation of known improvements to $1.08 billion if development and evaluations lead to full implementation of identified potential measures. The economic effects of system operation under the lower-cost scenario are the same as what is currently occurring, but they have not been evaluated for the higher-cost scenario.

Aggressive Program – Implementation cost of configuration measures is estimated to range from $750 million to $1 billion. The economic effects related to system operation have not been evaluated at this time.

Breach Lower Snake River Dams - Implementation cost of configuration measures ranges from $1.2 billion to $1.9 billion. At the low end of the range, $1.2 billion, there is an assumption that in addition to dam breaching, limited additional passage improvements are made at four dams on the Columbia River (McNary, John Day, The Dalles, and Bonneville). At the high end of the range, $1.9 billion, there is an assumption that in addition to dam breaching, studies and decisions lead to major passage improvements at these four Columbia River Dams.

The annual economic impact associated with the breach option, as estimated in the Lower Snake River Juvenile Salmon Migration Feasibility Study and Draft Environmental Impact Statement, is $171million to $220 million, not including annual implementation cost and as compared to existing conditions. National economic costs are as much as $290 million for power, $30 million for navigation, and $17 million for water supply, annually. These costs are partially offset by economic benefits in recreation ($82m) and commercial fishing ($5m), and by avoiding costs associated with maintaining operation of the four Lower Snake Dams ($30m).

SECTION V. IMPLEMENTATION OF HYDRO ACTIONS

The 1995 BO refined the structure for coordinating the decisions on configuration and operation of the FCRPS. That structure includes a group of program managers, known as the Implementation Team, which meets monthly. The structure contemplated in the BO also included an Executive Committee that would meet as needed to resolve disputes from the Implementation Team. That committee has not met in over a year and there appears to be little interest among the state and tribal managers to participate in such a committee.

Under the Implementation Team are several technical workgroups established to address different issues. The Technical Management Team meets weekly during the migration season to set hydropower operations. The System Configuration Team meets monthly and establishes priorities and schedules for capital improvements at the projects. The Water Quality Team provides scientific and technical recommendations on two critical water quality parameters: dissolved gas and temperature. In conjunction with these teams, there are existing groups that coordinate technical and programmatic aspects of regional activities in the hydropower arena. These include the COE's Fish Passage Operation and Maintenance Committee, Fish Facilities Design Review Workgroup, Studies Review Workgroup, and a workgroup associated with the Memorandum of Agreement (MOA) on BPA's investments in fish and wildlife recovery. A more detailed description of these groups, their origin, and related processes is included in Attachment 4.

The Federal agencies believe this type of intensive coordination in a hierarchical structure is appropriate and recommend it continue. There are a number of opportunities for improvement, including:

- Policy Oversight – we recommend using the newly formed Columbia River Basin Forum as the policy oversight body to consider disputes that cannot be resolved at the Implementation Team level.

- Participation – there is often minimal or inconsistent participation by key sovereign entities. Consistent participation would improve decisionmaking and timely implementation of actions and measures.

- Federal/non-Federal Coordination – presently there is informal coordination of activities at FERC-licensed projects, e.g., configuration measures at mid-Columbia projects, with Federal efforts at downstream dams. Although there is a Mid-Columbia Coordinating Committee, there could be better links established to ensure that coordination of programs and technology transfers occur. Also, the FERC-relicensing process for Idaho Power Company's Hells Canyon Complex should be integrated with other regional hydro efforts.

- Research Framework – a multiyear regional research plan identifying priorities and responsibilities, and enabling coordination of programs and budgets, could improve efficiency and enhance integration of research results into decisionmaking.

- In-Season Management of River Operations – while the coordination and decision structure currently in place for in-season management works well, the following improvements are recommended:

  – Place greater emphasis on an annual plan for the upcoming migration season.

  – Include criteria in the annual plan to guide decisions that have to be made during the season.

  – Prepare an experimental management plan prior to considering the implementation of any actions that are outside the requirements of existing BOs.

Attachment One

HYDRO CONFIGURATION DESCRIPTIONS

OPTION 1 – CURRENT PROGRAM (Framework #4)

Objectives and relationship to strategies – *This option would continue investigations of mainstem hydro configuration options for survival improvement potential, but would concurrently emphasize survival improvement investigations in the other H's. It includes adult passage configuration improvements, but does not initially include other configuration construction measures.*

(Refer to Table IV-1 in Section IV for abbreviated list of project-by-project actions for each option.)

MIDDLE COLUMBIA

Bonneville

a.1 Emergency Auxiliary Water Supply (AWS)

Description: Develop new emergency backup system, which may require conventional screen and bypass system to protect juvenile fish from entrainment into AWS.
Purpose and Rationale: Both auxiliary water turbines can be out of service at once. The existing emergency backup is the trash sluice chute, which is targeted as the new permanent surface bypass system at B-2.
Schedule and Decision Points: Alternatives study in year 2000, design and construct by 2003
Costs: $25 million
Benefits: This action is not necessarily to improve adult passage at B-2, but to keep from diminishing adequacy of passage if existing fish water AWS turbines are unable to operate (as in 1997 during the peak of the adult fall chinook passage period).

a.2 Adult Fallback

Description: Continue to investigate and develop adult fallback reduction alternatives. Implement as appropriate.
Purpose and Rationale: RM&E has correlated adult fallback to the tailrace as a factor in reducing the potential for spawning success. Fallback rates at Bonneville (especially Bradford Island fishway exit) are excessively high.
Schedule and Decision Points: Conduct additional RM&E in 2000, continue to investigate variables possibly associated with fallback at Bonneville, develop and implement solutions as appropriate.
Costs: $10 million
Benefits: Reduced fallback rates for adult fish and increased migration returns to natal streams with successful spawning completion.

The Dalles

b.1 Dissolved Gas Fast-Track and Physical Injury Investigations

Description: Maximize safe spillway passage while minimizing mortality and total dissolved gas levels. Minimize mechanistic mortality problems in the spillway tailrace as appropriate through deflector construction.

Purpose and Rationale: Total dissolved gas levels during high spill at The Dalles are relatively low. However, mortality studies have suggested that fish mortality rates rise at higher spill levels. Since the goal is to pass as many fish over the spillway at the highest survival rate, additional investigations are required to determine how to concurrently maximize spillway passage and survival rates. Deflectors may be required.

Schedule and Decision Points: RM&E was initiated in 1996 to address spillway discharge percentages versus mortality rates. Additional mortality studies are scheduled for 2000. Physical injury studies may be required to determine whether deflectors are required. A decision is targeted for 2003. Basin at spill percentages currently under investigation.

Costs: $13 million

Benefits: RM&E suggests spillway mortality rates may be reduced at some spill levels by up to 10 percent.

John Day

C1 Fishway Exit Modifications

Description: Investigate and implement corrective measures, as appropriate, to reduce adult fish holding in the north and south fishways.

Purpose and Rationale: Prolonged adult fish holding in the John Day fish ladders represents is a potential problem for many upstream migrants.

Schedule and Decision Points: Complete investigations, identify most-preferred alternative, determine whether to go into design phase.

Costs: $6 million

Benefits: Undetermined

McNary

d.1 Adult Auxiliary Water System Upgrade

Description: Improve reliability and performance of the adult fishway AWS.

Purpose and Rationale: Reduced risk of adult passage delays due to AWS failure during migration periods.

Schedule and Decision Points: A comprehensive AWS study for McNary has been completed, but is awaiting funding.

Costs: $3 million

Benefits: These measures would reduce the risk of delaying/losing adult fish during peak migration periods due to aging AWS facilities.

d.2 JBS Modification

Description: Investigate and implement JBS improvement measures associated with debris handling, appropriate improved juvenile separation, orifice collection channel, and intake screen and bypass performance.

Purpose and Rationale: Debris at McNary has created appreciable JBS, ESBS and bypass outfall problems. RM&E has shown the need for improved separation efficiencies that could result in higher transit and post-release survival of juvenile migrants. Other JBS needs include reducing excessive juvenile and predator holding in the orifice collection channel, bypass outfall pipe clogging, and other problems.
Schedule and Decision Points: Conclude separator testing, develop debris handling strategies and modifications, and address other JBS needs by late 2000. Initiate modifications design and construction after 2000.
Costs: $5 million
Benefits: Post-barge and truck release, and river bypass survival is expected to increase by an unknown quantity.

d.3 Adult Egress from JBS Orifice Collection Channel (OCC)

Description: Provide egress for adult fish which have fallen back through turbine intakes and been routed through gatewell orifices to the JBS-orifice collection channel. This may include a small adult fish ladder of some kind to assess whether adult fish will find and use the passage facility.
Purpose and Rationale: a significant number of adult fish are being deadended at the McNary and Ice Harbor OCC. These fish need to be afforded an opportunity to exit into forebay. If the problem is correctable, install permanent facility at both sites.
Schedule and Decision Points: Install and test fish responses to prototype adult egress facility in 2000. Proceed into design and construction phase for a permanent egress facility at both McNary and Ice Harbor if prototype is successful.
Costs: $1 million
Benefits: Number of adult fish in the McNary OCC is approximately a few hundred per year Adult Egress from Orifice Collection Channel.

LOWER SNAKE

Ice Harbor

e.1 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.
Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.
Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to

AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

e.2 Adult Egress from JBS Orifice Collection Channel

Description: Provide egress for adult fish which have fallen back through turbine intakes and been routed through gatewell orifices to the JBS-orifice collection channel. This may include a small adult fish ladder of some kind to assess whether adult fish will find and use the passage facility.

Purpose and Rationale: a significant number of adult fish are being deadended at the McNary and Ice Harbor OCC. These fish need to be afforded an opportunity to exit into forebay. If the problem is correctable, install permanent facility at both sites.

Schedule and Decision Points: Install and test fish responses to prototype adult egress facility in 2000. Proceed into design and construction phase for a permanent egress facility at both McNary and Ice Harbor if prototype is successful.

Costs: $1 million

Benefits: Number of adult fish in the McNary OCC is approximately a few hundred per year.

Lower Monumental

f.1 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.

Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.

Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.

Costs: $2.5 million

Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

Little Goose

g.1 Trash Boom

Description: Install trash boom to reduce debris at the powerhouse face and associated JBS debris problems that result in juvenile fish injuries.

Purpose and Rationale: During 1996-98, an unprecedented debris surveillance program was required to minimize juvenile descaling problems. This measure is expected to keep debris from accumulating at the powerhouse, thereby reducing the degree of adverse fish impact.

Schedule and Decision Points: Design is to be completed in late 1999, with construction in 2000. Since this is a containment boom that will

require debris removal, and contrasts with the Lower Granite shear boom, debris removal frequency criteria are in place.
Costs: $2.5 million
Benefits: Reduced descaling rates of transported fish of an undetermined quantity.

g.2 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.
Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.
Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

Lower Granite

h.1 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.
Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.
Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

Chief Joseph

Description: Design and construct spillway deflectors to abate total dissolved gas.
Purpose and Rationale: Total dissolved gas downstream of Chief Joseph is excessive during some years. Deflectors have the demonstrated ability to provide moderate reductions in supersaturation to levels not harmful to salmon.
Schedule and Decision Points: Hydraulic modeling commences in 1999; design will commence in 2000 pending funding. Construction could begin

in late 2000 pending funding, and be completed in two or less winter work windows.
Costs: $40 million
Benefits: Reduced total dissolved gas levels will be evident during wetter years, but the survival benefit has not been determined.

Universal

1. Replace/Refurbish Aging Fish Facilities
   Description: Columbia and Snake River COE Dams are aging, and in need replacement or refurbishing of some fish passage (and other) facilities. Turbines are already being (or soon will be) replaced/refurbished at some COE dams; the same will be required for fish passage facilities.
   Purpose and Rationale: Maintain satisfactory adult and juvenile passage at Columbia and Lower Snake River sites.
   Schedule and Decision Points: Some facilities are now being listed as needing major refurbishing. Others will continue to be listed. A major stumbling block is the need for unencumbered ability to fund these activities.
   Costs: Continuing at an increasing rate
   Benefits: Maintain satisfactory fish passage, versus gradual deterioration of fish passage facilities performance during the next decades.
2. Residual Fish Passage Needs – Assess, Scope, and Implement
   Description: This activity relates to continuously evolving and improving RM&E equipment and strategies that contribute to an increased understanding of fish passage on the Snake and Lower Columbia Rivers. As more is learned, clearer understanding of residual fish passage needs and priorities result. It is impossible to identify all future fish passage needs at this time. This activity is a placeholder.
   Purpose and Rationale: Assure that future and currently unidentified fish passage facilities needs are satisfactorily addressed.
   Schedule and Decision Points: Currently undefined
   Costs: Currently undefined
   Benefits: Currently undefined
3. Dissolved Gas Abatement
   Description: Additional RM&E is required to abate total dissolved gas beyond levels afforded by deflectors.
   Purpose and Rationale: Identification of safe means of lower dissolved gas levels to 110 percent supersaturation have not been identified at this time. However, additional efforts are needed before concluding that development of a satisfactory option is not possible.
   Schedule and Decision Points: The Dissolved Gas Abatement, Phase 2, Technical Report is to be completed in 2000. A decision on additional initiatives should occur at that time.
   Costs: $1 million in 2000, undetermined after 2000.

Benefits: While fish benefits are largely satisfied by spillway deflectors that drop supersaturation levels below 120 percent, the water quality goal of 110 percent cannot be satisfied without additional RM&D. Fish survival benefits of reducing total dissolved gas from 120 percent to 110 percent are undetermined.

OPTION 2 – AGGRESSIVE PROGRAM (4H)

Objectives and relationship to strategy – This strategy emphasizes dependence on aggressive configuration measures at each Lower Snake and middle Columbia COE mainstem hydro project to optimize fish passage survival, but recognizes that RM&E will dictate which configuration actions are constructed.

(Refer to Table IV-1 in Section IV for abbreviated list of project-by-project actions for each option.)

MID-COLUMBIA

Bonneville Dam

a.1 Emergency Auxiliary Water Supply (AWS)

Description: Develop new emergency backup system, which may require conventional screen and bypass system to protect juvenile fish from entrainment into AWS.
Purpose and Rationale: Both auxiliary water turbines can be out of service at once. The existing emergency backup is the trash sluice chute, which is targeted as the new permanent surface bypass system at B-2.
Schedule and Decision Points: Alternatives study in year 2000, design and construct by 2003
Costs: $25 million
Benefits: This action is not necessarily to improve adult passage at B-2, but to keep from diminishing adequacy of passage if existing fish water AWS turbines are unable to operate (as in 1997 during the peak of the adult fall chinook passage period).

a.2 Dissolved Gas Fast-Track

Description: Identify, design, and install optimum spillway deflector design.
Purpose and Rationale: Reduce dissolved gas levels to improve water quality and increase spill levels at the annually designated gas cap over largest possible voluntary and involuntary spill range to increase the percentage of juveniles passing the spillway.
Schedule and Decision Points: Near-field dissolved gas studies occurred in 1999. Fast-Track deflector optimization is prioritized at Bonneville Dam, and will result in hydraulic modeling in year 2000 and a decision on deflector design with which to proceed into design by late 2000 or 2001.

Costs: $25 million
Benefits: Targeted spill increases from the current dissolved gas cap level of 130,000 to 180,000 cfs. This would potentially increase Bonneville Dam fish passage efficiency (passage of juveniles through non-turbine routes) by 10 percent (unsubstantiated estimate of B-2 fish passage efficiency improvement).

a.3 Bonneville 1st Powerhouse (B-1) Extended Submerged Bar Screen (ESBS) and Juvenile Bypass System (JBS)
Description: Installation of 40' ESBS and vertical barrier screens (VBS), modify orifice to allow free discharge in the OCC, build new OCC dewatering screens, and route bypass flume to north shore sampling and B-2 outfall location.
Purpose and Rationale: These improvements would intercept and safely bypass a greater percentage of juvenile fish than with the current 20' submerged traveling screens (STS) and bypass system (which is known to intercept fewer fish and discharge them into near tailwater locations that result in excessive predation rate)s.
Schedule and Decision Points: Prototype test the ESBS for a second year in year 2000, complete design of the entire scope of work in year 2000, decide between ESBS-JBS and the prototype surface collection facilities in late 2000.
Costs: $95 million
Benefits: Current FGE for 20' STS is 38 percent for yearling chinook and 9 percent for subyearlings. Targeted increase is to 80 percent for yearlings and 60 percent for subyearlings.

a.4 Bonneville 2nd Powerhouse (B-2) Surface Bypass
Description: Design and construct permanent corner collector at the existing sluice chute at the south end of the powerhouse and relocate high-flow (5,000-10,000 cfs) bypass outfall to assure safe juvenile passage relative to mechanical and predation effects. Also, replace the sluice chute control gate and construct an ogee chute to reduce the potential for injuries within the system.
Purpose and Rationale: Existing B-2 STS FGE is marginal and an increase in non-turbine juvenile passage was demonstrated at B-2.
Schedule and Decision Points : Based on successful 1998 RM&E, this project activity was elevated in importance and an alternatives study was initiated to identify the most appropriate high-flow outfall location. Design of this facility is targeted for completion by 2001, with construction targeted for completion by 2003.
Costs: $25 million
Benefits: Increase FPE by 20 percent for yearling and subyearling chinook (unsubstantiated estimate).

a.5 Bonneville 1st Powerhouse (B-1) Surface Bypass
Description: The B-1 prototype is similar to the successful surface bypass facilities at Wells, and includes large deep entrances on the upstream powerhouse face that, if successful, could be designed to route

surface-oriented juvenile fish into a new collection channel. Multiple entrances would direct flow (approximately 15,000 cfs) southward, then to a safe outfall location in the B-1 tailrace.

Purpose and Rationale: Improve collection and bypass of juvenile fish at B-1, which currently has very high turbine entrainment rates. Current FGE for 20’ submerged traveling screens (STS) is listed as 38 percent for spring chinook yearlings and 9 percent for subyearlings.

Schedule and Decision Points: Concurrently develop surface bypass/collection prototype and outfall for comparison with extended submerged bar screen (ESBS) and bypass system alternative by end of year 2000. Decide on one or the other (or a hybrid with each) by 2001, on the basis of RM&E, and initiate design and construction of the selected permanent alternative by 2003, with completion in 2006-2007.

Costs: - Prototype, RM&E , and development costs in the near-term are approximately $10 million in year 2000 and, if retesting is required, 2001. Design and construction of permanent facilities are estimated at $250 million, although these figures are considered very preliminary.

Benefits: Targeted increases are to 80 percent for yearling chinook and 60 percent for chinook subyearlings.

a.6 Adult Fallback

Description: Continue to investigate and develop adult fallback reduction alternatives. Implement as appropriate.

Purpose and Rationale: RM&E has correlated adult fallback to the tailrace as a factor in reducing the potential for spawning success. Fallback rates at Bonneville Dam (especially Bradford Island fishway exit) are excessively high.

Schedule and Decision Points: Conduct additional RM&E in 2000, continue to investigate variables possibly associated with fallback at Bonneville Dam, develop and implement solutions as appropriate.

Costs: $10 million

Benefits: Reduced fallback rates for adult fish and increased migration returns to natal streams with successful spawning completion.

a.7 B-2 Intake Screen Fish Guidance Efficiency (FGE) Improvement

Description: Improve FGE of intake screens at B-2 through modifications downstream of intake trash racks, upstream of the intake trash racks, or both.

Purpose and Rationale: New juvenile bypass system and outfall were completed in 1998. Improved FGE would route more bypassed fish through the new, safer bypass and outfall.

Schedule and Decision Points: Conclude investigations by 2001, proceed with design development as appropriate

Costs: $30 million

Benefits: Undefined FGE improvement

The Dalles

b.1 Sluiceway Outfall Relocation and Emergency AWS

Description: This is a composite measure, with two inseparable features. Complete development and initiate implementation of the outfall relocation to a site immediately to the south of the spillway. Construct dewatering screens to allow use of 2500 cfs (of 4800 cfs sluiceway capacity) for emergency AWS supply for the adult fishway in case existing fish water turbines fail during adult passage periods.

Purpose and Rationale: This outfall is expected to leave juvenile migrants less vulnerable to aquatic predation than the existing sluiceway outfall, and reduce the risk of mechanical fish mortality in the conveyance and at the outfall (compared to the perceived level at the existing sluiceway outfall).

Schedule and Decision Points: Complete design in year 2000, retest existing outfall mortality rate of fish passing the current sluiceway outfall year 2000, decision to proceed with construction in late 2000 or 2001.

Costs: $30 million

Benefits: Approximately 13-50 percent of spring and summer juvenile migrants use the sluiceway, depending on conditions. The targeted fish mortality reduction via the ice and trash sluiceway is 5 percent, which would equate to up to a 2.5 percent mortality reduction of the entire migrant total. The AWS component would assure adult passage is not compromised by existing AWS failures, and is a feature to avoid a problem. It is not for the purpose of reducing fish mortality, but is to avoid mortality associated with disrupted adult fish passage facilities.

b.2 Dissolved Gas Fast-Track and Physical Injury Investigations

Description: Maximize safe spillway passage while minimizing mortality and total dissolved gas levels. Minimize mechanistic mortality problems in the spillway tailrace as appropriate through deflector construction.

Purpose and Rationale: Total dissolved gas levels during high spill at The Dalles are relatively low. However, mortality studies have suggested that fish mortality rates rise at higher spill levels. Since the goal is to pass as many fish over the spillway at the highest survival rate, additional investigations are required to determine how to concurrently maximize spillway passage and survival rates. Deflectors may be required.

Schedule and Decision Points: RM&E was initiated in 1996 to address spillway discharge percentages versus mortality rates. Additional mortality studies are scheduled for 2000. Physical injury studies may be required to determine whether deflectors are required. A decision is targeted for 2003. Basin at spill percentages currently under investigation.

Costs: $13 million

Benefits: RM&E suggests spillway mortality rates may be reduced at some spill levels by up to 10 percent.

b.3 Collection Channel Dewatering

Description: This measure is to provide a dewatering system for the adult powerhouse collection channel floor diffusers, for improved access.

Purpose and Rationale: AWS floor diffusers are currently accessible only by diving. Over time, floor diffusers become loose and connections fail, resulting in the ability of adult fish to enter the AWS. These fish cannot find their way out again, and perish. Ability to dewater and inspect/repair diffusers is imperative.
Schedule and Decision Points: Completion of alternatives study in 1999, commence design in 2000, with construction to follow once funding is available.
Costs: $6 million
Benefits: While not enhancing fish numbers over time, this measure prevents catastrophic adult fish kills during migration periods, such as occurred in the early 1990s.

b.4 Surface Bypass

Description: This initiative is also referred to as trash rack occlusion. since it occludes the upper portion of the turbine intake trash rack. This measure entails investigations of surface bypass principles demonstrated at Wells, Wanapum, B-1, Rocky Reach and Lower Granite.
Purpose and Rationale: Occluding the upper turbine intake in the appropriate manner drives strong turbine flows deeper and may allow mid-depth fish to more readily pass the ice and trash sluiceway or spillway at The Dalles.
Schedule and Decision Points: Surface bypass prototype facilities development is proceeding and testing by 2000 is expected.
Costs: $6 million
Benefits: This measure, if successful, would increase the percentage of fish passing through non-turbine routes by an undefined margin.

John Day

c.1 Dissolved Gas Fast-Track

Description: Increase 120 percent gas cap spill levels for improved fish passage and water quality improvements (at both voluntary and involuntary spill levels) through deflector optimization.
Purpose and Rationale: New deflectors were constructed in 1996-97. There is some evidence that additional spill under the 120 percent total dissolved gas cap is possible if deflector elevations are changed and end bays are constructed. This would, if verified by field tests, increase spillway fish passage and water quality during both voluntary and involuntary spill periods.
Schedule and Decision Points: Near-field testing of total dissolved gas levels is scheduled for 1999-2000. Resolution of deflector needs will be in 2000; construction, as required, is to be completed by 2002.
Costs: $15 million
Benefits: A mortality reduction of up to 2 percent is possible by spilling a higher percentage of project discharge than in 1998, when a reduced spill cap led to high turbine passage rates during the peak passage and discharge period.

c.2 Surface Bypass

Description: two alternative surface bypass alternatives are being investigated – powerhouse skeleton bay surface chutes (three for each skeleton bay unit) and raised spillway crest (spill bay #20). Both options have the potential to pass large surface quantities of flow (18,000 for each skeleton bay and up to 18,000 cfs for spill bay #20 raised-crest).

Purpose and Rationale: This measure is for the purpose of providing surface-oriented fish an opportunity to discover and use this new surface passage option, thereby potentially reducing turbine passage. Due to more restrictive spill levels during daylight hours at John Day, and the limited fish guidance of existing 20' STS, this type route would possibly increase spillway fish passage efficiency.

Schedule and Decision Points: The skeleton bay design memorandum was completed by the COE in 1998. Cost estimate for one skeleton bay surface bypass was estimated at $54 million. This figure will balloon to over $70 million within a few years. Therefore, the raised-spillway-crest option at spill bay 20 is being investigated. (Note that a similar option is scheduled for prototype testing at Lower Granite in 2001.) A decision between the two surface bypass options is tentatively scheduled for late 2001. The question of priority between surface bypass versus ESBS is also due in 2001.

Costs: $54 million

Benefits: It is estimated that 75 percent of juvenile fish pass within 100 meters of skeleton bay #20. It is uncertain whether these fish will pass the surface route even if the detect its presence.

c.3 ESBS-VBS

Description: This measure improves the fish guidance efficiency of those fish drawn into turbine intakes, relative to existing shorter screens. Additional biological and engineering investigations are required before implementation.

Purpose and Rationale: There will continue to be a significant flow routed through John Day Powerhouse turbines during fish passage periods. 1996 prototype ESBS FGE and other RM&E showed excellent fish protection results. However, gatewell mortality problems were detected for the first time in 1999. Now there are additional prototype tests scheduled for 2001 and 2002 to address whether gatewell problems can be adequately addressed through VBS design refinements.

Schedule and Decision Points: A decision will be made in late 2001 relative to the fate of ESBS-VBS at John Day.

Costs: $65 million without orifice modifications, $78 million with orifice modification.

Benefits: FGE increases from 58 percent to over 80 percent occurred for yearling chinook and from 32 percent to 60 percent for subyearling chinook for the prototype ESBS relative to STS.

c.4 Fishway Exit Modifications

Description: Investigate and implement corrective measures, as appropriate, to reduce adult fish holding in the north and south fishways.
Purpose and Rationale: Prolonged adult fish holding in the John Day fish ladders represents is a potential problem for many upstream migrants.
Schedule and Decision Points: Complete investigations, identify most-preferred alternative, determine whether to go into design phase.
Costs: $6 million
Benefits: Undetermined

McNary

d.1 Dissolved Gas Fast-Track

Description: Increase 120 percent gas cap spill levels through deflector optimization
Purpose and Rationale: McNary spillway deflectors were constructed in the 1970s. Some bays were not retrofitted with deflectors. Technological developments suggest additional spillway fish passage and water quality improvements (at both voluntary and involuntary spill levels) will occur through deflector optimization.
Schedule and Decision Points: Hydraulic modeling will commence in 2000, scope of required modifications and subsequent design and construction are targeted for completion by 2004.
Costs: $26 million
Benefits: Increased spillway passage of juvenile fish and improved water quality

d.2 Adult Auxiliary Water System Upgrade

Description: Improve reliability and performance of the adult fishway AWS.
Purpose and Rationale: Reduced risk of adult passage delays due to AWS failure during migration periods.
Schedule and Decision Points: A comprehensive AWS study for McNary has been completed, but is awaiting funding.
Costs: $3 million
Benefits: These measures would reduce the risk of delaying/losing adult fish during peak migration periods due to aging AWS facilities.

d.3 JBS Modification

Description: Investigate and implement JBS improvement measures associated with debris handling, appropriate improved juvenile separation, OCC, and intake screen and bypass performance.
Purpose and Rationale: Debris at McNary has created appreciable JBS, ESBS and bypass outfall problems. RM&E has shown the need for improved separation efficiencies that could result in higher transit and post-release survival of juvenile migrants. Other JBS needs include reducing excessive juvenile and predator holding in the OCC, bypass outfall pipe clogging, and other problems.

Schedule and Decision Points: Conclude separator testing, develop debris handling strategies and modifications, and address other JBS needs by late 2000. Initiate modifications design and construction after 2000.
Costs: $5 million
Benefits: Post-barge and truck release, and river bypass survival is expected to increase by an unknown quantity.

d.4 Surface Bypass

Description: Initiate investigations of surface bypass alternatives at McNary, develop prototype surface bypass alternative and test as appropriate, construct permanent bypass alternative as appropriate.
Purpose and Rationale: Prototype surface bypass alternatives need development at McNary, since this may be a site where successful application of this technology may be realized. There is currently no other surface-oriented passage route at this site.
Schedule and Decision Points: Initiate and complete alternatives study in 2000. Select and prepare for prototype surface bypass investigations, as appropriate, in 2001-02.
Costs: $55 million
Benefits: Undefined at this time

d.5 Adult Egress

Description: Provide egress for adult fish which have fallen back through turbine intakes and been routed through gatewell orifices to the JBS-orifice collection channel. This may include a small adult fish ladder of some kind to assess whether adult fish will find and use the passage facility.
Purpose and Rationale: a significant number of adult fish are being deadended at the McNary and Ice Harbor OCC. These fish need to be afforded an opportunity to exit into forebay. If the problem is correctable, install permanent facility at both sites.
Schedule and Decision Points: Install and test fish responses to prototype adult egress facility in 2000. Proceed into design and construction phase for a permanent egress facility at both McNary and Ice Harbor if prototype is successful.
Costs: $1 million
Benefits: Number of adult fish in the McNary OCC is approximately a few hundred per year.

LOWER SNAKE

Ice Harbor

e.1 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.
Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.

Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

e.2 Adult Egress from JBS OCC

Description: Provide egress for adult fish which have fallen back through turbine intakes and been routed through gatewell orifices to the JBS-OCC. This may include a small adult fish ladder of some kind to assess whether adult fish will find and use the passage facility.
Purpose and Rationale: a significant number of adult fish are being deadended at the McNary and Ice Harbor OCC. These fish need to be afforded an opportunity to exit into forebay. If the problem is correctable, install permanent facility at both sites.
Schedule and Decision Points: Install and test fish responses to prototype adult egress facility in 2000. Proceed into design and construction phase for a permanent egress facility at both McNary and Ice Harbor if prototype is successful.
Costs: $1 million
Benefits: Number of adult fish in the McNary OCC is approximately a few hundred per year.

Lower Monumental

f.1 Surface Bypass

Description: Develop and prototype test a 6000 cfs spillway raised-crest surface bypass option, then implement this measure. Assess use of simulated Wells intake (SWI) and/or a behavioral guidance structure (BGS) to augment surface bypass passage.
Purpose and Rationale: Successful passage through high-flow surface-oriented entrances at prototype surface bypass sites in the region suggest this is an effective approach for increasing spillway passage in a more efficient manner than spill-only operations. Further, prototype SWI and BGS have been shown to retard entrainment into turbines. Meanwhile, prototype surface collection investigations at Lower Granite have not yielded hoped-for stand-alone performance, and are not deemed worthy of additional costly development and investigations.
Schedule and Decision Points: A raised-crest spill bay prototype study is scheduled for Lower Granite in 2001. Pending expected results of those investigations, further develop this surface bypass option for use at other Lower Snake projects.
Costs: $25 million
Benefits: Increased juvenile spill efficiency when operating; can close spill gate to allow flexibility to maximize transportation during dry years.

f.2 Dissolved Gas Fast-Track

Description: Optimize deflector design to maximize spillway fish passage and total dissolved gas abatement.

Purpose and Rationale: Recently-constructed deflectors at John Day and Ice Harbor have yielded significant technological insights concerning the potential for water quality improvements during both voluntary and involuntary spill operations. Additionally, the ability to spill more under the 120 percent total dissolved gas limit has resulted in increased fish passage at spillways. These lessons, when applied to other locations, should yield similar results

Schedule and Decision Points: Deflector investigations and improvements, as appropriate, should be concluded by approximately 2005.

Costs: $8 million per Lower Snake project

Benefits: Increased spillway fish passage efficiency, decreased total dissolved gas, increased allowable spill under the 120 percent gas cap.

f.3 ESBS – VBS

Description: Install ESBS –VBS to replace 20' STS.

Purpose and Rationale: Longer intake screens allow more fish to be routed away from turbines and, as necessary, allow more fish to be transported.

Schedule and Decision Points: This improvement will yield predictable incremental fish passage protection improvements, and is therefore not in a developmental phase. Therefore, it can proceed at any time, dependent on broader regional prioritization and the 1999 decision for lower Snake.

Costs: $10 million

Benefits: Increase FGE from 56 percent to near 80 percent for spring chinook yearlings.

f.4 JBS Modification

Description: Retrofit an appropriate improved juvenile wet separator to increase separation efficiency, thereby allowing transportation of juvenile fish in a less stressful environment.

Purpose and Rationale: RM&E has shown greater stress levels in fish transported with fish of other species. Reduced stress could result in higher transit and post-release survival of juvenile migrants. Current separation efficiencies are approximately 50 percent at some transport sites.

Schedule and Decision Points: Testing at McNary and Ice Harbor will be concluded in 2000, after which an improved design will be selected and retrofitted at transport projects.

Costs: $2.5 million

Benefits: Post-barge and truck survival is expected to increase by an unknown quantity.

f.5 Outfall Relocation

Description: Relocate juvenile bypass and sample facilities outfall

Purpose and Rationale: The existing outfall location for both sample and unsampled fish is in a marginal location relative to predation. During Spring 1999, a barge lost control and slammed into the outfall exit, further marginalizing the outfall. New and higher spill percentages are also causing navigation problems that suggest the need to find an improved outfall location. This bypass outfall location was never satisfactory to the agencies. It does not satisfy current siting criteria.

Schedule and Decision Points: Conduct hydraulic model study of new location in 2000 and design/construct in 2001-2002. Decision to proceed due on barge accident is sufficient basis for proceeding into construction.

Costs: $6 million

Benefits: Improved prospect for survival relative to existing outfall site for both sampled fish and directly bypassed, non-transported fish.

f.6 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.

Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.

Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.

Costs: $2.5 million

Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

Little Goose

g.1 Dissolved Gas Fast-Track

Description: Optimize deflector design to maximize spillway fish passage and total dissolved gas abatement.

Purpose and Rationale: Recently-constructed deflectors at John Day and Ice Harbor have yielded significant technological insights concerning the potential for water quality improvements during both voluntary and involuntary spill operations. Additionally, the ability to spill more under the 120 percent total dissolved gas limit has resulted in increased fish passage at spillways. These lessons, when applied to other locations, should yield similar results.

Schedule and Decision Points: Deflector investigations and improvements, as appropriate, should be concluded by approximately 2005.

Costs: $8 million per Lower Snake project

Benefits: Increased spillway fish passage efficiency, decreased total dissolved gas, increased allowable spill under the 120 percent gas cap.

g.2 Surface Bypass

Description: Develop and prototype test a 6000 cfs spillway raised-crest surface bypass option, then implement this measure. Assess use of simulated Wells intake (SWI) and/or a behavioral guidance structure (BGS) to augment surface bypass passage.

Purpose and Rationale: Successful passage through high-flow surface-oriented entrances at prototype surface bypass sites in the region suggest this is an effective approach for increasing spillway passage in a more efficient manner than spill-only operations. Further, prototype SWI and BGS have been shown to retard entrainment into turbines. Meanwhile, prototype surface collection investigations at Lower Granite have not yielded hoped-for stand-alone performance, and are not deemed worthy of additional costly development and investigations.

Schedule and Decision Points: A raised-crest spill bay prototype study is scheduled for Lower Granite in 2001. Pending expected results of those investigations, further develop this surface bypass option for use at other Lower Snake projects.

Costs: $25 million

Benefits: Increased juvenile spill efficiency when operating; can close spill gate to allow flexibility to maximize transportation during dry years.

g.3 Trash Boom

Description: Install trash boom to reduce debris at the powerhouse face and associated JBS debris problems that result in juvenile fish injuries.

Purpose and Rationale: During 1996-98, an unprecedented debris surveillance program was required to minimize juvenile descaling problems. This measure is expected to keep debris from accumulating at the powerhouse, thereby reducing the degree of adverse fish impact.

Schedule and Decision Points: Design is to be completed in late 1999, with construction in 2000. Since this is a containment boom that will require debris removal, and contrasts with the Lower Granite shear boom, debris removal frequency criteria are in place.

Costs: $2.5 million

Benefits: Reduced descaling rates of transported fish of an undetermined quantity.

Description, purpose, rationale of measures

Schedule, cost, and decision points

Analysis of benefit

g.4 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.

Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.

Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

g.5 JBS Modification

Description: Retrofit an appropriate improved juvenile wet separator to increase separation efficiency, thereby allowing transportation of juvenile fish in a less stressful environment.
Purpose and Rationale: RM&E has shown greater stress levels in fish transported with fish of other species. Reduced stress could result in higher transit and post-release survival of juvenile migrants. Current separation efficiencies are approximately 50 percent at some transport sites.
Schedule and Decision Points: Testing at McNary and Ice Harbor will be concluded in 2000, after which an improved design will be selected and retrofitted at transport projects.
Costs: $2.5 million
Benefits: Post-barge and truck survival is expected to increase by an unknown quantity.

Lower Granite

h.1 Dissolved Gas Fast-Track

Description: Optimize deflector design to maximize spillway fish passage and total dissolved gas abatement
Purpose and Rationale: Recently-constructed deflectors at John Day and Ice Harbor have yielded significant technological insights concerning the potential for water quality improvements during both voluntary and involuntary spill operations. Additionally, the ability to spill more under the 120 percent total dissolved gas limit has resulted in increased fish passage at spillways. These lessons, when applied to other locations, should yield similar results.
Schedule and Decision Points: Deflector investigations and improvements, as appropriate, should be concluded by approximately 2005.
Costs: $8 million per Lower Snake project
Benefits: Increased spillway fish passage efficiency, decreased total dissolved gas, increased allowable spill under the 120 percent gas cap Dissolved Gas Fast-Track.

h.2. Surface Bypass

Description: Develop and prototype test a 6000 cfs spillway raised-crest surface bypass option, then implement this measure. Assess use of simulated Wells intake (SWI) and/or a behavioral guidance structure (BGS) to augment surface bypass passage.

Purpose and Rationale: Successful passage through high-flow surface-oriented entrances at prototype surface bypass sites in the region suggest this is an effective approach for increasing spillway passage in a more efficient manner than spill-only operations. It is NMFS' view that prototype surface collection investigations at the Lower Granite powerhouse have not yielded expected performance, and further development is questionable. However, if ongoing evaluations indicate transport of a greater portion of the juvenile fish passing Lower Granite is warranted, the COE believes that a successful powerhouse surface collector is feasible and may be beneficial. The COE describes this specific option in the Lower Snake Feasibility Study, and it is not further defined in this document.

Schedule and Decision Points: A raised-crest spill bay prototype study is scheduled for Lower Granite in 2001. Pending expected results of those investigations, further develop this surface bypass option for use at other Lower Snake projects.

Costs: $25 million

Benefits: Increased juvenile spill efficiency when operating; can close spill gate to allow flexibility to maximize transportation during dry years.

h.3 JBS Modifications

Description: Design and construct a new open-channel JBS, with separation of large and small migrant fish for separate transportation according to size. Improve OCC and increase orifice size.

Purpose and Rationale: Lower Granite is one of only two remaining JBS with pressurized bypass conduit, and collects the most juveniles for transportation of any other project, yet has no provision for separation of transported fish by size. RM&E suggests this may adversely influence post-release survival.

Schedule and Decision Points: Deferred until after 1999 Decision on Lower Snake passage.

Costs: $25 million

Benefits: Undetermined – relates to delayed (post-release) mortality, which is not well understood JBS Modifications

Description, purpose, rationale of measures

Schedule, cost, and decision points

Analysis of benefit

h.4 More Barges

Description: Construct additional barges to allow improved transportation of juvenile fish.

Purpose and Rationale: This would allow reduced loading densities and holding delays at transport collection projects, and would allow direct loading.

Schedule and Decision Points: Design Memorandum was completed in 1997. Two new barges were added. Seven more were not constructed.

Additional resolution of total number of barges required is needed relative to the 1999 decision on juvenile protection.
Costs: $5 million
Benefits: The incremental influence on survival is undetermined.

h.5 Adult Fishway AWS Measures

Description: Evaluate the need for, and implement as required, adult fishway AWS improvements.
Purpose and Rationale: The adult fishway AWS does not pass sufficient flow to allow operation in accordance with Fish Passage Plan operating criteria. Additionally, increased reliability measures are required.
Schedule and Decision Points: AWS evaluation reports will be completed in 1999. A decision on upgrade measures will be made in 2000. Design and construction will be initiated after year 2000.
Costs: $2.5 million
Benefits: Benefits will include increased reliability and fishway performance, which will reduce the risk of adult migration delays due to AWS failures, and will improve daily fishway performance by discharging incrementally more attraction flow.

Chief Joseph

Description: Design and construct spillway deflectors to abate total dissolved gas
Purpose and Rationale: Total dissolved gas downstream of Chief Joseph is excessive during some years. Deflectors have the demonstrated ability to provide moderate reductions in supersaturation to levels not harmful to salmon.
Schedule and Decision Points: Hydraulic modeling commences in 1999; design will commence in 2000 pending funding. Construction could begin in late 2000 pending funding, and be completed in two or less winter work windows.
Costs: $40 million
Benefits: Reduced total dissolved gas levels will be evident during wetter years, but the survival benefit has not been determined.

Libby

Description: Add three turbine/generators to reduce spill, construct deflectors to reduce total dissolved gas.
Purpose and Rationale: Excessive levels of total dissolved gas are produced at this projects during wet years. Abatement of elevated supersaturation is needed.
Schedule and Decision Points: Undefined
Costs: $20 million
Benefits: Incremental reductions of total dissolved gas are desired (for listed sturgeon and bull trout below the project). Total survival benefit for anadromous fish has not been determined.

Universal

1. Replace/Refurbish Aging Fish Facilities

   Description: Columbia and Snake River COE Dams are aging, and in need replacement or refurbishing of some fish passage (and other) facilities. Turbines are already being (or soon will be) replaced/refurbished at some COE dams; the same will be required for fish passage facilities.
   Purpose and Rationale: Maintain satisfactory adult and juvenile passage at Columbia and Lower Snake River sites.
   Schedule and Decision Points: Some facilities are now being listed as needing major refurbishing. Others will continue to be listed. A major stumbling block is the need for unencumbered ability to fund these activities.
   Costs: Continuing at an increasing rate
   Benefits: Maintain satisfactory fish passage, versus gradual deterioration of fish passage facilities performance during the next decades.

2. Turbine Passage RM&E

   Description: Continue turbine RM&E relative to minimum gap runner replacement of existing aging turbines. Continue other turbine fish passage research, as substantiated by RM&E.
   Purpose and Rationale: As aging turbines at COE hydro projects are replaced, minimum gap runner replacements should continue to be investigated as the replacement alternative. Other RM&E should continue as long as clearly substantiated by a definitive progression toward an end-product that will provide significant and demonstrable fish survival benefit.
   Schedule and Decision Points: Replacement of existing turbines with minimum gap runners will occur only when necessary due to aging of existing turbines. Relative to other turbine research, yearly RM&E prioritization, relative to other fish passage needs, will occur.
   Costs: Power benefits should pay for replacement of minimum gap runners. This will come from a non-fisheries source. Turbine RM&E is expected to cost approximately $2 million per year.
   Benefits: Benefits of new minimum gap runners will be studied at Bonneville 1st Powerhouse in 1999-2000. The relative survival benefit, relative to existing aging turbines, will be assessed at that time. However, attainment of a small, overall survival benefit of fish passage through the new minimum gap runner turbines is not currently planned.

3. Residual Fish Passage Needs – Assess, Scope, and Implement

   Description: This activity relates to continuously evolving and improving RM&E equipment and strategies that contribute to an increased understanding of fish passage on the Snake and Lower Columbia Rivers. As more is learned, clearer understanding of residual fish passage needs and priorities result. It is impossible to identify all future fish passage needs at this time. This activity is a placeholder.

Purpose and Rationale: Assure that future and currently unidentified fish passage facilities needs are satisfactorily addressed.
Schedule and Decision Points: Currently undefined
Costs: Currently undefined
Benefits: Currently undefined

4. Dissolved Gas Abatement

Description: Additional RM&E is required to abate total dissolved gas beyond levels afforded by deflectors.
Purpose and Rationale: Identification of safe means of lower dissolved gas levels to 110 percent supersaturation have not been identified at this time. However, additional efforts are needed before concluding that development of a satisfactory option is not possible.
Schedule and Decision Points: The Dissolved Gas Abatement, Phase 2, Technical Report is to be completed in 2000. A decision on additional initiatives should occur at that time.
Costs: $1 million in 2000, undetermined after 2000.
Benefits: While fish benefits are largely satisfied by spillway deflectors that drop supersaturation levels below 120 percent, the water quality goal of 110 percent cannot be satisfied without additional RM&D. Fish survival benefits of reducing total dissolved gas from 120 percent to 110 percent are undetermined.

OPTION 3 – LOWER SNAKE DAMS NATURAL RIVER (Framework #3)

Objectives and relationship to strategies. This option assumes that the investment of breaching the Lower Snake COE' dams will be accompanied by a reduced number of configuration actions at the four COE middle Columbia River mainstem hydro projects, as listed in Option 1. Similarly, RM&E will dictate whether additional passage actions are required.

(Refer to Table IV-1 in Section IV for abbreviated list of project-by-project actions for each option.)

MID COLUMBIA

Bonneville

a.1 Emergency Auxiliary Water Supply (AWS)

Description: Develop new emergency back-up system, which may require conventional screen and bypass system to protect juvenile fish from entrainment into AWS.
Purpose and Rationale: Both auxiliary water turbines can be out of service at once. The existing emergency backup is the trash sluice chute, which is targeted as the new permanent surface bypass system at B-2.
Schedule and Decision Points: Alternatives study in year 2000, design and construct by 2003.

Costs: $25 million

Benefits: This action is not necessarily to improve adult passage at B-2, but to keep from diminishing adequacy of passage if existing fish water AWS turbines are unable to operate (as in 1997 during the peak of the adult fall chinook passage period).

a.2 Adult Fallback

Description: Continue to investigate and develop adult fallback reduction alternatives. Implement as appropriate.

Purpose and Rationale: RM&E has correlated adult fallback to the tailrace as a factor in reducing the potential for spawning success. Fallback rates at Bonneville Dam (especially Bradford Island fishway exit) are excessively high.

Schedule and Decision Points: Conduct additional RM&E in 2000, continue to investigate variables possibly associated with fallback at Bonneville Dam, develop and implement solutions as appropriate.

Costs: $10 million

Benefits: Reduced fallback rates for adult fish and increased migration returns to natal streams with successful spawning completion.

The Dalles

b.1 Dissolved Gas Fast-Track and Physical Injury Investigations

Description: Maximize safe spillway passage while minimizing mortality and total dissolved gas levels. Minimize mechanistic mortality problems in the spillway tailrace as appropriate through deflector construction.

Purpose and Rationale: Total dissolved gas levels during high spill at The Dalles are relatively low. However, mortality studies have suggested that fish mortality rates rise at higher spill levels. Since the goal is to pass as many fish over the spillway at the highest survival rate, additional investigations are required to determine how to concurrently maximize spillway passage and survival rates. Deflectors may be required.

Schedule and Decision Points: RM&E was initiated in 1996 to address spillway discharge percentages versus mortality rates. Additional mortality studies are scheduled for 2000. Physical injury studies may be required to determine whether deflectors are required. A decision is targeted for 2003. basin at spill percentages currently under investigation.

Costs: $13 million

Benefits: RM&E suggests spillway mortality rates may be reduced at some spill levels by up to 10 percent.

John Day

C.1 Fishway Exit Modifications

Description: Investigate and implement corrective measures, as appropriate, to reduce adult fish holding in the north and south fishways.

Purpose and Rationale: Prolonged adult fish holding in the John Day fish ladders represents is a potential problem for many upstream migrants.

Schedule and Decision Points: Complete investigations, identify most-preferred alternative, determine whether to go into design phase.
Costs: $6 million
Benefits: Undetermined

McNary

d.1 Adult Auxiliary Water System Upgrade

Description: Improve reliability and performance of the adult fishway AWS.
Purpose and Rationale: Reduced risk of adult passage delays due to AWS failure during migration periods.
Schedule and Decision Points: A comprehensive AWS study for McNary has been completed, but is awaiting funding.
Costs: $3 million
Benefits: These measures would reduce the risk of delaying/losing adult fish during peak migration periods due to aging AWS facilities.

d.2 JBS Modification

Description: Investigate and implement JBS improvement measures associated with debris handling, appropriate improved juvenile separation, orifice collection channel, and intake screen and bypass performance.
Purpose and Rationale: Debris at McNary has created appreciable JBS, ESBS and bypass outfall problems. RM&E has shown the need for improved separation efficiencies that could result in higher transit and post-release survival of juvenile migrants. Other JBS needs include reducing excessive juvenile and predator holding in the orifice collection channel, bypass outfall pipe clogging, and other problems.
Schedule and Decision Points: Conclude separator testing, develop debris handling strategies and modifications, and address other JBS needs by late 2000. Initiate modifications design and construction after 2000.
Costs: $5 million
Benefits: Post-barge and truck release, and river bypass survival is expected to increase by an unknown quantity.

d.3 Adult Egress from JBS OCC

Description: Provide egress for adult fish which have fallen back through turbine intakes and been routed through gatewell orifices to the JBS-OCC. This may include a small adult fish ladder of some kind to assess whether adult fish will find and use the passage facility.
Purpose and Rationale: a significant number of adult fish are being deadended at the McNary and Ice Harbor OCC. These fish need to be afforded an opportunity to exit into forebay. If the problem is correctable, install permanent facility at both sites.
Schedule and Decision Points: Install and test fish responses to prototype adult egress facility in 2000. Proceed into design and construction phase for a permanent egress facility at both McNary and Ice Harbor if prototype is successful.
Costs: $1 million

Benefits: Number of adult fish in the McNary OCC is approximately a few hundred per year Adult Egress from OCC.

Chief Joseph

Description: Design and construct spillway deflectors to abate total dissolved gas.
Purpose and Rationale: Total dissolved gas downstream of Chief Joseph is excessive during some years. Deflectors have the demonstrated ability to provide moderate reductions in supersaturation to levels not harmful to salmon.
Schedule and Decision Points: Hydraulic modeling commences in 1999; design will commence in 2000 pending funding. Construction could begin in late 2000 pending funding, and be completed in two or less winter work windows.
Costs: $40 million
Benefits: Reduced total dissolved gas levels will be evident during wetter years, but the survival benefit has not been determined.

Universal

1. Replace/Refurbish Aging Fish Facilities
   Description: Columbia and Snake River COE Dams are aging, and in need replacement or refurbishing of some fish passage (and other) facilities. Turbines are already being (or soon will be) replaced/refurbished at some COE dams; the same will be required for fish passage facilities.
   Purpose and Rationale: Maintain satisfactory adult and juvenile passage at Columbia and Lower Snake River sites.
   Schedule and Decision Points: Some facilities are now being listed as needing major refurbishing. Others will continue to be listed. A major stumbling block is the need for unencumbered ability to fund these activities.
   Costs: Continuing at an increasing rate
   Benefits: Maintain satisfactory fish passage, versus gradual deterioration of fish passage facilities performance during the next decades.
2. Residual Fish Passage Needs – Assess, Scope, and Implement
   Description: This activity relates to continuously evolving and improving RM&E equipment and strategies that contribute to an increased understanding of fish passage on the Snake and Lower Columbia Rivers. As more is learned, clearer understanding of residual fish passage needs and priorities result. It is impossible to identify all future fish passage needs at this time. This activity is a placeholder.
   Purpose and Rationale: Assure that future and currently unidentified fish passage facilities needs are satisfactorily addressed.
   Schedule and Decision Points: Currently undefined
   Costs: Currently undefined
   Benefits: Currently undefined

3. Dissolved Gas Abatement

Description: Additional RM&E is required to abate total dissolved gas beyond levels afforded by deflectors.

Purpose and Rationale: Identification of safe means of lower dissolved gas levels to 110 percent supersaturation have not been identified at this time. However, additional efforts are needed before concluding that development of a satisfactory option is not possible.

Schedule and Decision Points: The Dissolved Gas Abatement, Phase 2, Technical Report is to be completed in 2000. A decision on additional initiatives should occur at that time.

Costs: $1 million in 2000, undetermined after 2000.

Benefits: While fish benefits are largely satisfied by spillway deflectors that drop supersaturation levels below 120 percent, the water quality goal of 110 percent cannot be satisfied without additional RM&D. Fish survival benefits of reducing total dissolved gas from 120 percent to 110 percent are undetermined.

LOWER SNAKE

Lower Snake Dams – BREACH

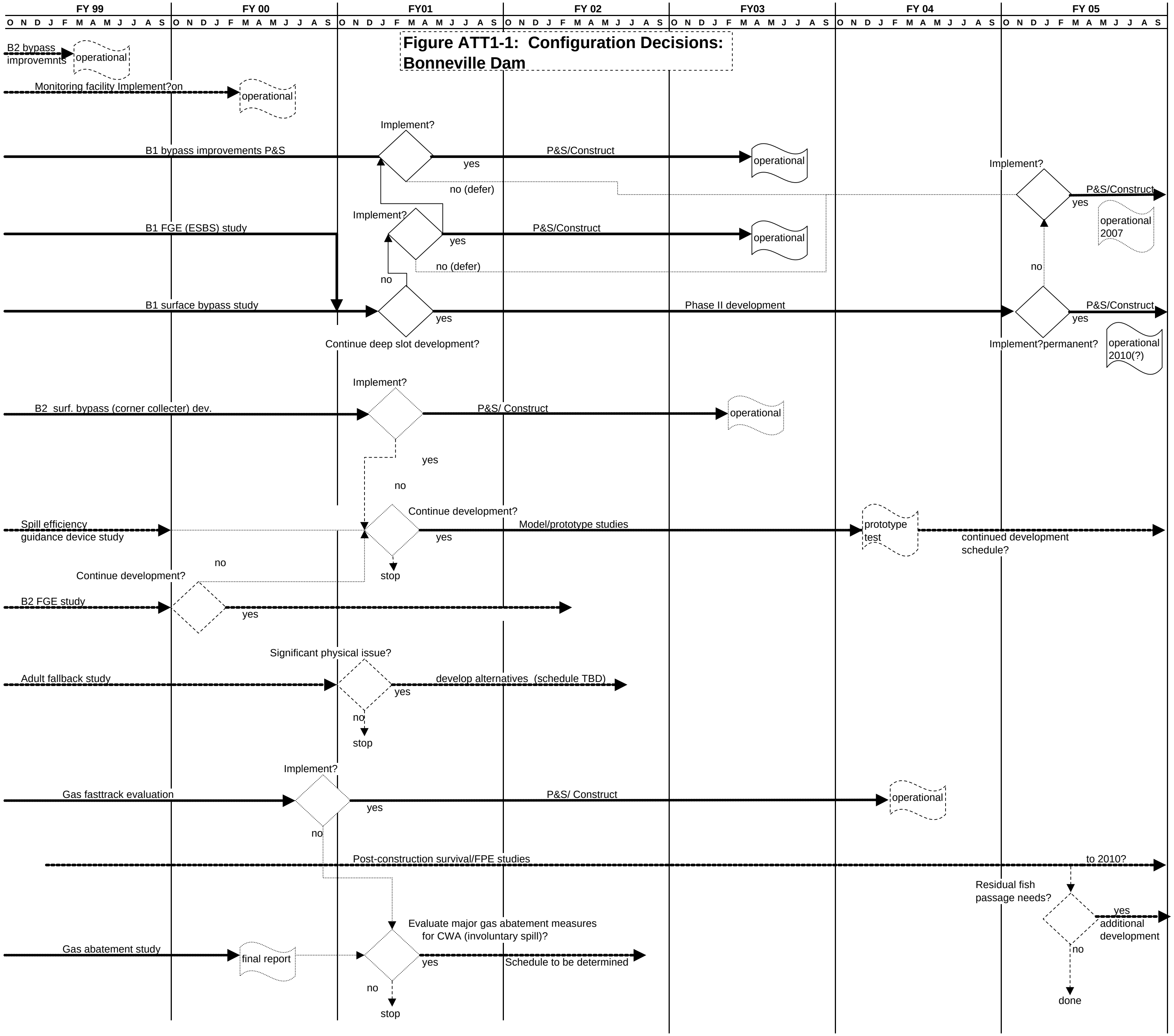


Figure ATT1-1: Configuration Decisions: Bonneville Dam

Figure ATT1-2: Configuration Decisions: John Day Dam

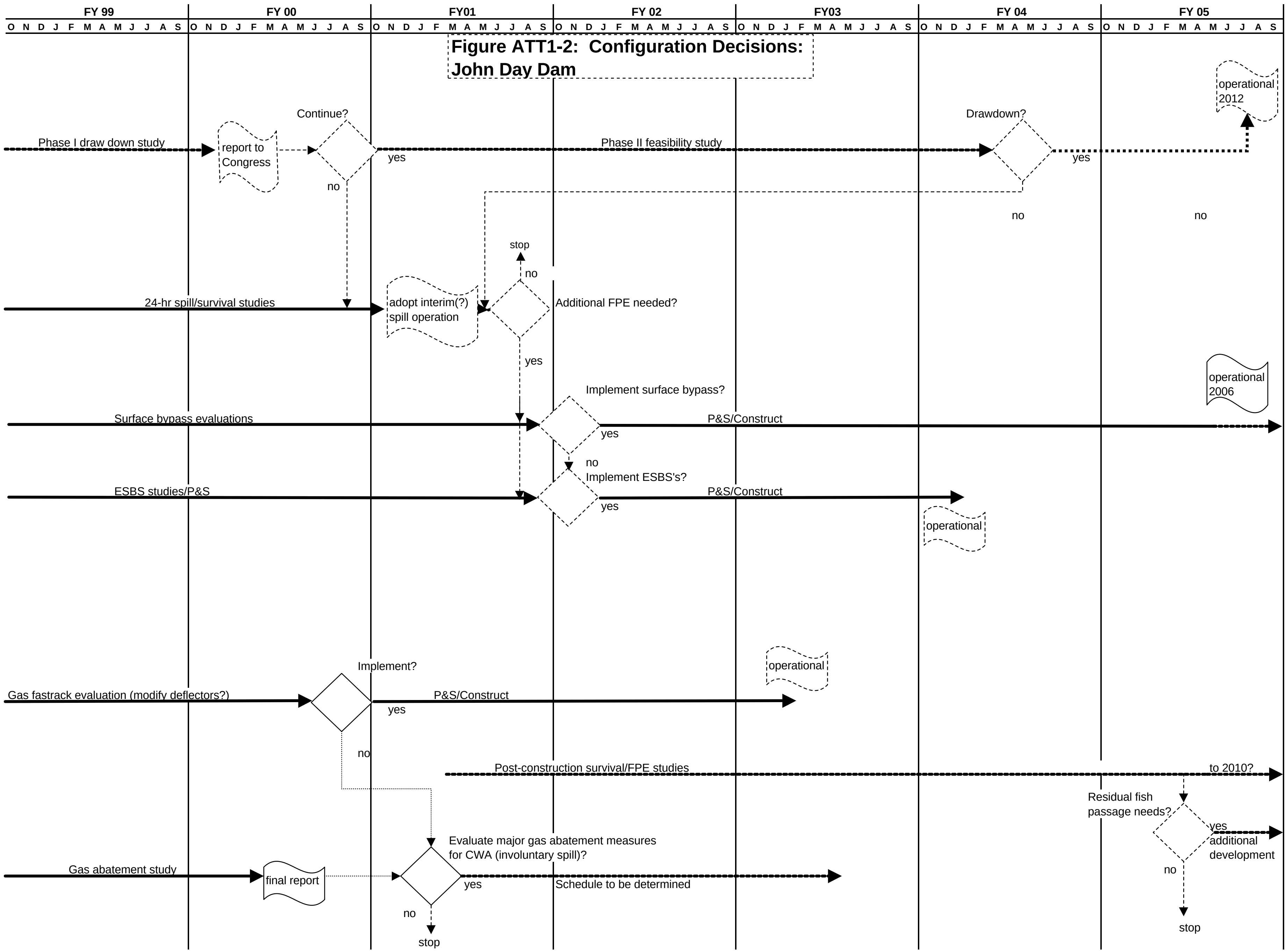
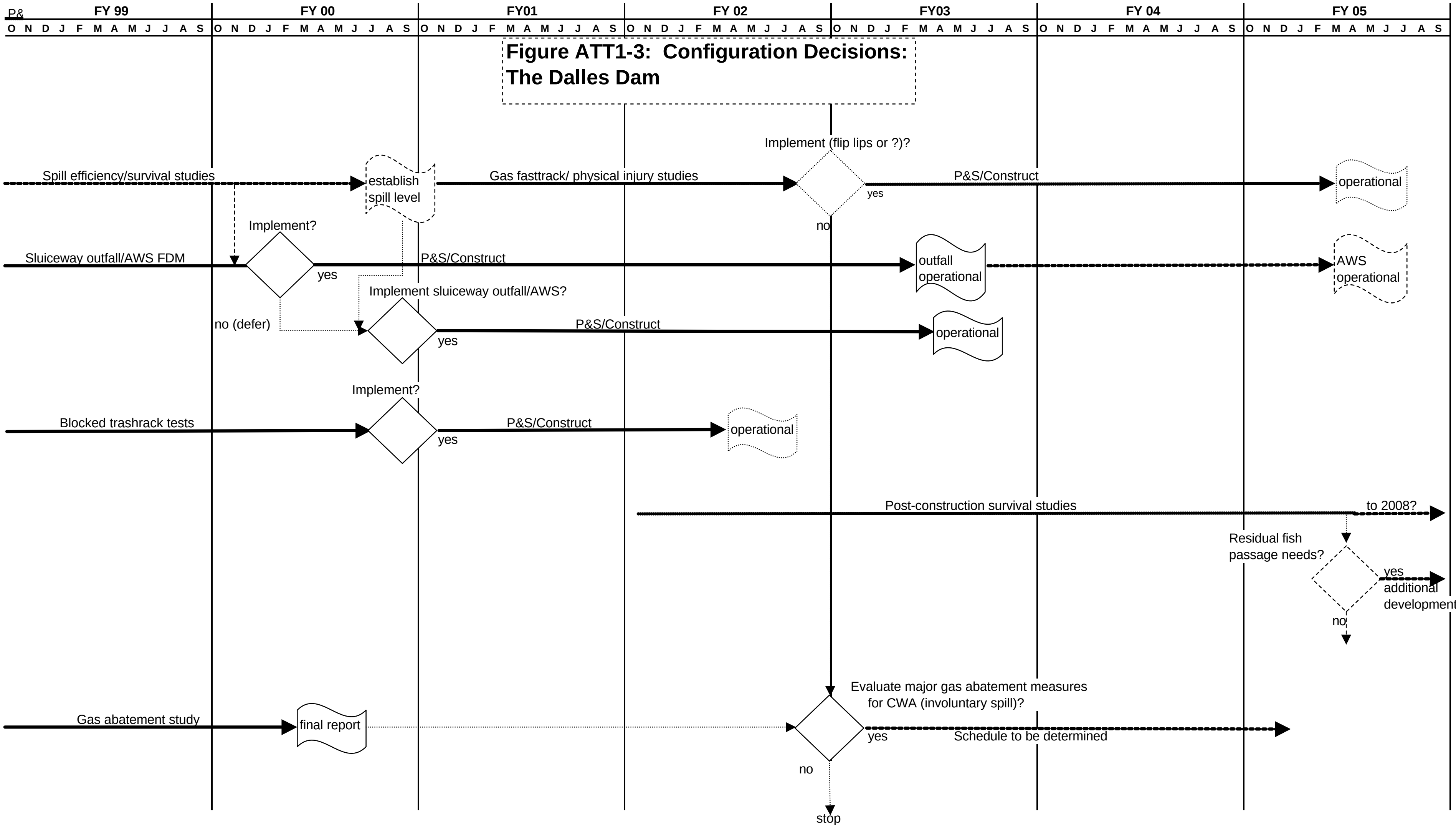


Figure ATT1-3: Configuration Decisions: The Dalles Dam



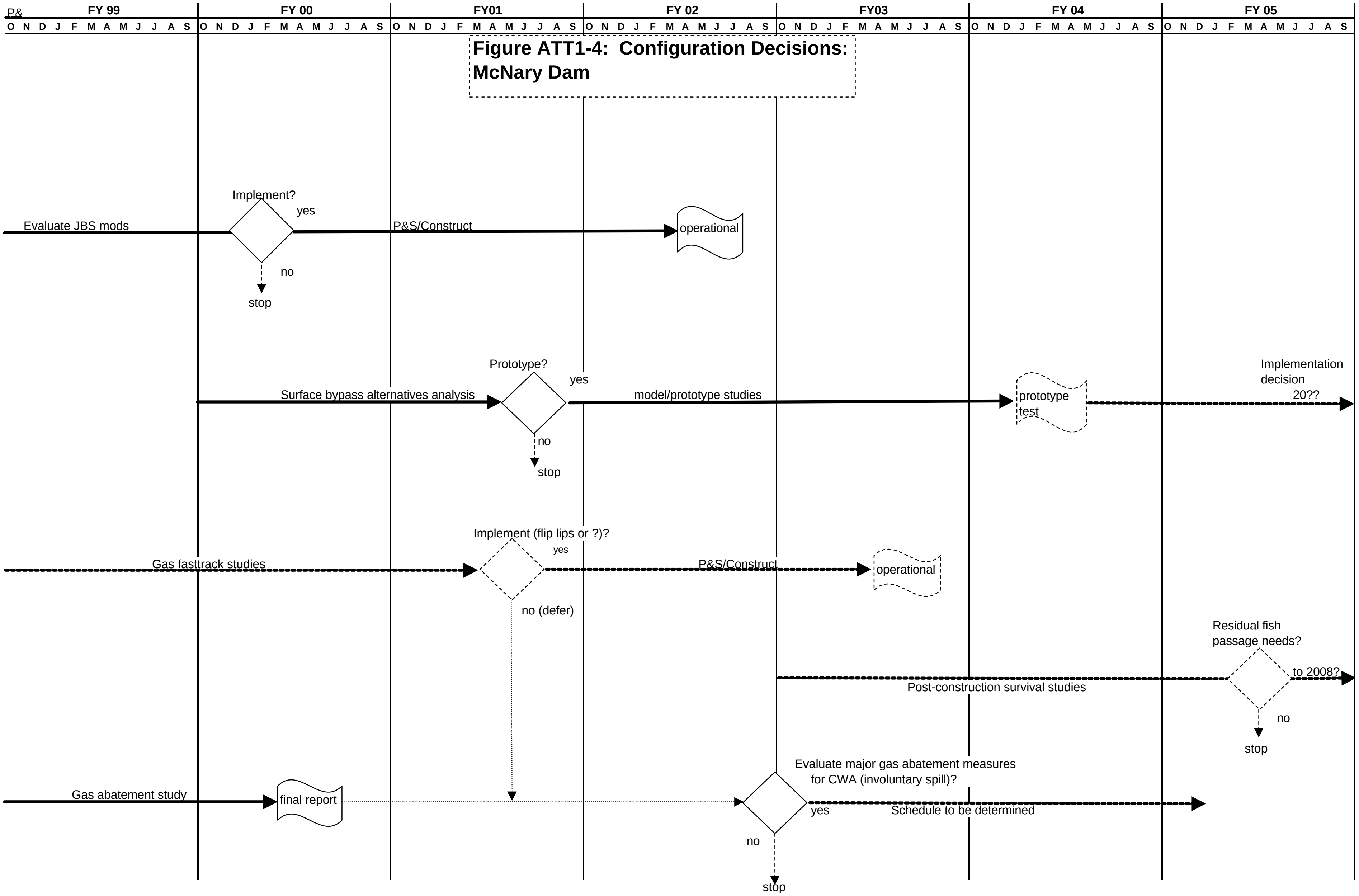

P&
FY 99
FY 00
FY01
FY 02
FY03
FY 04
FY 05
O N D J F M A M J J A S
Figure ATT1-4: Configuration Decisions: McNary Dam
Implement?
yes
Evaluate JBS mods
P&S/Construct
operational
no
stop
Prototype?
yes
Surface bypass alternatives analysis
model/prototype studies
prototype test
Implementation decision 20??
no
stop
Implement (flip lips or ?)?
yes
Gas fasttrack studies
P&S/Construct
operational
no (defer)
Residual fish passage needs?
to 2008?
Post-construction survival studies
no
stop
Evaluate major gas abatement measures for CWA (involuntary spill)?
Gas abatement study
final report
yes
Schedule to be determined
no
stop

Table ATT1-1

Configuration Dates and Cost Summaries, Options 1-3

Notes:

1. Decision date - date decision is made to proceed with design and construction of permanent facility
2. Implementation date - completion date for the new facility, assuming no funding delays
3. Costs are projections only and are in current dollars
4. Action item "Residual fish passage needs...." for "Current Program" and "4-H" options leaves opportunity for adaptive management identification of other passage needs based on RM+E."

Glossary:

1. RM + E - Research, Monitoring and Evaluation
2. AWS - Adult fishway auxiliary water modifications
3. Unk - Unknown scope of work and/or cost estimate
4. ESBS/VBS - Extended submerged bar screens/vertical barrier screens
5. TBD - To be determined

Option 1

Current Program (Framework #4) Configuration Activities - Assumes continued research on main-stem hydro survival improvement potential, concurrent with survival improvement potential in other three H's. Leaves open additional configuration activities as dictated by future RM+E.

Project	Action	Decision Date	Implementation Date	$ Cost (millions)
Middle Columbia - Bonneville	1. Emergency AWS	1999	2003	20.0
	2. Adult Fallback	Unk	Unk	10.0
Middle Columbia - The Dalles	1. Gas Fast-Track and Physical Injury Investigation	TBD	TBD	13.0
Middle Columbia - John Day	1. Fishway Exit Mods	Unk	Unk	6.0
Middle Columbia - McNary	1. AWS - Pump Rebuild	1997	TBD	3.0
	2. JBS Mods	2000	2002	5.0
	3. Investigate Adult Egress Out of the JBS Orifice Collection Channel	1998	2001	1.0
Lower Snake - Ice Harbor	1. Adult AWS Ladder Improvements	2000	2003	1.5
	2. Adult Egress From JBS	2000	2002	1.0
Lower Snake - Lower Monumental	1. Adult AWS	2000	2003	2.5
Lower Snake - Little Goose	1. Trash Boom	1999	2001	3.0
	2. Adult AWS Ladder Improvements	2000	2002	2.5
Lower Snake - Lower Granite	1. Adult AWS Ladder Improvements	2000	2002	1.0
Upper Columbia - Chief Joseph	1. Flow Deflectors	2000	2002	40.0
Universal	1. Replacement of Aging Passage Facilities	Unk	Unk	Unk
CRFM Dams	1. RM+E (includes surface bypass, FGE, and other at all COE projects)			75.5

Option 1 - Summary of costs ($Millions)

Reach Configuration Actions	$ Cost (Millions)
Middle Columbia	58
Lower Snake	12
Upper Columbia	40
Subtotal	110
RM+E (CRFM Dams)	75
LOWEST ESTIMATED TOTALS	**185**

Possible Additional Configuration Totals (Per RM+E)

Reach	$ Cost (Millions)
Middle Columbia	687
Lower Snake	190
Upper Columbia	20
HIGHEST ESTIMATED TOTALS	**1082**
Cost Estimate Range (Millions) = $185 - 1,082	

Option 1 - Annual Cost Estimate Range - Configuration Development and Construction

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Lowest Est. ($Millions)	20	55	55	26	20	20	10	4	4	4
*Highest Est. ($Millions)	70	120	150	150	150	150	120	120	120	100

*This assumes $150 million maximum annual outlay.

Annual totals exceed "summary of costs" estimates due to 3% inflation adjustment

Table ATT-1 (Continued) - Option 2

Non-Breach Aggressive (Also "4-H" and Framework #5) Configuration Activities - Assumes most aggressive non-breach measures

Project	Action	Decision Date	Implementation Date	$ Cost (millions)
Middle Columbia - Bonneville	1. B-1 Surface Bypass	2001	2007	250.0
	2. B-1 ESBS (Includes DSM/Bypass Outfall)	2001	2004	95.0
	3. B-1 Minimum Gap Runners	1996	2006	COE Funded
	4. B-2 Surface Bypass	2000	2003	25.0
	5. Adult Fallback RM+E (Operational/Biological/Structural Needs)	Unk	Unk	10.0
	6. Spillway Gas Fast-Track (Spill Efficiency and Survival RM+E)	2001	2004	25.0
	7. AWS Improvements (Trashrack Cleaning and B-2 AWS)	2000	2004	25.0
	8. B-2 FGE	2001	2006	30.0
Middle Columbia - The Dalles	1. Surface Bypass (Similated Wells Intake)	2000	2002	6.0
	2. Gas Fast-Track and Physical Injury Investigations	2002	2005	13.0
	3. Ice and Trash Sluiceway Outfall Relocation and Emergency AWS	2001	2005	30.0
	4. Collection Channel Dewatering	1999	2002	6.0
Middle Columbia - John Day	1. Gas Fast-Track	2000	2003	15.0
	2. Surface Bypass (Raised Crest Spillbay, Skeleton Bay)	2001	2005	54.0
	3. Adult Fishway Modification	Unk	Unk	6.0
	4. ESBS/VBS	2001	2005	65.0
Middle Columbia - McNary	1. Gas Fast-Track	2001	2004	26.0
	2. Surface Bypass	2002	2009	55.0
	3. AWS - Pump Rebuild	1997	TBD	3.0
	4. JBS Mods	2000	2002	5.0
	5. Investigate Adult Egress Out of the JBS Orifice Collection Channel	1998	2001	1.0
Lower Snake - Ice Harbor	1. Adult AWS Ladder Improvements	2000	2003	1.5
	2. Adult Egress	2000	2002	1.0
Lower Snake - Lower Monumental	1. Surface Bypass (Raised Spillbay Crest)	2003	2005	25.0
	2. Gas Fast-Track	2001	2004	12.0
	3. Install ESBS/VBS	2001	2005	20.0
	4. JBS Modifications (Improve Separation/Existing Facilities)	2000	2005	20.0
	5. Juvenile Bypass Outfall Relocation	2000	2003	10.0
	6. Adult Fishway AWS	2000	2003	2.5
Lower Snake - Little Goose	1. Gas Fast-Track	2002	2004	12.0
	2. Surface Bypass (Raised Spillbay Crest)	2004	2006	25.0
	3. Trash Boom	1999	2001	3.0
	4. Adult AWS Ladder Improvements	2000	2002	1.0

	5. JBS Modifications (Improve Separation/Existing Facilities)	2001	2003	5.0
Lower Snake - Lower Granite	1. Gas Fast-Track	2002	2004	7.5
	2. Surface Bypass (Raised Spillbay Crest)	2001	2004	25.0
	3. JBS Modifications (Improve Separation/Existing Facilities)	2000	2003	24.0
	4. More Barges	2000	2004	6.6
	5. Adult AWS Ladder Improvements	2000	2002	1.0
Upper Columbia - Chief Joseph	1. Flow Deflectors	2000	2002	40.0
Upper Columbia - Libby	1. Gas Abatement	Unk	Unk	20.0
Universal	1. O+M Replacement of Aging Passage Facilities	Unk	Unk	Unk
	2. Residual Fish Facilities Needs - Assess, Scope and Implement	Unk	Unk	Unk
	3. Turbine Passage RM+E	Unk	Unk	Unk
	4. Dissolved Gas Abatement	Unk	Unk	Unk

Option 2 - Summary of costs	
Reach Configuration Activities	**$ Cost (Millions)**
Middle Columbia	745
Lower Snake	202
Upper Columbia	60
Subtotal	1000
***LOWEST ESTIMATED TOTALS**	**750**
HIGHEST ESTIMATED TOTALS	**1000**
Cost Estimate Range (Millions) = $750 - 1,000	

*This assumes RM+E suggests proceeding with 75% of highest configuration "Actions" estimate.

Option 2 - Annual Cost Estimate Range - Configuration Development and Construction

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Lowest Est. ($Millions)	60	90	113	113	113	113	90	66	60	60
**Highest Est. ($Millions)	80	120	150	150	150	150	120	90	80	80

**This assumes $150 million maximum annual outlay.

Annual totals exceed "summary of costs" estimates due to 3% inflation adjustment

Table ATT1-1 (Continued) - Option 3

Lower Snake Dams to Natural River (Framework #3) - Assumes continued research on middle Columbia main-stem hydro survival improvement potential, concurrent with breaching Lower Snake Dams. Assumes (as in Option #1) that RM+E results may dictate additional configuration actions beyond those shown below.

Project	Action	Decision Date	Implementation Date	$ Cost (millions)
Middle Columbia - Bonneville	1. Emergency AWS	1999	2003	20.0
	2. Adult Fallback	Unk	Unk	10.0
Middle Columbia - The Dalles	1. Gas Fast-Track and Physical Injury Investigation	TBD	TBD	13.0
Middle Columbia - John Day	1. Fishway Exit Mods	Unk	Unk	6.0
Middle Columbia - McNary	1. AWS - Pump Rebuild	1997	TBD	3.0
	2. JBS Mods	2000	2002	5.0
	3. Investigate Adult Egress Out of the JBS Orifice Collection Channel	1998	2001	1.0
Lower Snake	1. Breach to Natural River	2000	2006	1000.0
Upper Columbia - Chief Joseph	1. Flow Deflectors	2000	2002	40.0
Universal	1. Replacement of Aging Passage Facilities	Unk	Unk	Unk
Middle Columbia CRFM Dams	1. RM+E (includes surface bypass, FGE, and other at all COE projects)			75.0

Option 3 - Summary of costs

Reach Configuration Activities	$ Cost (Millions)
Middle Columbia	58
Lower Snake	1000
Upper Columbia	40
Subtotal	1098
RM+E	75
LOWEST ESTIMATED TOTALS	**1173**

Possible Additional Configuration Totals (Per RM+E)

Reach	$ Cost (Millions)
Middle Columbia	687
Lower Snake	0
Upper Columbia	20
HIGHEST ESTIMATED TOTALS	**1880**
Cost Estimate Range (Millions) = $1,173 - 1,880	

Option 3 - Annual Cost Estimate Range - Configuration Development and Construction

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
† ***Lowest Est.($Millions)	74	78	63	136	235	240	232	82	47	9
† ***Highest Est.($Millions)	115	131	141	238	342	347	322	177	142	87

***This assumes need to exceed annual spending cap of $150 million assumed for Option 1&2 annual costs.

† This assumes pre-construction engineering and design (PED) starts in 2001. Congressional authorization process may delay PED.

Annual totals exceed "summary of costs" estimates due to 3% inflation adjustment

Attachment Two

HYDRO OPERATION DESCRIPTIONS

OPTION 1 – CURRENT PROGRAM

Flow Operations

Flows would be shaped by the TMT to meet existing flow objectives (1995 and 1998 BOs) at Lower Granite, Priest Rapids and McNary Dams. In low water years, however, the flows at Lower Granite and the shape of releases from Dworshak may be adjusted (water stored for summer) based on the runoff. Flows at Bonneville would be modified to aid salmon spawning below this project.

System flood control would remain status quo.

Lower Snake Projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Spill would remain at the 1998 BOs levels and duration.

Temperature control also would remain at the status quo.

Fish transportation would remain at the status quo, meaning a “spread the risk” approach -- some fish are transported and others are passed with the spill at each project.

Lower Columbia River Projects: Bonneville, The Dalles, John Day, McNary

Spill would remain at the 1998 BO levels and durations.

Mid-Columbia Projects

Modified flow operations at Priest Rapids would be established in the spring to provide juvenile fish protection in the Hanford Reach.

Chief Joseph Dam

Operation would remain at status quo.

Grand Coulee Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 85 percent of the time. Grand Coulee could be drafted to elevation 1,280 feet during the flow augmentation season, which ends on August 31st to help achieve Priest Rapids and

McNary flow objectives. Grand Coulee would also help support the modified spring operations for the Hanford Reach and the fall operation below Bonneville Dam.

Albeni Falls Dam

Operation would remain at status quo.

The project would be studied for the feasibility of reestablishing bull trout passage.

The project would be operated to accommodate cultural resource surveys.

Libby Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 75 percent of the time. The project could be drafted to elevation 2,439 feet during the flow augmentation season, which ends on August 31st to help achieve the McNary flow objective. In order to keep Libby higher in the summer months, the U.S. Entity would negotiate with Canada to swap the draft from Libby for draft from Arrow.

The project would provide spawning and recruitment flows for sturgeon and other reservoir operations for bull trout according to the USFWS 1999 Recovery Plan or as specified in the 1999 BO for sturgeon and bull trout. Year-around ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish.

Hungry Horse Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 75 percent of the time. The project could be drafted to elevation 3,540 feet during the flow augmentation season, which ends on August 31st to help achieve the McNary flow objective.

Year-around ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish.

Dworshak Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted. The project would be operated at minimum discharge outside of the flow augmentation season or as necessary to satisfy flood control requirements. The project would be drafted to elevation 1,520 feet during the flow augmentation season, which ends on August 31st to help achieve Lower Granite and McNary flow objectives.

Brownlee Reservoir

The project would provide a flow augmentation volume of 237,000 acre-feet each year as specified through TMT. Flows would likely be provided during the summer period when natural flows are at their lowest.

The project would predraft and/or pass through an additional amount of flow augmentation water coming from the Upper Snake River Basin.

Upper Snake Projects

Flow augmentation of 427,000 acre-feet would be provided to help meet the Lower Granite and McNary flow objectives.

Canadian Storage

Flow augmentation would remain at the status quo within the current constraints of the Non-Treaty Storage Agreement.

OPTION 2 – AGGRESSIVE PROGRAM

Flow Operations

Flows would be shaped by the TMT to meet existing flow objectives (1995 and 1998 BOs) at Lower Granite, Priest Rapids and McNary Dams. In low water years, however, the flows at Lower Granite and the shape of releases from Dworshak may be adjusted (water stored for summer) based on the runoff. Flows at Bonneville would be modified to aid salmon spawning below this project.

Review and implement modified system flood control operations to provide higher spring flows and refill probability in average and below average runoff years. This would include adoption of Variable Q (VARQ) at Libby and Hungry Horse and evaluation of initial control flow operations.

Lower Snake Projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Spill would remain at the 1998 BOs levels and duration initially, but as configuration additions, water quality improvements, transmission system upgrades, or spill evaluations are completed, the levels are expected to increase. The duration of spill at Lower Granite, Little Goose, and Lower Monumental are also expected to increase to 24 hours a day.

Temperature control would remain at the status quo.

Fish transportation would remain status quo, meaning a "spread the risk" approach--some fish are transported and others are passed with the spill at each project. Evaluations of the transportation program may lead to alterations in this program.

Lower Columbia River Projects: Bonneville, The Dalles, John Day, McNary

Spill would remain at the 1998 BOs levels and duration but as configuration additions, water quality improvements, transmission system upgrades, or spill evaluations are completed, the levels are expected to increase. Upon completion of spill test, spill at John Day may increase to a 24-hour duration.

The options for transportation would be developed based on the transportation evaluation studies.

Mid-Columbia Projects

Modified flow operations at Priest Rapids would be established in the spring to provide juvenile fish protection in the Hanford Reach.

Chief Joseph Dam

Operation would remain at status quo.

Grand Coulee Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 85 percent of the times. The reservoir behind Grand Coulee could be drafted to elevation 1,280 feet, or in low water conditions, to some other lower level through the flow augmentation season ending on August 31st to help achieve Priest Rapids and McNary flow objectives. Grand Coulee would also help support the modified spring operation for the Hanford Reach and the fall operation below Bonneville Dam.

Albeni Falls Dam

Operation would remain at status quo. Consideration would be given to using this project as a source for flow augmentation to meet summer flow objectives during low water years.

The project would be studied for the feasibility of reestablishing bull trout passage.

The project would be operated to accommodate cultural resource surveys.

Libby Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 75 percent of the time. Variable Q flood control operation would be established at the reservoir. The project could be drafted to elevation 2,439 feet, or in low water conditions, to some other lower level through the flow augmentation season ending on August 31st to help achieve the McNary flow objective. In order to keep Libby higher in the summer months, the U.S. Entity would negotiate with Canada to swap the draft from Libby for draft from Arrow.

The project would provide spawning and recruitment flows for sturgeon according to the USFWS 1999 Recovery Plan or as specified in the 1999 BO for sturgeon and bull trout. Configuration changes would be pursued at the project to allow for higher project discharges to support sturgeon flow objectives. Year-around ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish.

The project would also operate in the winter to protect burbot and westslope cutthroat trout (winter draft limits).

Hungry Horse Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 75 percent of the times. Variable Q flood control operation would be established at the reservoir. The project could be drafted to elevation 3,540 feet, or in low water conditions, to some other lower level through the flow augmentation season ending on August 31st to help achieve the McNary flow objective.

Year-round ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish. The project would operate in the winter to protect westslope cutthroat trout (winter draft limits).

Dworshak Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted. The project would be operated at minimum discharge outside of the flow augmentation season or as necessary to satisfy flood control requirements. The project would be drafted to elevation 1,520 feet during the flow augmentation season, which ends on August 31st to help achieve Lower Granite and McNary flow objectives.

Brownlee Reservoir

The present volume of flow augmentation provided by this project (237,000 acre-feet) would increase by an additional 200,000 acre-feet by changing the draft limit from elevation 2,059 feet to elevation 2,041 feet. The TMT would continue to specify the draft rate. With FERC relicensing, flow augmentation volume could increase. Flows would likely be reshaped to cover the summer period when natural flows are at their lowest.

The project would predraft and/or pass through an additional amount of flow augmentation water coming from the Upper Snake River Basin.

Upper Snake Projects

Flow augmentation of 427,000 to 1,427,000 acre-feet would be provided to help meet the Lower Granite and McNary flow objectives. If flow augmentation is increased above the current program level, there may be a need to address the potential impacts to bull trout in tributaries that are contributing water and to assess the effects on other listed species.

Canadian Storage

Flow augmentation would initially remain at the status quo within the current constraints of the Non-Treaty Storage Agreement. BPA would pursue negotiations on new treaty and Non-Treaty operations with Canada to increase storage and flow releases during the spring and summer.

OPTION 3 – LOWER SNAKE RIVER DAMS NATURAL RIVER

Flow Operations

Initially, flows would be shaped by the TMT to meet existing flow objectives (1995 and 1998 BOs) at Lower Granite, Priest Rapids, and McNary Dams. In low water years, however, the flows at Lower Granite and the shape of releases from Dworshak may be adjusted (water stored for summer) based on the runoff. Flows at Bonneville would be modified to aid salmon spawning below this project.

Lower Snake River Projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Spill would remain at the 1998 BOs levels and duration until breaching.

Temperature control also would remain at the status quo until breaching.

Fish transportation would remain at the status quo, meaning a "spread the risk" approach--some fish are transported and others are passed with the spill at each project.

Once a project is breached, no operational requirements would be specified.

Lower Columbia River Projects: Bonneville, The Dalles, John Day, McNary

Spill would remain at the 1998 BOs in level and duration. Based on spill evaluations, spill at John Day may increase to 24-hour duration. As configuration additions, water quality improvements, transmission system upgrades, or spill evaluations are completed, the levels are expected to increase.

The options for transportation would be developed based on the transportation evaluation studies.

Mid-Columbia Projects

Modified flow operations at Priest Rapids would be established in the spring to provide juvenile fish protection in the Hanford Reach.

Chief Joseph Dam

Operation would remain at status quo.

Grand Coulee Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10^{th} would be targeted and expected to be achieved 85 percent of the time. The reservoir behind Grand Coulee could be drafted to elevation 1,280 feet, or in low water conditions, to some other lower level through the flow augmentation season ending on August 31^{st} to help achieve Priest Rapids and McNary flow objectives during low flow years. Grand Coulee would also help support the modified spring operation for the Hanford Reach and the fall operation below Bonneville Dam.

Albeni Falls Dam

Operation would remain at status quo. Consideration would be given to using this project as a source for flow augmentation to meet summer flow objectives during low water years.

The project would be studied for the feasibility of reestablishing bull trout passage.

The project would be operated to accommodate cultural resource surveys.

Libby Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10^{th} would be targeted and expected to be achieved 75 percent of the time. Variable Q flood control operation would be established at the reservoir. The project could be drafted to elevation 2,439 feet, or in low water conditions, to some other lower level through the flow augmentation season ending on August 31^{st} to help achieve the McNary flow objective. In order to keep Libby higher in the summer months, the U.S. Entity would negotiate with Canada to swap the draft from Libby for draft from Arrow.

The project would provide spawning and recruitment flows for sturgeon according to the USFWS 1999 Recovery Plan or as specified in the 1999 BO for sturgeon and bull trout. Year-around ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish.

The project would operate in the winter to protect burbot and westslope cutthroat trout (winter draft limits).

Hungry Horse Dam

Flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted and expected to be achieved 75 percent of the times. Variable Q flood control operation would be established at the reservoir. The project could be drafted to elevation 3,540, or in low water conditions, to some other lower level feet through the original flow augmentation season ending on August 31st to help achieve the McNary flow objective.

Year-around ramping rates and minimum flow evaluations would be conducted for bull trout and other resident fish. The project would operate in the winter to protect westslope cutthroat trout (winter draft limits).

Dworshak Dam

Initially prior to any Lower Snake River project breach, flow augmentation would remain as specified in the 1995 and 1998 BOs. Refill to flood control levels by April 10th would be targeted. The project would be operated at minimum discharge outside of the flow augmentation season or as necessary to satisfy flood control requirements. The project would be drafted to elevation 1,520 feet during the flow augmentation season, which ends on August 31st to help achieve Lower Granite and McNary flow objectives.

Following breaching, refill the reservoir every year, with some amount of the volume shaped to ensure adequate temperature control in the Lower Snake during late summer. An issue remains with regard to whether flows out of Dworshak should be used to help meet a flow objective at McNary Dam.

Brownlee Reservoir

The project would provide a flow augmentation volume of 237,000 acre-feet each year as specified through TMT. Flows would likely be reshaped to cover the summer period when natural flows are at their lowest.

The project would predraft and/or pass through an additional amount of flow augmentation water coming from the Upper Snake River Basin.

After breaching, the project operation would be examined to determine whether flow augmentation volume should be changed and the flow reshaped into the summer period when natural flows are at their lowest. With increased flow augmentation, there would be a need to address the potential impacts to bull trout in the tributaries that are contributing water and to assess the effects on other ESA-listed species.

Upper Snake Projects

Flow augmentation of 427,000 acre-feet would be provided to help meet the Lower Granite (initially until breaching) and McNary flow objectives.

After breaching, possibly increase the level of flow augmentation to an amount over 427,000 acre-feet to ensure water quality (temperature control) in the Middle Snake. If flow augmentation is increased, there would be a need to address the potential impacts to bull trout in tributaries that are contributing water and to assess the effects on other ESA-listed species.

Canadian Storage

Flow augmentation would initially remain at the status quo within the current constraints of the Non-Treaty Storage Agreement.

Attachment Three

DAM PASSAGE – EXISTING CONDITIONS

Walla Walla District Projects

Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary Dams

Direct Dam Passage Survival

Juvenile salmon pass a dam through one of two primary routes: the spillway or the powerhouse. An unknown proportion, believed to be quite small, may use the navigation lock or adult fishway. The fish that pass via the powerhouse are divided into those deflected into the bulkhead gatewell slots by turbine intake screens (guided) and entering conventional juvenile bypass systems (JBS), and those that pass through the turbines (unguided). Mortality associated with various routes of passage has been evaluated in studies over the past 50+ years. The relative proportion of juvenile fish using passage routes depends on spill rate and effectiveness, and the fish guidance efficiency of intake screens.

Standard Estimate of Turbine Survival

The proportion of juvenile fish that are not spilled nor guided into JBS by powerhouse intake screens is the basis for determining the proportion that pass through the turbines. Turbine survival is defined as the proportion of juvenile fish surviving direct turbine passage exposure. Turbine passage may also have indirect effects on fish survival such as stress, injury, and disorientation. All of the latter have potential to increase vulnerability to predation. Iwamoto *et al.,* (1993) reviewed appropriate turbine survival studies conducted prior to 1990. Based on nine studies, direct turbine survival estimates ranged from 80 to 98 percent and averaged 90 percent. Estimates of direct mortality of subyearling chinook include: 3.9 percent at Bonneville I, 1 percent at McNary, and 13 percent at John Day. Based on three years of testing at Bonneville II, mortality of subyearling chinook has been estimated at 2.3 percent direct plus 6.8 percent indirect mortality near the JBS outfall. For modeling turbine passage survival, a 0.90 parameter has normally been applied. However, since results vary from 2.3 to 13 percent, modeling parameters of 0.90 +0.03 have been recommended by the PATH Hydro Group. More recent studies using balloon tags have shown higher turbine survivals, but results have not been widely accepted.

Standard Estimate of Spillway Passage Survival

Results of published studies conducted in the Lower Snake and the Columbia River through 1995 were reviewed by the Independent Scientific Group (ISG) (1996) and by Whitney *et al.,* (1997). Nearly all of the studies involved steelhead and yearling chinook. Estimates of spillway passage mortality in 10 of the 13 studies reviewed ranged from zero to 2.2 percent. Results of the three other studies were extremely variable, ranging from four to 27.5 percent and should be viewed with caution. In some studies, mortality estimates were higher in spillways with deflectors than in spillways without deflectors, but results were generally not statistically significant (Muir *et al.*, 1995). The PATH Hydro Group agreed to use a parameter of 0.98 for spillway passage survival.

Standard Estimate of Spill Passage Effectiveness

Two metrics are traditionally used to describe spillway passage: spill efficiency and spill effectiveness. Spill efficiency was defined by Johnson *et al.*, (1997) as the proportion of the population passing the dam via the spillway. Johnson *et al.*, further defined spill effectiveness as the ratio of spill efficiency to the proportion of total project flow that is discharged as spill. Hydroacoustic-based estimates do not pertain to a particular species/life stage but to the entire migration. However, radio-telemetry-based estimates have generally been consistent with those derived using hydroacoustics (PATH 1998).

The Snake River spring/summer chinook passage model analyzed by PATH used a spill effectiveness value of 1.0 for most dams on the Lower Snake and Lower Columbia Rivers. This was based on PATH's review of published investigations through 1995. More recent studies have been conducted at some dams on the Lower Snake and Columbia Rivers. The most prominent studies are hydroacoustic-based investigations that included a more quantitatively rigorous estimation procedure (PATH 1998).

For this effort, spillway effectiveness was assumed to be 1.5:1 for spring migrants at the four Lower Snake Dams and McNary. This was based on recent analyses by NMFS and the Fish Passage Center of the proportion of salmon originating above Lower Granite that were transported (R.Graves *et al.*, 1998, Berggren 1998). Based on juvenile radio-telemetry, Giorgi *et al.*, 1988 estimated the spill efficiency at Lower Granite Dam with total flows of approximately 100 kcfs and spillway discharges of 20 percent and 40 percent. Reported spill effectiveness for the two spill percentages was two and 1.5:1, respectively. In some analyses, use of an effectiveness greater than 1.5 resulted in the estimated population arriving in the Lower Granite forebay that exceeded the number of hatchery fish released upstream. In part based on those results, Graves *et al.*, elected to use an estimate of 1.5:1. Voluntary spill at the four collector dams is not prescribed due to warm water temperatures and long travel times and related poor in-river survival. In the Snake, summer spill is limited to Ice Harbor Dam.

Recent project-specific data on spill effectiveness is briefly described below. For detailed information, refer to the cited reports.

Lower Granite: Based on hydroacoustic monitoring, Johnson *et al.*, (1997) estimated a spill effectiveness of 1.45 for Lower Granite. These estimates are consistent with telemetry-based estimates for yearling chinook by Wilson *et al.*, (1991), who reported a 1.5 effectiveness with 40 percent spill.

Little Goose: Based on PIT-tag data, Muir *et al.*, (1998) estimated an effectiveness of 1.24 for hatchery steelhead.

Lower Monumental: Based on hydroacoustic monitoring, Johnson *et al.*, (1997) estimated an effectiveness of 1.9 for spring migrants and near 1.9 for summer migrants.

Ice Harbor: Based on radio-telemetry, Eppard *et al.*, (1997) estimated an effectiveness of 1.2 for fall chinook.

McNary: Unknown

Standard Estimate of Juvenile Bypass System Survival

Direct bypass survival is defined as survival past systems including turbine intake screens, gatewells, orifices, bypass flumes, and, in some cases, dewatering screens, wet separators, sampling facilities including holding tanks, and bypass outfall conduits. Indirect bypass mortality may be associated with predation that occurs at a poorly sited bypass outfall or delayed mortality caused by bypass passage but expressed further downstream. A minimum estimate of mortality can be determined from observations of dead fish in sampling facilities. Recent yearling chinook and wild steelhead facility mortality estimates at juvenile sampling facilities suggest that direct bypass mortality of both wild steelhead and yearling chinook is generally less than 1 percent and that in nearly all cases, juvenile steelhead facility mortality is less than yearling chinook mortality.

Recent studies based on PIT-tag data estimate reach survival via all passage routes, i.e., from the tailrace of the dam immediately upstream to the tailrace of the next dam downstream. Derivations are possible to partition survival parameters. The methodology is viewed by some as questionable since an FGE value must be assumed. For example, based on an assumption of 90 percent FGE, Muir *et al.*, (1998) reported a bypass survival of 0.95 for hatchery steelhead at Little Goose Dam. JBS survival for spring migrants has generally been assumed by most modelers to be 0.98, comparable with assumed spillway survival. PATH scientists recommend using survival estimates between 0.97 and 0.99.

JBS survival for summer-migrating subyearling fall chinook in the Lower Snake River passing is very limited. Muir *et al.*, estimated that in 1996 JBS survival at Lower Granite was only 79 percent. That estimate is believed to be unreliable as the survival of the bypass release groups was only about half of the primary release group passing that project. In a subsequent study at Lower Granite Dam that estimated reach survival of subyearling chinook in 1997, JBS survival was estimated to be 0.87 (Muir *et al.*, 1999). The latter estimate is believed to be more reliable than the earlier estimate. Muir *et al.*, however, reported that the small number of paired releases resulted in a large standard error for the estimate. Additionally, differences in post-release performance of fish handled at Lower Granite compared to those not handled makes the 1997 post-detection survival estimate suspect. This is the only reported estimate and may be used until additional data become available.

No measure of indirect mortality (following outfall release) is available at most projects for juvenile steelhead. However, studies of subyearling chinook bypass mortality at Bonneville I and II (Ledgerwood *et al.*, 1990, 1994; Dawley *et al.*, 1996) indicate that high bypass mortality may be associated with predation that occurs at a poorly sited bypass outfall. It is recognized that there may be an additional mortality associated with predation at the bypass outfall at some locations and in some years, but information is insufficient to estimate this additional mortality for yearling chinook salmon. Estimates are generally lower than the survival that would be estimated from direct facility mortalities, so we assume that these estimates largely encompass any delayed bypass mortality. There is no information to suggest that indirect mortality is higher for steelhead than for yearling chinook salmon at any projects under current conditions.

Fish Guidance Efficiency

The effectiveness of intake screens in diverting fish approaching the turbines into bypass systems is known as fish guidance efficiency. FGE appears to differ among wild and hatchery yearling chinook salmon (Krasnow *et al.*, 1998) but appears to be similar for wild and hatchery steelhead (S. Smith, NMFS, pers. comm. 1998) based on analysis of recent PIT-tag detection rates. For both species, there is uncertainty regarding the change in FGE occurring since the replacement of standard-length traveling screens (STS) with extended-length submersible bar screens (ESBS) at several projects (Krasnow *et al.*, 1998; Marmorek and Peters *et al.*, 1998). Side-by-side estimates of STS versus ESBS FGE using fyke-net recoveries indicate that FGE is considerably higher with ESBS than with STS (e.g., McComas *et al.*, 1993; Gessel *et al.*, 1994; Brege *et al.*, 1994). However, this difference has not been confirmed under full operating conditions, based on PIT-tag detection rates before and after ESBS installation at Snake River projects (IDFG analysis reported in Krasnow *et al.*, 1998). The PATH analytical group has recommended examining sensitivity to both assumptions.

Available data indicate that relative guidance of steelhead and yearling chinook salmon varies by project, chinook origin, and ESBS versus STS guidance performance assumption. Steelhead FGE is estimated to be 3 percent to 29 percent higher than yearling chinook FGE at all projects except McNary, The Dalles (which does not have a screened bypass system), and Bonneville II.

FGE estimates for yearling chinook and steelhead used in this document came from the NMFS 1999 supplemental BO and were described in detail by Krasnow (1998). FGE data for subyearling chinook were described in Krasnow *et al.*, 1998. FGE estimates for Snake River sockeye are limited have been assumed to parallel those of yearling chinook although reported data are slightly lower.

Fish Passage Efficiency

Fish passage efficiency (FPE) is defined as the proportion of the total number of fish passing a project that does not pass through the powerhouse turbine units.

Voluntary Spill Caps

The 1998 supplemental BO requires spill to the 120 percent total dissolved gas saturation cap at identified projects. Voluntary spill at the collector projects occurs for 12 hours beginning at 6 p.m., whereas spill at Ice Harbor occurs 24 hours per day. When spill occurs, limits are established to afford acceptable tailwater conditions for adult and juvenile passage.

Spill volume parameters in this document were taken from the 1999 Water Management Plan being developed by the Technical Management Team (April 6, 1999 draft).

Project Specific Data

McNary Dam

Juvenile migrating fish can pass McNary Dam through three primary pathways: spill bays, juvenile bypass system, and turbine units.

Spillway. The spillway contains 22 vertical split-leaf gates. The gates are 50 feet wide and 51.8 feet high. The spillway has a baffled horizontal apron-stilling basin. Two rows of baffles and an end sill assist in dissipating energy. There are 16 spillway deflectors installed in bays 4-19 at McNary Dam. The normal head difference between high forebay and normal tailwater is 75 feet. The maximum spillway discharge is 1,368,000 cfs at normal full pool elevation of 340 feet.

Juvenile Bypass. The juvenile fish facilities consist of ESBS with flow vanes, vertical barrier screens, gatewell orifices, collection channel, dewatering structures, and a flume for transporting fish to the juvenile facilities or bypassing them back to the river. Juvenile transportation facilities include a separator to sort juvenile fish by size and to separate them from adult fish, a flume system to load raceways, covered raceways for holding fish, barge and truck loading facilities, and a PIT tag detection and deflection system.

Turbines. The powerhouse at McNary Dam has 14 Kaplan turbines with six automatically adjustable blades. The nameplate rating is 70 megawatt (MW) per turbine. The total hydraulic capacity of the powerhouse is 175,000 cfs at 75 feet of head and within 1 percent of best efficiency.

McNary Modeling Parameters.

Total Flow: 240 kcfs
Spill 120 percent Cap: 120 kcfs
Spill Hours: 1800-0600 spring only
Forced Day Spill: 65 kcfs (240-175)
SE: 1.5:1 (standard estimate)
Diel: 0.68

FGE: Yearling chinook (mixed) 0.83
Steelhead (mixed) 0.89
Suby. fall Chinook 0.62
Turbine survival: 0.90 (standard estimate)
Spillway survival: 0.97- 0.99
JBS survival: spring migrants 0.97- 0.99
summer migrants 0.87
FPE: Yearling chinook (mixed) 0.93
Steelhead (mixed) 0.96
Suby. fall chinook 0.74

Ice Harbor Dam

Juvenile migrating fish can pass Ice Harbor Dam through three primary pathways: spillbays, JBS, and turbine units.

Spillway. The spillway at Ice Harbor Dam has a total length of 590 feet and consists of 10 radial gate controlled bays, each 50 feet wide and 52.9 feet high. The spillway has a horizontal apron-stilling basin with two rows of baffles and an end sill. Each spillbay has a flow deflector. The normal head difference between full pool and normal tailwater is about 95 feet. At the normal full pool elevation of 440 feet the maximum spillway discharge is 685,000 cfs.

JBS. The juvenile facilities consist of standard length STSs, vertical barrier screens, 12-inch-diameter orifices, collection channel and dewatering structure, sampling facilities, and transportation flume/pipe to the tailrace below the project.

Turbines. The powerhouse includes six Kaplan turbines. The nameplate ratings of units 1-3 and 4-6 are 90 MW and 111 MW, respectively per turbine. The hydraulic capacity of the powerhouse is approximately 89 kcfs.

Ice Harbor Modeling Parameters.

Total Flow: 100 kcfs
Spill Cap: 45 kcfs (adult passage day)
120 percent Cap: unknown (115-130 kcfs estimate)
Minimum Ph operation: 9 kcfs (night)
Spill Hours: 24 hours per day
SE: 1.5:1 (standard estimate)
Diel: 0.68
FGE: Yearling chinook (mixed) 0.62
Steelhead (mixed) 0.74
Suby. fall Chinook 0.46
Turbine survival: 0.90 (standard estimate)
Spillway survival: 0.97- 0.99
JBS survival: spring migrants 0.97- 0.99

summer migrants 0.87
FPE: Yearling chinook (mixed) 0.96
Steelhead (mixed) 0.97
Suby. fall chinook 0.90

Lower Monumental Dam

Juvenile migrating fish can pass Lower Monumental Dam through three primary pathways: spillbays, JBS, and turbine units.

Spillway. The spillway at Lower Monumental Dam has a total length of 498 feet and consists of eight gate–controlled bays, each 50 feet wide and 60.6 feet high. Spillway deflectors have been installed on bays 2-7. The spillway has a horizontal-apron stilling basin with a sloping end sill. The normal head difference between full pool and normal tailwater is approximately 100 feet. The maximum capacity of the spillway is 676,000 cfs when the forebay is at the normal full pool elevation of 540 feet.

Turbines. The powerhouse includes six Kaplan turbines. The nameplate rating of units 1-6 is 135 MW per unit. The hydraulic capacity of the powerhouse is approximately 123 kcfs.

JBS. The Lower Monumental juvenile facilities consist of standard length STS, vertical barrier screens (VBS), 12-inch-diameter orifices, collection gallery, dewatering structure, and bypass flume to the tailrace below the project. Transportation facilities consist of a separator to sort juvenile fish by size and to separate them from adult fish, sampling facilities, raceways, truck and barge loading facilities, and PIT tag detection and deflector systems.

Lower Monumental Modeling Parameters.

Total Flow: 100 kcfs
Spill 120 percent Cap: 40 kcfs
Spill Hours: 1800-0600 spring only
SE: 1.5:1 (standard estimate)
Diel: 0.68
FGE: Yearling chinook (mixed) 0.49
Steelhead (mixed) 0.82
Suby. fall Chinook 0.49
Turbine survival: 0.90 (standard estimate)
Spillway survival: 0.97- 0.99
JBS survival: spring migrants 0.97- 0.99
summer migrants 0.87
FPE: Yearling chinook (mixed) 0.70
Steelhead (mixed) 0.89
Suby. fall chinook 0.49

Little Goose Dam

Juvenile migrating fish can pass Little Goose Dam through three primary pathways: spillbays, JBS, and turbine units.

Spillway. The spillway at Little Goose Dam has a total length of 512 feet and consists of eight gate-controlled bays, each 50 feet wide and 60 feet high. The spillway has a roller bucket-type stilling basin. Spillway deflectors have been installed in bays 2-7. The normal head difference between full pool and normal tailwater is approximately 98 feet. The maximum capacity of the spillway is 676,000 cfs when the forebay is at the normal full pool elevation of 638 feet.

Turbines. The powerhouse includes six Kaplan turbines. The nameplate rating of units 1-6 is 135 MW per unit. The hydraulic capacity of the powerhouse is approximately 123 kcfs.

JBS. The Little Goose juvenile facilities consist of a bypass system and juvenile transportation facilities. The bypass system contains ESBS with flow vanes, VBS, 12-inch-diameter gatewell orifices, a bypass channel, a transport flume and dewatering system, and a flume to transport fish to either the transportation facilities or to the river. The transportation facilities include a separator structure, raceways for holding fish, sampling facilities, truck and barge loading facilities, and a PIT tag detection and deflection system.

Little Goose Modeling Parameters.

Total Flow: 100 kcfs
Spill 120 percent Cap: 60 kcfs
Spill Hours: 1800-0600 spring only
SE: 1.5:1 (standard estimate)
Diel: 0.68 (based on Lower Monumental data)
FGE: Yearling chinook (mixed) 0.78
Steelhead (mixed) 0.81
Suby. fall Chinook 0.45
Turbine survival: 0.90 (standard estimate)
Spillway survival: 0.97-0.99
JBS survival: spring migrants 0.97- 0.99
summer migrants 0.87
FPE: Yearling chinook (mixed) 0.91
Steelhead (mixed) 0.93
Suby. fall chinook 0.45

Lower Granite Dam

Juvenile migrating fish can pass Lower Granite Dam through three primary pathways: spillbays, JBS, and turbine units.

Spillway. The spillway at Lower Granite Dam has a total length of 512 feet and consists of eight gate-controlled bays, each 50 feet wide and 60.1 feet high. The spillway has a horizontal apron-type stilling basin. Spillway deflectors have been installed in bays 1-8. The normal head difference between full pool and normal tailwater is approximately 103 feet. The maximum capacity of the spillway is 678,000 cfs when the forebay is at normal full pool elevation of 738 feet.

JBS. The Lower Granite juvenile facilities consist of a bypass system and juvenile transportation facilities. The bypass system contains ESBS with flow vanes, VBS, gatewell orifices, a bypass channel, a transport flume and dewatering system, and a flume to transport fish to either the transportation facilities or to the river. The transportation facilities include an upwell and separator structure, raceways for holding fish, sampling facilities, truck and barge loading facilities, and a PIT tag detection and deflection system.

Turbines. The powerhouse includes six Kaplan turbines. The nameplate rating of units 1-6 is 135 MW per unit. The hydraulic capacity of the powerhouse is approximately 123 kcfs.

Lower Granite Modeling Parameters.

Total Flow: 100 kcfs
Spill 120 percent Cap: 45 kcfs
Spill Hours: 1800-0600 spring only
SE: 1.5:1 (standard estimate); prototype SBC/BGS not included
Diel: 0.68 (based on Lower Monumental data)
FGE: Yearling chinook (mixed) 0.75
Steelhead (mixed) 0.81
Suby. fall Chinook 0.53
Turbine survival: 0.90 (standard estimate)
Spillway survival: 0.97- 0.99
JBS survival: spring migrants 0.97- 0.99
summer migrants 0.87
FPE: Yearling chinook (mixed) 0.86
Steelhead (mixed) 0.90
Suby. fall chinook 0.53

Lower Columbia River Projects

Bonneville, The Dalles, and John Day Dams

Standard Estimates

Many of the juvenile passage routes at Lower Columbia River projects have not been evaluated for survival, passage efficiency, or daily fish passage (diel) timing. FPE and project survival calculations in the following descriptions use the standard estimates defined by the PATH Hydro Group, Data Subcommittee.

Bonneville Dam

Juvenile salmonid migrants can pass Bonneville Dam through five primary pathways, including spillway, bypasses, and turbines in each of the two powerhouses. A relatively minor amount of passage occurs through the first powerhouse ice and trash sluiceway.

Spillway. The spillway includes 18 vertically operating gates with a hydraulic head of 50 to 70 feet. Two of these gates do not operate except to pass a small volume of attraction water to enhance adult passage. The stilling basin is of conventional apron-type design and includes two rows of baffle blocks for energy dissipation. The center 13 spillbays have spill deflectors. The current 120 percent total dissolved gas cap flow is approximately 120 kcfs (draft 1999 Columbia River Water Management Plan). Hydroacoustic information indicates that the diel timing through the powerhouses and spillway is generally well distributed throughout the day, both spring and summer (Hensleigh *et al.,* 1998, BioSonics 1998). Spillway passage efficiency under the current 24-hour spill program has generally been assumed to equal the project flow passing through it. However, radio tracking studies conducted with yearling chinook and steelhead in 1997 (Hensleigh *et al.,* 1998), indicated that at higher spillway flow volumes, the guidance efficiency may be better than 1:1. More studies with both radio tagged fish and hydroacoustics are needed to establish a more precise estimate for the general migration. Survival studies that included the spillway were conducted in the 1940s and again in 1989. Both studies indicated a spillway survival estimate of approximately 98 percent for subyearling chinook (Holmes *et al.*, 1952, Ledgerwood *et. al.,* 1990). There are no yearling salmon spillway survival estimates.

Bypasses (including first powerhouse sluiceway). The bypasses at each powerhouse are similar in general design but different in detail. Each consists of 20-foot submersible traveling screens that guide fish into gatewell slots containing one or two 12 or 13-inch orifices. These orifices discharge fish and flow into a collection channel that ends in a large dewatering screen. Flow, reduced to between 30 and 130 cfs, transports fish through a pipe to a location below the dam. The Bonneville I bypass was completed in 1981. It differs from the Bonneville II design in that it has submerged orifices and an outfall consisting of a 24-inch diameter full flow transport pipe that discharges below the surface of the powerhouse tailrace approximately 300 feet downstream of turbines 9 and 10.

The Bonneville II powerhouse bypass was completed in 1999 and differs from the first powerhouse bypass in that it has free discharge orifices that pass fish into a streamlined collection channel designed for a constant velocity flow (about 5 fps) through the channel and screening facility. Flow and fish then pas through a partially filled 48-inch transport pipe to an above-water outfall located in a swift-flowing section of the river approximately two miles below the powerhouse.

Fish guidance efficiency at Bonneville I is a combination of guidance through the bypass system and the ice and trash sluiceway. Fish passage into this sluiceway has not been studied under its current configuration; however, a generally agreed upon estimate of 4 percent guidance is used. The combined bypass and sluiceway FGE estimates are: wild yearling chinook 38 percent, hatchery yearling chinook 32 percent, mixed yearling chinook 32 percent, subyearling chinook (summer migrating) 9 percent, and steelhead 51 percent. At Bonneville II, FGE for wild yearling chinook is 44 percent, hatchery yearling chinook is 37 percent, mixed yearling chinook is 38 percent, subyearling chinook (summer migrating) is 28 percent, and steelhead is 39 percent. Most of these estimates are from Krasnow (1998); subyearling chinook and mixed yearling chinook estimates are from Fredricks and Graves (1997). [The Krasnow (1998) subyearling numbers were not used because there is evidence these estimates should not be adjusted for fyke net frame position, as explained in Fredricks and Graves (1997)].

Bypass survival for subyearling chinook was studied at Bonneville I in 1992. No point estimates of survival are available since there was no control release group. However, recovery comparisons among groups released through the first powerhouse bypass, turbines, and a location downstream of the dam indicated bypass survival was the lowest of all and 28 percent lower than the downstream release (Ledgerwood *et al.*, 1994). Since the comparison includes a downstream release, it must be noted that the survival differences include mortality occurring in the tailrace outside the specific passage route. There are no yearling salmon survival estimates. There are also no yearling or subyearling survival estimates for the new Bonneville II bypass system. Survival studies at the new system are scheduled to begin within the next few years, but until then, it is reasonable to assume the standard PATH survival estimate for both spring and summer migrants. Assigning PATH standard survival estimates to the Bonneville I bypass is problematic given the relatively low measured survival for subyearlings. Given the magnitude of the differences in recoveries from the 1992 survival studies, it is probably not unreasonable to assume that subyearling chinook bypass survival is no better than Bonneville I turbine survival (85 to 89 percent). There is no data to support the application of this reasoning to yearling migrants.

Turbine. The turbines at Bonneville Dam are standard Kaplan units operating under approximately 50 feet of hydraulic head. The 10 first powerhouse units are just over 60 years old and have an estimated peak efficiency of approximately 88 to 90 percent. The eight-second powerhouse units went on line in 1982 and have an estimated peak efficiency of approximately 93 percent. The powerhouse capacity of the first and second powerhouses is 120 and 136 kcfs, respectively.

Turbine survival has been estimated for both powerhouses using subyearling chinook only. Estimates from several years of study in the early 1940s at Bonneville I indicated survival in the 85 to 89 percent range (Holmes 1952). More recent studies at Bonneville II indicate a subyearling chinook survival in the 96 to 99 percent range (Ledgerwood *et al.*, 1990, 1991), perhaps reflecting the higher peak efficiency and newer design of the turbines in this powerhouse. No yearling salmon turbine passage survival estimates have been made for either powerhouse.

The Dalles Dam

Outmigrating salmonids can pass The Dalles Dam through three routes including the spillway, turbines, and ice and trash sluiceway.

Spillway. The Dalles Dam spillway consists of 23 radial gate controlled bays, each 50 feet wide with a hydraulic head of 75 to 87 feet. The stilling basin dissipates energy with one row of baffle blocks and an endsill. There are no flow deflectors. The current spill cap at 120 percent total dissolved gas is approximately 230 kcfs (draft 1999 Columbia River Water Management Plan). Spill efficiency (fish per unit flow) varies with the percentage of river flow spilled. In general, the higher the spill volume, the lower the efficiency. Hydroacoustic studies on mixed stocks in 1998 (BioSonics 1999) indicated that at 30 percent and 64 percent spills, the spill efficiency for spring migrants is approximately 1.7:1 and 1.9:1, respectively. For summer migrants, 30 and 64 spills provided efficiencies of 1.1:1 and 1.0:1, respectively. These percentages comport well with earlier studies conducted in 1986 and 1996 (BioSonics 1999).

Specific spillway survival for The Dalles Dam is the topic of current research. These evaluations have indicated that survival estimates for the current 64 percent spill level are 87 and 89 percent in the spring and 75 and 92 percent in the summer for 1997 and 1998, respectively (Dawley *et al.*, 1998, Dawley, pers com.). These data are preliminary pending completion of the research program.

Sluiceway. The Dalles Dam ice and trash sluiceway has been used as a fish passage route since the early 1970s. The passage route includes three open chain-gates above the intake for unit 1 (west end of the powerhouse) that pass surface flow into a sluice channel that runs the distance of the powerhouse. This flow passes over an end gate and into a chute that ends in the tailrace just west of the powerhouse afterbay deck. Water volume is approximately 6 kcfs and velocity can reach 60 fps at the outfall. In addition to chain gates, fish can enter this system through 6-inch orifices from the gatewells. There are no guidance screens to concentrate fish in these gatewells, so fish passage through the orifices is volitional and considered to be negligible at about 2 percent (Krasnow 1998).

Fish passage efficiency through the chain gates has been evaluated several times during the past 20 years. The generally accepted guidance efficiency has been 40 percent of the project passage (Krasnow 1998). This percentage does not account for a change in sluiceway guidance when the spillway is in operation. Data from hydroacoustic studies in 1998 indicate that when 64 percent spill is occurring, the guidance efficiency estimate of the sluiceway is 26 percent for both spring and summer migrants. When 30 percent spill is occurring, this estimate increases to 41 percent for spring and 35 percent for summer migrants (BioSonics 1999). Sluiceway survival was also studied in 1998. The preliminary estimates for spring migrants (test fish were coho and chinook) and subyearling chinook are 96 percent and 89 percent, respectively during the 30 percent spill condition (Dawley, pers. com.). Both the 1998 passage efficiency and survival estimates are the subject of ongoing research at this dam and as such, should be used with caution until studies are completed and the final reports published.

Turbine. The Dalles Dam has 22 Kaplan turbines that provide a total powerhouse flow of 345 kcfs at 1 percent peak efficiency. These units are contained in a powerhouse that is placed parallel to the normal river flow. This unusual orientation and the resultant forebay hydraulics appears to contribute to the high observed sluiceway passage and low turbine passage. Turbine entrainment was measured in 1998 at between 5 and 7 percent in the spring and 8 to 9 percent in the summer for 30 and 64 percent spill levels, respectively (BioSonics 1999). There are no project specific turbine survival estimates for The Dalles Dam.

John Day Dam

There are three primary juvenile passage routes at John Day Dam including the spillway, turbines, and a conventional bypass system.

Spillway. The John Day Dam spillway contains 20 radial gate bays, each 50 feet wide with an average hydraulic head of 95-105 feet. Flow deflectors are installed on the middle 18 bays. Energy is dissipated in a standard apron-type stilling basin with one row of baffle blocks and a sloping endsill. The 120 percent total dissolved gas cap at this project is currently estimated at 180 kcfs (draft 1999 Columbia River Water Management Plan). Spill for fish passage is provided primarily between one hour before sunset and one hour after sunrise. Passage efficiency for nighttime spill of 60 percent has not been specifically evaluated, however, radio tracking studies conducted in1998 indicate that passage efficiency was approximately 1:1 for spring and summer chinook and steelhead (derived from Martinelli *et al.,* 1998). Hydroacoustic studies in 1998 also indicated that spring and summer guidance efficiency was approximately 1.2:1 and 1.1:1, respectively, at the 60 percent nighttime spill level (BioSonics 1999). While not a part of the current operation, the 1998 studies indicated that daytime spill was two to six times more efficient than nighttime spill. This is the topic of a 1999 study program. Spillway survival has not been evaluated at this project.

Bypass. The bypass system is of conventional design with 20-foot turbine intake screens, gatewells, 14-inch orifices, collection channel, and transport flumes. The primary difference at this project is that the collection channel is a pressurized full flow conduit that ends at a small radial control gate. Fish and flow passing through this gate can either be passed to the river as is or passed through a dewatering and monitoring facility. Normal operation is through the dewatering and monitoring facility. In either case, fish are returned to the river through a relatively high volume outfall (400-600 cfs) into swift-moving water in the tailrace.

Fish guidance efficiency was measured in 1985 and 1986. For the current configuration, FGE for wild yearling chinook is 64 percent; hatchery yearling chinook is 54 percent; mixed yearling chinook is 58 percent; subyearling chinook is 32-34 percent; and steelhead is 68 percent (Krasnow *et al.,* 1998, Fredricks and Graves *et al.,* 1997). There are no FGE estimates for sockeye. Diel passage has been measured at the powerhouse in 1985 and 1997. The average proportion of 24-hour passage that occurs during the nighttime spill hours is approximately 80 percent for both spring and summer migrants (derived from Martinson *et al.*, 1998). There are no survival estimates for this system.

Turbine. The 16 turbines at this project are standard Kaplan units operating under 95-105 feet of hydraulic head. Powerhouse capacity at 1 percent peak efficiency is approximately 340 kcfs. There are no project specific turbine survival estimates for these units.

Attachment Four

IMPLEMENTATION OF HYDRO ACTIONS

A. Introduction

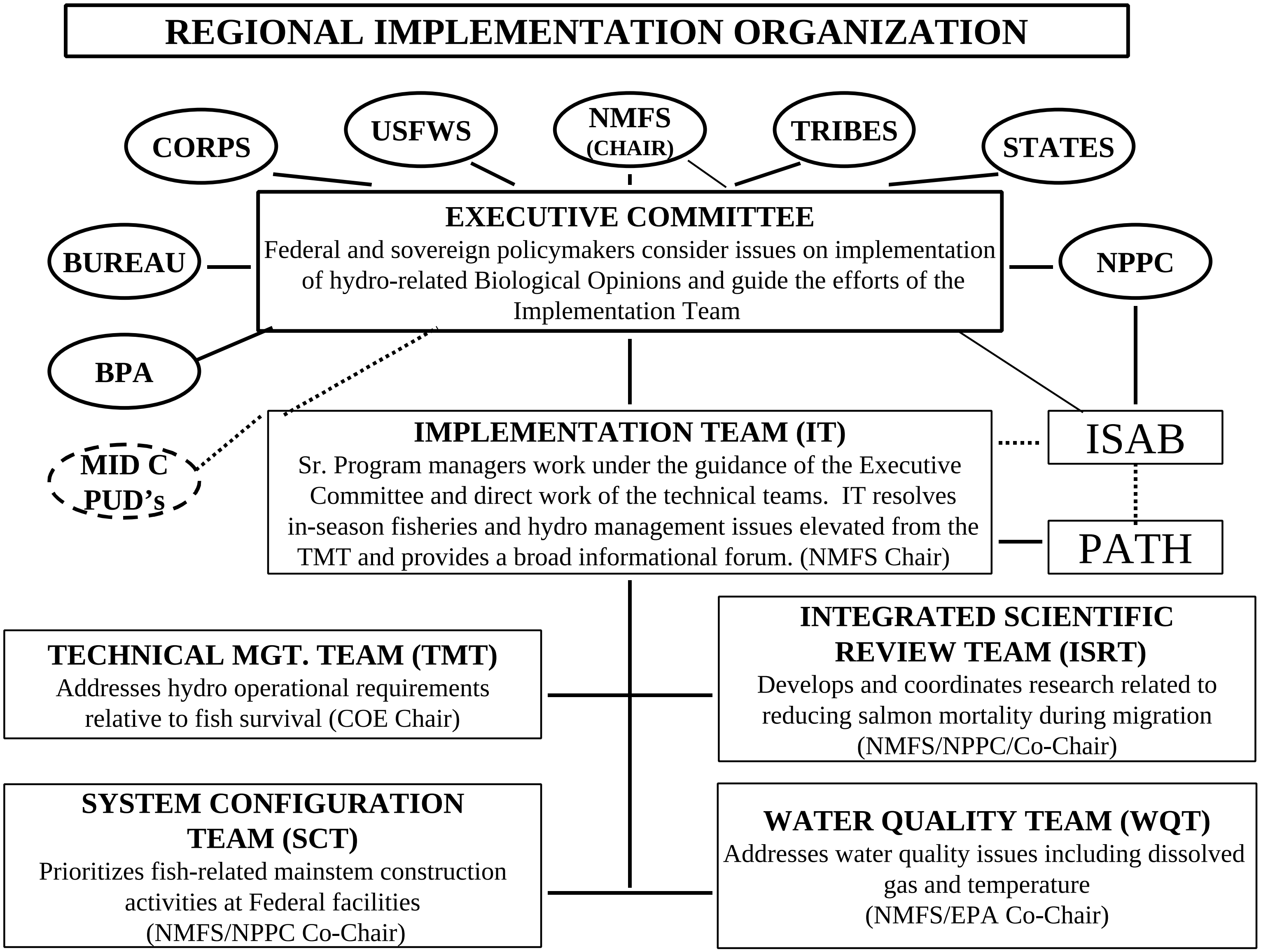
The coordination of fish and wildlife measures at major Federal projects in the PNW largely began in 1920s when the COE began to design ladders and lifts to allow passage of adult anadromous fish at Bonneville Dam. Oregon Senator Charles McNary had suggested that the COE share management at Bonneville Dam with a Columbia River Administrator, but the COE argued successfully that it should maintain responsibility for fish passage at its project. Thus began a long history of remarkable engineering achievements and extensive program coordination between Federal, state, and tribal governments over the passage of fish at Federal dams.

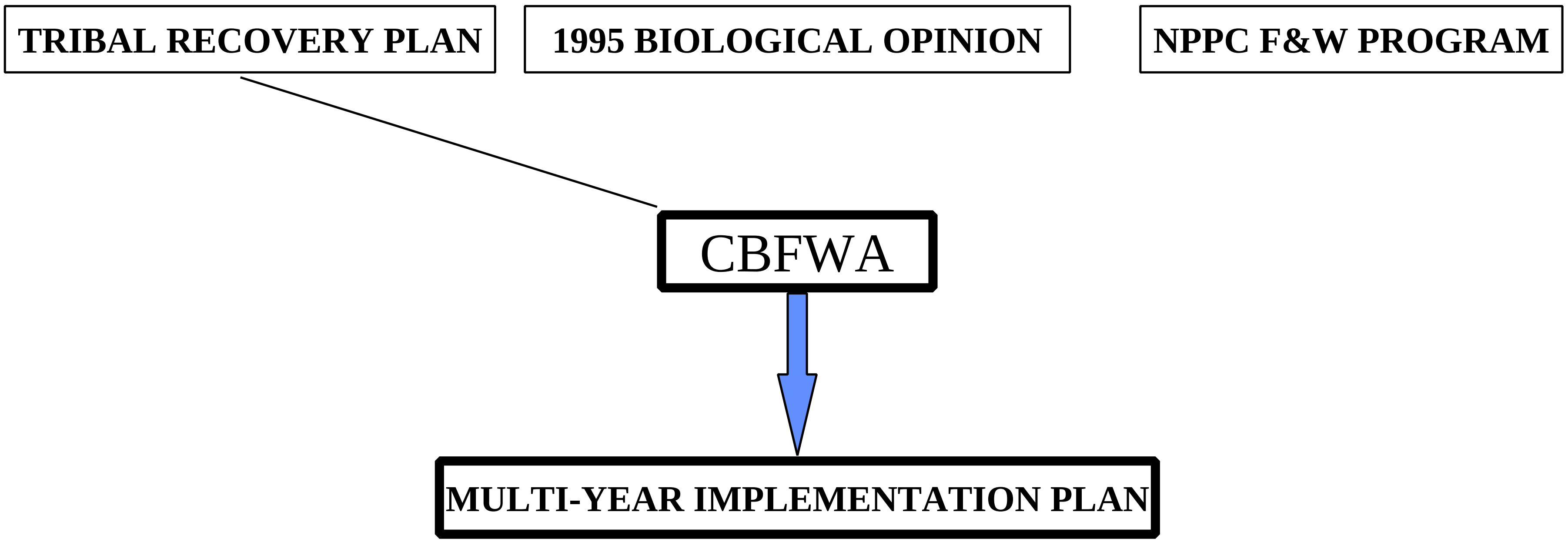
This section of the Hydro Appendix identifies the existing organizations that coordinate fish and wildlife protection at Federal hydropower facilities. It also describes the sources of Federal fish and wildlife money. Finally, it attempts to take measure of the coordination and spending and propose some alternatives.

1. *The Regional Forum - Coordination Under the ESA*

Since 1995, Federal, state, tribal, and non-governmental representatives have planned current and future project research, monitoring, operations, and configurations for the FCRPS through a tri-level regional forum; see Figure ATT4-1. The Regional Forum commenced with the 1995 ESA BO. The BO identified measures that the FCRPS action agencies, the COE, Reclamation, and BPA, agreed to implement, and it established the Forum to give each regional representative a voice in the implementation of the measures. The Forum uses a facilitator to resolve disputes.

At the highest level of the Forum, an Executive Committee (EC) meets periodically to resolve conflicts among sovereign governments. At the second Forum level, an Implementation Team (IT) meets monthly to direct the work of several technical teams, consistent with the direction of the EC. Finally, three technical teams meet sometimes weekly to make complex technical decisions about reconfiguration and operations. A System Configuration Team (SCT) identifies and prioritizes physical improvements to the dams. The improvements include design, construction, monitoring and evaluation activities. The SCT is co-chaired by NMFS and the NWPPC. A Technical Management Team (TMT) coordinates the operations of the FCRPS projects during the juvenile fish migration. The TMT decisions are guided by the BO that sets spill and flow targets for ESA-listed fish.


REGIONAL IMPLEMENTATION ORGANIZATION
CORPS
USFWS
NMFS (CHAIR)
TRIBES
STATES
EXECUTIVE COMMITTEE
Federal and sovereign policymakers consider issues on implementation of hydro-related Biological Opinions and guide the efforts of the Implementation Team
BUREAU
NPPC
BPA
MID C PUD's
IMPLEMENTATION TEAM (IT)
Sr. Program managers work under the guidance of the Executive Committee and direct work of the technical teams. IT resolves in-season fisheries and hydro management issues elevated from the TMT and provides a broad informational forum. (NMFS Chair)
ISAB
PATH
TECHNICAL MGT. TEAM (TMT)
Addresses hydro operational requirements relative to fish survival (COE Chair)
INTEGRATED SCIENTIFIC REVIEW TEAM (ISRT)
Develops and coordinates research related to reducing salmon mortality during migration (NMFS/NPPC/Co-Chair)
SYSTEM CONFIGURATION TEAM (SCT)
Prioritizes fish-related mainstem construction activities at Federal facilities (NMFS/NPPC Co-Chair)
WATER QUALITY TEAM (WQT)
Addresses water quality issues including dissolved gas and temperature (NMFS/EPA Co-Chair)


TRIBAL RECOVERY PLAN
1995 BIOLOGICAL OPINION
NPPC F&W PROGRAM
CBFWA
MULTI-YEAR IMPLEMENTATION PLAN

A water management plan is prepared annually to guide system operations to meet the BO's targets, while accounting for the vagaries of the weather through a seasonal water supply forecast. The COE chairs the TMT. A Water Quality Team (WQT) plans the physical and operational improvements to meet Federal and state water quality standards at the FCRPS projects. NMFS and EPA jointly chair the WQT.

2. *Other Programs*

Several programs overlap with the activities of the Forum. Most of these programs existed prior to the Forum and continue because of legal obligations, or a perceived need or desire for representation outside the Forum. In hydro activities, the program coordinators have made an effort to be consistent. Sometime inefficiencies occur because of staff shortages.

(a) The Columbia Basin Forum

The Columbia Basin Forum provides Federal, state, and tribal sovereign governments an opportunity to discuss and form public policy regarding the conservation and management of fish and wildlife resources in the Columbia River Basin. At the Forum board level, membership consists of the four Governors, a member of each of the 13 Columbia Basin Indian Tribes, and a representative of the Federal government. At the committee level, appointees include one representative from each of the four Northwest states, four representatives of the 13 tribes, and four Federal representatives. Forum members provide high-level policy direction to fish and wildlife managers in the Columbia Basin. By encouraging public participation, the Forum provides a place for regional governments and interested parties in the region to discuss alternative management approaches to the Basin and test regional agreement on the various alternatives. The Forum presently has executive power but no legislative authority.

(b) The NWPPC's Fish and Wildlife Program

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 established the NWPCC. The council is a form of regional government with strong state autonomy. Although Congress adopted the Act, Oregon, Idaho, Montana, and Washington legislatures approved formation of the NWPPC, and the four state governors appoint two members each. A professional staff supports the council. Revenues from Federal hydropower generation pay for NWPPC programs.

The Northwest Power Act requires the council to plan the region's energy future, with thorough public involvement, emphasizing energy efficiency, renewable energy sources, and energy conservation, while giving equal consideration to fish and wildlife. The public reviews and comments at formal meetings, often through organized special interest groups or government representatives.

Every five years, the NWPPC develops a Columbia Basin Fish and Wildlife Program. Since 1980 the council's programs have directly affected Federal hydropower operations by calling for water from Federal reservoirs and spill at Federal dams for fish migrations. The fish and wildlife program is based on recommendations from the region's fish and wildlife agencies, Indian tribes, environmental organizations, and others. In recent years, nearly $130 million in BPA funding has been allocated annually toward fish and wildlife recovery projects recommended by the Council in hydro, habitat, harvest, and hatchery arenas.

(c) The Multispecies Framework

The Framework is sponsored by the NWPPC and aims to develop a science-based vision for the council's fish and wildlife program. The Framework process has developed a set of alternative scenarios for future management of the fish and wildlife resources. The Framework will prepare a final report in late 1999 documenting and evaluating the alternatives.

Federal state and tribal representatives participate mainly through the Framework Management Committee. In particular, the Federal hydropower caucus and the Framework Management Committee and its representatives have coordinated extensively on planning and analysis activities.

(d) The Fish Passage Center and the Columbia Basin Fish and Wildlife Authority (CBFWA)

Shortly after the passage of the Northwest Power Act, the NWPPC directed BPA to fund a Fish Passage Center. The center has the responsibility to plan and implement an annual smolt monitoring program, coordinate flow and spill requests by fish managers, and monitor and evaluate the effects of flow and spill on fish passage and survival. The center relies on regular meetings with a Fish Passage Advisory Committee made up of Federal, state, and tribal fish managers.

The council's fish and wildlife program not only planned and coordinated fish and wildlife research, evaluation and mitigation at FCRPS projects, it also solicited project proposals to implement the program throughout the Columbia River Basin, and secured BPA funds to pay for the projects. Since most of the proposals came from fish and wildlife agencies and tribes, the council's program became the breadbasket for professional fish and wildlife managers. As fish and wildlife management grew, the managers organized themselves under the CBFWA. CBFWA's membership includes four state and two Federal fish and wildlife agencies, and 13 Indian tribes of the Columbia River

Basin. CBFWA was established by charter in 1987 to plan and coordinate fish and wildlife protection, enhancement and mitigation, to provide an open exchange of information, and to reach consensus positions on implementation of measures to improve fish and wildlife populations. In particular, CBFWA attempts to guide the planning and implementation of the council's fish and wildlife program.

(e) Independent Science Review Process

A November 1996 amendment to the Northwest Power Act called on the council to appoint an 11-member Independent Scientific Review Panel (ISRP). The amendment, authored by U.S. Senator Slade Gorton (R-Wash.), provides that scientists will review projects proposed to be funded through that portion of the BPA's annual fish and wildlife budget that implements the council's fish and wildlife program.

The Gorton Amendment, Section 4(h)(10)(D) of the Northwest Power Act, directs the council to appoint scientists recommended by the National Academy of Sciences. By law, expertise in ocean fisheries and wildlife biology must be represented on the panel, in addition to expertise in anadromous and resident fish. The council is required to appoint peer reviewers to assist the ISRP. The panel's recommendations shall be based on a determination that projects rely on sound science principles, benefit fish and wildlife, and have a clearly defined objective and outcome with provisions for monitoring and evaluation of results. The ISRP must make its recommendations to the council by June 15 of each year.

(f) The COE Anadromous Fish Evaluation Program (AFEP)

The AFEP is a long-standing COE process to coordinate construction, research, monitoring, evaluation, and reporting activities for fish passage among the Northwestern Division and the Portland and Walla Walla Districts and regional fisheries managers. The division and district coordinators who manage AFEP recommend fish passage solutions, design studies, schedule construction, hire and manage contractors, and create reports. The coordinators work closely with COE engineering and operations offices to assure that studies adequately address program needs and regional preferences.

Three workgroups comprised of regional engineers and biologists advise the AFEP coordinators. The Studies Review Workgroup (SRWG) reviews research proposals and reports within the seven areas of the AFEP, including surface bypass, transportation, conventional bypass systems, feasibility/drawdown, in-river passage (spill, gas, reach survival), adult fish migration, and turbine passage. The Fish Facilities Design Review Workgroup (FFDRWG) reviews proposals to modify existing fish facilities, and considers and recommends new fish passage technologies. The workgroup pays keen attention to the effects of facilities on fish behavior, condition, and survival, and it also follows AFEP programs from conception through engineering, design, and construction. The Fish Passage Operations and Maintenance Workgroup (FPOM) provides input on ongoing project operations. In particular, the group follows the adult fish counting program, outage schedules for turbines and fishways, and special operations required to conduct AFEP studies or other needs. The FPOM also reviews the COE' annual Fish Passage Plan. This document describes fish facility and project operating criteria that will be in effect in a particular year to provide acceptable passage conditions.

(g) The Mid-Columbia Coordination Process

Three PUDs in Washington State own and operate five mainstem Columbia River hydropower projects that are licensed by FERC. In the 1970s, Federal and state agencies, and tribes petitioned FERC to require the PUDs to protect the downstream passage of juvenile salmon and steelhead. FERC's response was to structure a coordination process, including all the major stakeholders, to develop fish passage improvements. This coordination process is now termed the Mid-Columbia Coordinating Committee. The committee meets at least once a month to develop passage studies and implement passage improvements.

In the late 1980's and early 1990s, Chelan and Douglas PUDs, FERC, and the fishery agencies developed two long-term agreements: the Rock Island agreement and the Wells agreement. These agreements outlined what Chelan and Douglas PUDs would research and implement for salmon and steelhead passage at Rock Island and Wells Dams. The agreements also created the Rock Island and Wells Coordinating Committees, which oversee implementing the terms of the agreement. These two committees work in conjunction with the Mid-Columbia Coordinating Committee to plan studies and passage improvements at the five PUD dams.

(g) Mid-Columbia Habitat Conservation Plan

FERC and NMFS are currently in formal consultation on Interim Protection Plans (IPPs) proposed by Douglas, Chelan, and Grant County PUDs. The parties are implementing through formal ESA consultation a Habitat Conservation Plan (HCP). The HCP will address the long-term reconfiguration and operation of the five mid-Columbia PUD dams. The Habitat Conservation Plan also will address the recovery of ESA-listed Upper Columbia River spring chinook salmon and steelhead, and other salmon stocks that migrate through the mid-Columbia PUD projects. The HCP commits the PUDs to specific dam passage performance standards and a goal of "no net loss" achieved through funding for habitat improvement and hatchery production.

A NMFS draft BO on the IPP is expected in January 2000. A NEPA document is also under preparation. Meanwhile NMFS, in cooperation with other parties, is developing a Quantitative Analytical Report for the listed species that may be affected by the mid-Columbia projects. The QAR will quantitatively assess the biological requirements and survival and recovery for Upper Columbia ESA-listed salmon and steelhead.

(h) Hanford Reach Protections

The Hanford reach of the Columbia River near Richland, Washington, between Priest Rapids Dam and the McNary Dam pool, is the last free-flowing section of the Columbia River above Bonneville Dam. It is the most productive segment of the river for fall chinook salmon, annually producing tens of thousands of redds. Power-peaking operations to meet daily electrical load demand can result in highly variable discharge downstream from Priest Rapids Dam. Such fluctuations can adversely impact salmon production by drying out salmon redds.

In the mid 1970s, Federal, state, and tribal fish management agencies petitioned FERC to limit the effect of power-peaking operations. The 1988 Vernita Bar Agreement set hydropower operations to limit and protect fall chinook spawners in the Hanford reach, from the time of spawning initiation in the fall until emergence in the spring. The three mid-Columbia PUDs and BPA cooperate with the fish and wildlife agencies and tribes to manage Vernita Bar flows.

Recently the Independent Scientific Advisory Board (ISAB) visited the Hanford reach area at the time of fall chinook emergence and discovered that thousands of salmon fry were stranded in shallow areas partly due to operations outside the operating period under the Vernita Bar Agreement. In 1998, a study found that power-peaking operations of the mid-Columbia operators were having a negative impact on survival of the juvenile fall chinook rearing in this reach. The problem was the result of flooding habitat that attracted juvenile fish and then dewatering that habitat, trapping fish in the process. An effort was made to develop a power operation for the 1999 season that would eliminate or greatly reduce these entrapments. The essential elements of the 1999 program were to provide steady or increasing flow through the spring season and limit the fluctuations in flow to a 20 kcfs band when flows were below 150 kcfs. The results of the 1999 operation were promising and a similar operation is planned for 2000.

(j) Hells Canyon Complex - FERC ESA Consultation and Relicensing

The Hells Canyon Complex (HCC) is owned by Idaho Power Company (IPC) and is composed of Hells Canyon, Oxbow, and Brownlee Dams. Historically, salmon and steelhead were present in large numbers in the Snake River and its tributaries above this complex. Nearly all of the remaining Snake River fall chinook spawning habitat is in the mainstem between the project and Lower Granite reservoir.

The HCC supports the flow augmentation requirements identified in the BO by providing flow augmentation from its Brownlee project and by shaping a portion of Reclamation's 427 kaf from the Upper Snake. Idaho Power is reimbursed by BPA for energy losses associated with the operation. Most Snake River fall chinook spawn downstream of the HCC and are directly affected by project operations. For this reason, IPC has voluntarily adopted operating rules to provide adequate spawning habitat for this population. The current FERC license expires in 2005.

The licenses of six other IPC projects on the mainstem Snake River (seven dams) above HCC have also expired or will expire within the next 10 years. These projects are primarily run-of-river projects with little storage capacity, but are located within the historic range of Snake River salmon and steelhead. All of this relicensing activity is being carried out under FERC's traditional relicensing process; however, IPC's collaborative process for relicensing is somewhat similar to FERC's alternative relicensing procedures.

In addition to the relicensing activity, FERC has agreed to consult with NMFS on operation of the HCC under the current license. A 1980 settlement agreement (signed by NMFS, among others) addressed hatchery production as compensation when fish passage at the project failed. FERC has provided a biological assessment with a "not likely to adversely affect" determination, which would result in an informal consultation. NMFS responded with a letter of non-concurrence informing FERC that formal consultation would be initiated. The scope of the consultation includes:

1. operations to meet FCRPS BO flow objectives
2. operations to meet fall chinook spawning, incubation, and rearing requirements
3. operation of Idaho Power Company hatcheries
4. project-related impacts to water quality.

NMFS expects that this consultation will be concluded by February 29, 2000.

3. The Budgeting Process

(a) The BPA Fish and Wildlife Cost MOA

In 1996 the Secretaries of Energy, Commerce, Army, and Interior signed a MOA on behalf of five Federal agencies - BPA, NMFS, COE, USFWS and Reclamation. The MOA establishes BPA's financial commitment for fish and wildlife restoration activities in the Columbia River Basin for the period 1996-2001. By setting funding limits, the MOA also gave BPA the financial predictability it needs in a deregulated electricity market.

The MOA pays an average $252 million per year for fish and wildlife obligations. It also pays the additional average costs associated with FCRPS operations under the 1995 BO.

The $252 million fish and wildlife obligation is divided three ways. First $100 million is available for BPA's direct fish and wildlife program (research, habitat improvements, facilities operations, monitoring and evaluation, etc. Second approximately $40 million is budgeted for reimbursable funds, including payments to the COE, Reclamation, and USFWS, and part of the NWPPC's fish and wildlife operating budget. Third an average $112 million is available for debt service on capital investments (fish bypass facilities, spillway modifications, hatcheries, etc.). If the actual expense in any of these three categories for a particular year is less than the forecasted amount, the unspent dollars are carried over with interest to the next year and remain available to the program.

The direct-funded Fish and Wildlife Program Budget is subject to review by CBFWA and the ISRP and is approved by the NWPPC.

(b) The COE Budget

The COE has two primary programs involving fish passage operations and facilities' improvements at its Columbia River Basin dams: the Columbia River Fish Mitigation Project and hydro project operation and maintenance (O&M). The Columbia River Fish Mitigation Project is a program for developing, evaluating, and implementing passage improvements at the COE' eight mainstem dams. Congress appropriates funding annually as part of the Energy and Water Development appropriation. Work in the CRFM is coordinated primarily through the System Configuration Team and includes measures such as the Lower Snake River Juvenile Salmon Migration Feasibility Study, surface bypass facilities, and dissolved gas abatement. The COE seeks recommendations on its budget and program priorities, as called for in the Fish and Wildlife Funding Agreement with BPA. In recent years, the annual expenditures in CRFM have been about $80 million. The COE has provided Congress with an estimate of $1.4 billion for the total program.

BPA reimburses the U.S. Treasury for the CRFM costs that are allocated to power, which is on average about 80 percent of the total costs.

O&M of fish passage facilities, transportation of juvenile fish, hatchery operations related to mitigation, and research related to O&M of fish passage are carried out through the COE' O&M program. BPA directly funds the portion of these O&M activities that are allocated to hydropower. The remaining costs are funded through requests for appropriations made to Congress. Coordination of program activities and budgets is carried out through the FPOM. The annual O&M program cost is approximately $29 million of which BPA directly funds about 80 percent.

(c) The Bureau of Reclamation Budget

Reclamation's budget is appropriated annually by Congress under the Water and Energy Appropriation. Generally, Reclamation's budget can be separated into categories of reimbursable activities and non-reimbursable activities. Reimbursable activities are those actions that require payment or reimbursement by the beneficiaries of Reclamation projects. O&M costs of existing Reclamation projects are usually 100 percent reimbursable. Direct project beneficiaries including irrigation, recreation, power generation, and other functional uses are allocated a share of the annual O&M costs.

The costs allocated to the operation of Reclamation power facilities under the FCRPS are reimbursed by BPA under a direct funding agreement; these costs include annual operation costs related to ESA mitigation of hydropower operations. All non-FCRPS costs related to ESA recovery efforts are paid out of the Federal General Fund and thus are included in Reclamation's annual appropriations.

With the exception of funds reimbursed to Reclamation through the BPA direct funding agreement, Reclamation appropriations are made on a case-by-case basis and in accordance with existing project authorizations. Reclamation's water acquisition funds for flow augmentation water from the Upper Snake River basin are appropriated annually under the Fish and Wildlife Fund of the Water and Related Resources Appropriation. Reclamation generally has limited discretion concerning the reallocation of appropriated funds.

4. Opportunities for Improved Coordination

The 1995 BO refined the structure for coordinating the decisions on configuration and operation of the FCRPS. That structure includes a group of program managers, known as the Implementation Team, which meets monthly. The structure contemplated in the BO also included an Executive Committee that would meet as needed to resolve disputes from the Implementation Team. That committee has not met in over a year and there appears to be little interest among the state and tribal managers to participate in such a committee.

Under the Implementation Team are several technical workgroups established to address different issues. The Technical Management Team meets weekly during the migration season to set hydropower operations. The System Configuration Team meets monthly and establishes priorities and schedules for capital improvements at the projects. The Water Quality Team provides scientific and technical recommendations on two critical water quality parameters: dissolved gas and temperature. In conjunction with these teams, there are existing groups that coordinate technical and programmatic aspects of regional activities in the hydropower arena. These include the COE's FPOM Committee, FFDRWG, Studies Review Workgroup, and a workgroup associated with the MOA on BPA's investments in fish and wildlife recovery.

The Federal agencies believe this type of intensive coordination in a hierarchical structure is appropriate and recommend it continue. There are a number of opportunities for improvement, including:

- Policy Oversight – we recommend using the newly formed Columbia River Basin Forum as the policy oversight body to consider disputes that cannot be resolved at the Implementation Team level.

- Participation – there is often minimal or inconsistent participation by key sovereign entities. Consistent participation would improve decisionmaking and timely implementation of actions and measures.

- Federal/non-Federal Coordination – presently there is informal coordination of activities at FERC-licensed projects, e.g., configuration measures at mid-Columbia projects, with Federal efforts at downstream dams. Although there is a Mid-Columbia Coordinating Committee, there could be better links established to ensure that coordination of programs and technology transfers occur. Also, the FERC-relicensing process for Idaho Power Company's HCC should be integrated with other regional hydro efforts.

- Research Framework – a multiyear regional research plan identifying priorities and responsibilities, and enabling coordination of programs and budgets, could improve efficiency and enhance integration of research results into decisionmaking.

- In-Season Management of River Operations – while the coordination and decision structure currently in place for in-season management works well, the following improvements are recommended:

  – Place greater emphasis on an annual plan for the upcoming migration season.

- Include criteria in the annual plan to guide decisions that have to be made during the season.

- Prepare an experimental management plan prior to considering the implementation of any actions that are outside the requirements of existing BOs.

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